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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 2

U.S. Department of the Interior
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Volume 2

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
JIP	Joint Industry Programme
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
NPC	National Petroleum Council
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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7. Synthesis of Documented Effects of Oil and Gas on Marine Mammals by Species and Region with Mitigation Measures in Place

This chapter summarizes the effects of oil and gas taking into consideration the mitigation and monitoring measures implemented for activities in the Beaufort and Chukchi seas (*i.e.*, U.S. Arctic) and Cook Inlet. This chapter presents effects that have been documented through research or observations (as cited). In contrast, Chapter 4 (Potential Effects of Oil and Gas on Marine Mammals) presents potential effects that may not have been directly observed during oil and gas activities in the Chukchi and Beaufort seas or Cook Inlet. As such, certain types of effects that are described in Chapter 4 are not discussed for each species in this chapter because information on those effects is lacking. For example, physiological effects (*i.e.*, TTS), non-auditory effects or stress are difficult to measure in the field and direct evidence of these effects on marine mammals during the period 2000–2020 are not evident in the literature, except as summarized below. In addition, research on marine mammal hearing and behavior is ongoing. More information is needed to adequately describe how or if disturbances caused by oil and gas result in meaningful biological effects on marine mammal species.

This synthesis is based on the body of literature reviewed, as described in Chapter 2, primarily for the period 2000–2020. This chapter is organized by species or species groups (as appropriate) for each region.

7.1. Bowhead Whales (*Balaena mysticetus*)

7.1.1. Current Status and Relevant Baseline Information: Western Arctic Stock

Bowhead whales of the western Arctic stock are distributed seasonally in ice-covered waters of the Arctic and near-Arctic (Figure 7-1). The NMFS 2020 draft stock assessment for the western Arctic stock of bowhead whales (Muto, Helker et al. 2020) lists the abundance estimate as 16,820 animals (coefficient of variation [CV=0.052]), as based on data collected in 2011. The Bering-Chukchi-Beaufort stock of bowhead whales has increased at a rate of about 3.7% per year from 1978- 2011 (95% confidence interval [CI] 2.9% - 4.6%) (IWC 2019). The exposure to exploration activities in the Beaufort and Chukchi seas since the late 1960s does not indicate an effect on population growth given their increasing numbers in the area. Independent aerial line transect surveys to better define bowhead whale abundance were conducted in the eastern Beaufort Sea as a joint effort by U.S. and Canada researchers (Muto, Helker et al. 2021).

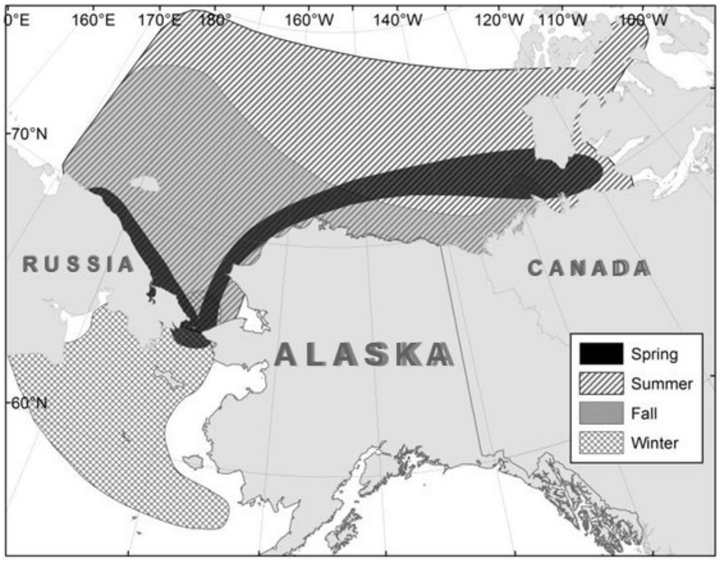

Figure 7-1. Annual Range of the Western Arctic Stock of Bowhead Whales 2006-2017

Sources: Quakenbush, Citta et al. (2018), Muto, Helker et al. (2021)

As of 2020, the maximum annual removal level consistent with mandates under the MMPA and ESA, and which is used to manage interactions between commercial fisheries and marine mammal populations, referred to as the Potential Biological Removal (PBR) level, was 161 whales. Under the authority of the IWC, annual removals of bowhead whales in the western Arctic for subsistence is managed using a harvest quota level (i.e., not PBR). The current quota for this stock is 67 strikes per year, plus up to 33 previously unused strikes (Thewissen and George 2021). For additional information on subsistence hunting of bowhead whales, please see Chapter 8.

The most recent information on human-caused mortality and serious injury and non-serious injury of bowhead whales reported by NMFS is for the years 2011–2015 (Helker, Muto et al. 2017). The estimated average annual mortality level was 46.2 animals per year, where 46 animals were taken by subsistence hunters from Alaska, Russia, and Canada and 0.2 animals were taken in commercial fisheries. Thewissen and George (2021) reported that the average annual harvest between 2010 and 2020 was 44 animals or approximately 0.5% of the population. Mortalities (*i.e.*, lethal takes) related to commercial fishing are considered a minimum estimate. Specific estimates of mortality related to ship strikes or entanglement in commercial fishing gear are not available. George, Sheffield et al. (2017) estimated that approximately 12% of 904 bowhead whales examined had evidence of entanglement in fishing gear (*i.e.*, mostly from fishing/crab pot gear in the Bering Sea (NMFS 2019). Approximately 2% of whales examined between 1990 and 2012 showed clear scarring from ship propellers (George, Sheffield et al. 2017). George, Sheffield et al. (2017) noted that ship strike injuries of bowhead whales in the western Arctic were uncommon. Hauser *et al.* (2018) commented that bowhead whales, because they occur seasonally in geographic bottleneck areas, would become more vulnerable to ship strikes, as open-water periods expand in the U.S. Arctic.

George, Philo et al. (1994) and George, Sheffield et al. (2017) reported that evidence related to killer whale predation on bowhead whales in the western Arctic (*i.e.*, "rake" marks) varied between 4.1% to 7.9% of harvested animals examined. These data represent bowhead whales that survived a predation attempt by killer whales. George, Sheffield et al. (2017) also noted that the incidence of killer whale predation attempts between 2002 and 2012 was greater than the previous decade.

Habitat use patterns of bowhead whales have been documented and typically reflect interannual changes in sea ice presence, ocean currents, distance offshore, water depth, prey availability and prey preference (Moore 2000, Moore, DeMaster et al. 2000, Moore, George et al. 2021); *i.e.*, bowhead whales selected shallow, inner-shelf waters under light ice conditions, and deeper slope habitat in heavy ice conditions (Quakenbush, Citta et al. 2018). Moore, George et al. (2021) noted that the combination of loss of sea ice and warmer seawater has “reset the clock on ecological processes in subarctic and Arctic seas”. It is likely, therefore, that habitat use patterns of bowhead whales in the near future will be either more variable or novel. As critical habitat has not been designated for the western Arctic stock of bowhead whales, a determination regarding potential impacts on critical habitat was not, and to date, has not been made. Fall aerial survey data for bowhead whales in the Alaskan Beaufort Sea over a 19-year period were reviewed by Treacy, Gleason et al. (2009). The results of this review indicated that transect sighting rate (transect sightings/km) indicated (ANOVA; $F_{2,980} = 143.84$, $p<0.0001$) that during years of heavy ice conditions (73.4 km, 95% CL:67.2-79.6 km), bowhead whales occurred further offshore as compared to years of moderate ice (49.3 km, 95% CL: 44.8–53.84 km) or light ice (31.2 km, 95% CL: 30.0–32.4 km).

As described in Section 6.1 (Acoustic Monitoring), since 2001, acoustic data have been collected using cabled hydrophones (2001–2003)[1] or DASARs (2003 - 2021) around Northstar. Instruments were deployed in late August and retrieved in late September or early October each of these years to detect bowhead whale calls during migration and to characterize other marine mammals that may be present (Norman and Greene 2000, Greene, McLennan et al. 2004, NMFS 2012). In addition, sounds associated with industrial activities including construction, drilling, production, and support activities (e.g., crew ships, barging, etc.) at Northstar were also collected during the fall bowhead whale migration. . Results for 2011–2017 are described in annual summary reports for those years (Richardson and Kim 2012, Richardson and Kim 2013, Richardson and Kim 2014, Richardson and Kim 2015, Kim and Richardson 2016, Kim and Richardson 2016, Kim and Richardson 2020). The most recent report available was presented to agencies in 2021 and presents data for 2019 (Kim and Richardson 2020) (Section 6.1.1). See also Blackwell and Thode (2021) for a summary of bowhead whale responses to ambient and anthropogenic noise levels.

In addition, the effects of oil and gas activities on bowhead whales in the western Arctic have been evaluated in a number of BiOps by NMFS, including the NMFS’ 2012 BiOp related to potential impacts of exploratory drilling in the Beaufort Sea and NMFS’ 2015 opinion related to potential impacts of oil and gas exploration in the Chukchi Sea. In these and other BiOps summarized in the Annotated Bibliography (Appendix B), NMFS concluded that the potential effects of oil and gas activities were not likely to jeopardize the continued existence of this stock. NMFS’ 2002 BiOp concluded that the Liberty Project was not likely to adversely affect any other listed marine mammal in the Gulf of Alaska or North Pacific due to transport of oil originating from the Alaska North Slope.

Regarding the impacts of oil and gas on the western Arctic stock of bowhead whales (and other marine mammal species), Ireland, Bisson et al. (2016) noted:

> *Although bowheads are the best studied species in the Chukchi and Beaufort seas, and less information is available on the abundance of other marine mammal species in the Chukchi and Beaufort seas, there is no evidence that oil and gas exploration activities in this area have resulted in population-level effects to any species. Species such as ringed seals, gray whales, and Pacific walrus remain abundant in areas where offshore exploration activities have occurred since the 1970s. Intensive monitoring of recent exploration activities in the Arctic OCS has suggested that impacts to marine mammals were limited to localized and short-term effects.*

[1] In 2003, hydrophones were used in the first part of the year, while DASARs were used the second part of the year.

For a comprehensive list of relevant literature that includes information regarding bowhead whales within this context, please refer to Appendix A.

7.1.2. Mortality and Serious Injury

There are no reports of direct mortality or serious injury of a bowhead whale due to oil and gas activities in the Chukchi or Beaufort seas. In a number of BiOps, NMFS has consistently concluded that bowhead whales exposed to oil and gas activities and the associated noise levels would experience temporary, nonlethal effects, assuming reasonable mitigation measures were adopted (NMFS 2006, NMFS 2008). Upon review of more than 40 MMPA 90-day, annual, and comprehensive monitoring reports and plans for the period 2000–2020, no bowhead whale mortalities or serious injuries have been documented as a result of oil and gas activities in the Beaufort or Chukchi seas.

7.1.3. Physiological Effects (Threshold Shift)

Direct evidence of physiological effects from oil and gas activities on bowhead whales is lacking. While there is the potential that certain sound sources, such as seismic airguns, could cause hearing (auditory) injury or PTS if operated in close proximity to whales, most whales are expected to move away from sounds that could cause injury. NMFS' 2002 BiOp for construction and operation of Liberty Oil Production Island concluded that avoidance reactions of bowheads to approaching seismic vessels would likely prevent exposure to potentially injurious noise pulses (NMFS 2002). Generally, seismic surveys occur in open ocean areas following standard survey lines where highly mobile whales are able to move freely to avoid the acoustic footprint of the relatively slow-moving sound source, thus potentially avoiding exposure to injurious sound levels. The onset of TTS (considered Level B harassment under the MMPA), might also occur in individuals or small groups. TTS also has the potential to decrease the range over which socially critical communication takes place (*e.g.*, communication between mothers and calves). The effect of Level B harassment to bowhead whales and other marine mammal species beyond the immediate behavioral response is a matter of ongoing investigation (Blackwell and Thode 2021).

Further, survey protocols and other mitigation measures are meant to reduce the potential for Level A and Level B exposures. Noise modeling used to estimate exposures (see Section 6.1.2) largely do not take into account the effect these mitigations have in reducing exposures (and therefore potential for take). The 2003 LOA issued for Northstar stated that activities could produce noise resulting in Level B harassment of approximately 765 bowheads annually, with a maximum of 1,533 in 2 out of 5 seasons, and a total of 3,585 in 5 years (NMFS 2003). NMFS concluded that with mitigation measures in place and based on the results from the monitoring program carried out since 1999, there have been no indications that determinations made in 2000 and 2001 were in error, nor that estimated levels of incidental harassment have been exceeded, and because the activity previously reviewed in 2001 (oil production activities) had not changed, these determinations remained valid. In the 2008 BiOp for the MMS Oil and Gas Leasing in the Chukchi and Beaufort seas 2006–2013, NMFS concluded that the proposed actions would likely have no more than a temporary adverse effect on bowhead, fin, and humpback whales due to vessel operations, marine geophysical (seismic) exploration, aircraft traffic, and drilling noises. Available data did not indicate that noise or disturbance from oil and gas exploration and development activities since the mid-1970s would result in PTS, or any serious injury that might have had a lasting population-level adverse effect on bowhead whales. Further, in the Chukchi Sea in 2006 and 2008, 13 cetaceans were sighted within the ≥180 dB re 1 μPa rms radius before mitigation measures could be implemented. Most of these cetaceans exhibited no reaction or a minimal behavioral response (Haley *et al.* 2010, as cited in (NMFS 2013) regardless of received sound levels (~96% of sightings).

Therefore, implementation of mitigation measures, such as safety zones (based on the estimated distance to threshold levels that may cause TTS [≥180 dB re 1 μPa rms radius for cetaceans]), likely reduce exposure to high levels of sounds such as seismic or pile-driving, that could result in PTS. The short duration and exposure to these intermittent sound sources reduces the likelihood for behavioral response that may affect vital functions (reproduction or survival), TTS, or PTS.

7.1.4. Behavioral Response Due to Disturbance

Marine mammal behavior is variable among species as well as individual animals. Determining whether a change in behavior is biologically meaningful for an individual or a population of animals is considerably difficult, particularly in environments such as the U.S. Arctic or Cook Inlet. That said, long-term monitoring of exposure to noise from oil and gas activities can be used to help understand behavioral responses of bowhead whales to those sounds. The primary direct and indirect effects on bowhead whales from activities associated with oil and gas exploration in the Beaufort and Chukchi seas result from noise exposure (NMFS 2016).

Oil and gas activities can affect bowhead whale behavior by acoustically limiting their "communication space" due to increased noise levels during seismic surveys. The communication space is defined by Clark, Ellison et al. (2009) as "the volume of space surrounding an individual, within which acoustic communication with other conspecifics can occur." As described in Section 4.1.5, masking refers to noise, environmental or anthropogenic, that interferes with the ability of an animal to detect a specific sound signal. Masking in marine mammals is a function of the animal's hearing sensitivity, ambient noise source level, and animal distance from the source. Therefore, when noise interferes with marine mammal communications, it is said to "mask" the sound (*e.g.*, a call to another whale might be masked by an icebreaker operating at a certain distance away) (Clark, Ellison et al. 2009). Masking can effectively degrade the quality of the acoustic habitat or "soundscape" for whales (see Section 4.1.5).

A key objective of the long-term Northstar monitoring program is to characterize the late summer, early fall westward migration of bowhead whales past the island and the possible effects of sound from Northstar on that migration. Since 2000, seafloor recorders have documented bowhead whale calls relative to Northstar between late August and October every year. During this time of year, whales are migrating past the island and their calls may be recorded. The Northstar acoustic monitoring program allows for a long-term comparison of the numbers, locations, and types of bowhead whale calls during periods when oil and gas activities associated with Northstar occur. Differences in whale calls over time, however, do not necessarily equate to changes in behavior or migration. An overview of the results from monitoring between 2000 and 2004 are described in detail in the first of two comprehensive reports (Richardson 2008). For the period 2005–2010, monitoring results are summarized in annual reports and in a second comprehensive report (Richardson 2011). Results for 2011–2017 are described in annual summary reports for those years (Richardson and Kim 2012, Richardson and Kim 2013, Richardson and Kim 2014, Richardson and Kim 2015, Kim and Richardson 2016, Kim and Richardson 2016, Kim and Richardson 2020). The most recent report available was published in 2020 and presents data for 2019 (Kim and Richardson 2020). In 2012, statistical analyses of the 2003 (McDonald, Richardson et al. 2012) and the 2001–2004 (Richardson, McDonald et al. 2012) acoustic monitoring datasets were undertaken to evaluate an apparent shift in localized whale calls offshore. The results of these analyses are discussed in more detail in Section 7.1.4.2 and more detailed information is available in McDonald, Richardson et al. (2012), Richardson, McDonald et al. (2012).

7.1.4.1. Behavioral Responses during Seismic Surveys and Exploratory Drilling

Observed behavioral reactions of bowhead whales due to sounds from seismic surveys may include avoidance or changes in calling rates (Richardson, Finley et al. 1995, Miller, Elliott et al. 1998, Blackwell and Thode 2021). Controlled playback experiments were conducted by Richardson, Finley et al. (1995) and Richardson (1997, 1998, as cited in (NMFS 2013) to assess bowhead whale responses to sound. Bowheads tended to avoid drill ship noise at levels estimated between 110 and 115 dB re 1µPa and seismic noise at received levels around 110 to 132 dB re 1µPa. The authors concluded that some marine mammals would tolerate continuous sounds at received levels above 120 dB re 1 µPa for a few hours and assumed most animals would avoid levels greater than 140 dB re 1µPa at frequencies in the most sensitive hearing range. During the Northstar acoustic monitoring program in 2009, distant seismic sounds were recorded in the bowhead whale migration corridor that were not associated with Northstar activities. Consequently, a specific relationship between offshore distance of bowhead whale calls and Northstar sound could not be conclusively identified (McDonald *et al.* 2012).

As cited in Patterson, Blackwell et al. (2007), bowhead whales generally avoid areas around operating seismic vessels, but the distance of avoidance is variable and depends on the time of year, location, and whale activity during the exposure. In certain instances, bowheads begin to show active avoidance upon receiving airgun sounds above approximately 160 dB re 1 µPa rms (Richardson, Würsig et al. 1986, Ljungblad, Moore et al. 1988, Richardson and Greene Jr. 1993, Miller, Moulton et al. 2005). Data for the period 1996–1998, as summarized in Miller *et al.* (1999) and Richardson *et al.* (1999, as cited in (Patterson, Blackwell et al. 2007), indicated migrating bowhead whale avoidance of seismic operations at lower received levels and longer distances. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn showed avoidance out to 20 to 30 km from a medium-sized airgun source at received sound levels of around 120 to 130 dB re 1 µPa rms (Miller *et al.* 1999 and Richardson *et al.* 1999, as cited in (Patterson, Blackwell et al. 2007). Avoidance of the area did not last more than 12 to 24 hours after seismic shooting stopped; however, shifts in whale movements were documented as far as 35 km and were persistent at distances 25 to 40 km, with the farthest distance of measured shifts in movements up to 50 km of passing seismic-survey operations (Miller *et al.* 1999, as cited in (Patterson, Blackwell et al. 2007). Data for the period 1996–1998, as summarized in Miller *et al.* (1999) and Richardson *et al.* (1999), both cited in (Patterson, Blackwell et al. 2007), indicated migrating bowhead avoidance of seismic operations at lower received levels and longer distances. Analyses of data on traveling bowheads in the Alaskan Beaufort Sea also showed a stronger tendency to avoid operating airguns than was evident for feeding bowheads (Koski, Ireland et al. 2008, Christie, Lyons et al. 2009).

Beginning in 1996, a marine mammal and acoustic monitoring program was conducted during 3D seismic programs in the central Alaskan Beaufort Sea using airguns varying in size from a 560-in^3 array with 8 airguns to a 1,500-in^3 array with 16 airguns. A peer-review group at the June 5-6, 2001, Arctic Open-Water Noise Peer Review Workshop in Seattle summarized the Beaufort Sea monitoring for seismic surveys in Simpson Lagoon:

> *Monitoring studies of 3-D seismic exploration (8-16 airguns totaling 560-1,500 in^3) in the nearshore Beaufort Sea during 1996–1998 have demonstrated that nearly all bowhead whales will avoid an area within 20 km of an active seismic source, while deflection may begin at distances up to 35 km. Sound levels received by bowhead whales at 20 km ranged from 117-135 dB re 1 µPa rms and 107-126 dB re 1 µPa rms at 30 km. The received sound levels at 20-30 km are considerably lower levels than have previously been shown to elicit avoidance in bowhead or other baleen whales exposed to seismic pulses (NMFS 2012).*

In a 2001 IHA issued for WesternGeco open-water seismic surveys in the Beaufort Sea (NMFS 2001), NMFS concluded that based on data from 1996 through 1998, analysis indicated that bowhead whales avoid nearshore seismic operations by a distance of approximately 20 km. Provided mitigation measures were implemented as planned, NMFS determined there would be no more than a negligible impact on marine mammals from the issuance of the IHA and there would not be any unmitigable impacts to subsistence communities.

In 2006, a tagged bowhead whale was tracked through the northern Chukchi Sea to the Chukotka coast. The tagged whale approached an eastward moving GXT seismic vessel *Discoverer* on October 15 and 16, 2006 within the estimated 120 dB re 1µPa radius around the airgun array (3,320 in^3 total volume), although the exact distance could not be determined based on observations (Ireland, Hannay et al. 2007) (Figure 7-2).

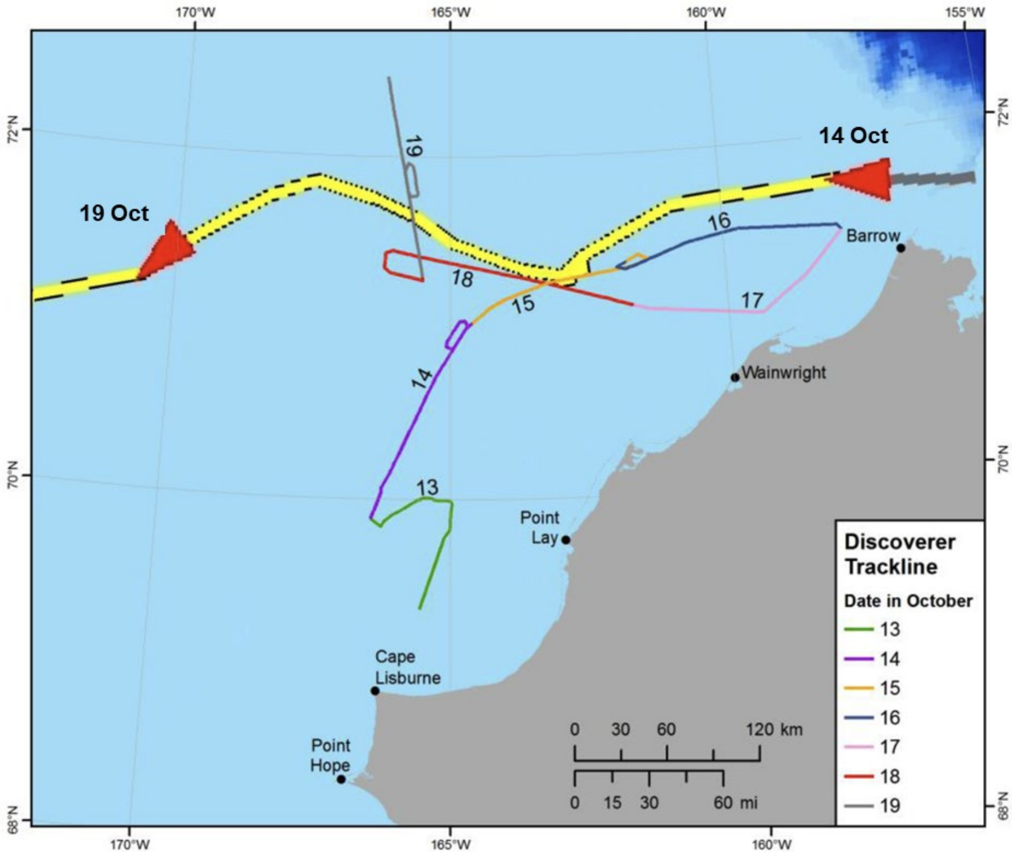

Figure 7-2. Tracklines of Satellite-tagged Bowhead Whale (Yellow) and the GXT Seismic Vessel *Discoverer* (Colored Lines Numbered by Date of Month) from October 13–19, 2006

Source: Ireland, Broker et al. (2016); adapted from Quakenbush (2007)

As reported in the 2016 comprehensive report for Shell's offshore exploration activities in the Alaskan Chukchi Sea during the 2015 open-water season in the U.S. Arctic, vessel-based monitoring effort and observations of bowhead whales in the Chukchi Sea from years when seismic or shallow-hazards surveys occurred were pooled and sighting rates within received sound level bins calculated. The combined sighting rate from both source and monitoring vessels was very similar in areas where received sound levels were ≥160 dB re 1 μPa rms SPL and ≤120 dB re 1 μPa rms SPL. This demonstrates that whales did not completely avoid areas with higher received sound levels from seismic airguns. Overall, monitoring results cannot rule out that bowheads may have responded to or avoided exploration drilling activities at relatively short distances (<10 - 15 km), but they do not show that large-scale disruptions to the bowhead migration timing or use of the Chukchi Sea occurred. Vessel-based sightings data do not show clear evidence of bowhead avoidance of drilling activities in the Beaufort Sea. Additionally, mitigation measures applied during these activities appear to have been effective in limiting impacts from offshore seismic operations in the Beaufort Sea to bowhead whales and to the subsistence bowhead hunts in Utqiaġvik, Kaktovik, and Nuiqsut (Ireland, Bisson et al. 2016).

Bowhead whales that are feeding have shown less avoidance to underwater sound sources than whales that are migrating (BOEMRE 2011). Behavioral changes were not exhibited by whales exposed to seismic airgun pulses with received sound levels of 107 to 158 dB re 1 μPa from vessels ranging 6 to 99 km away. When seismic vessels approached within 3 to 7 km of the whales and received sound levels of airguns ranged from 152 to 178 dB re 1μPa, avoidance responses were observed (Richardson, Würsig et al. 1986).

During this same study, feeding bowheads approximately 2 km from a seismic vessel were observed turning away from a 30-airgun array. Further analysis of data for the period 1998–2000 was undertaken by Robertson, Koski et al. (2013). While modeling indicated that dive durations were affected by seismic operations, behavioral changes in bowhead whales exposed to seismic operations appeared context-dependent. Although (Robertson, Koski et al. 2016) evaluated data from a 2008 aerial survey that indicated the number of bowhead whales around seismic operations are likely underestimated if behavioral effects on whales, such as reduced surface times and increased dive durations, are not accounted for.

In the Alaskan Beaufort Sea, data collected during an aerial survey 2006 to 2008 indicated that feeding bowheads did not exhibit largescale distribution changes in relation to late summer, early autumn seismic operations (Funk, Ireland et al. 2010). Koski, Ireland et al. (2008) reported that aerial surveys conducted in the central Beaufort Sea during late summer and early autumn of 2007 detected large numbers of feeding bowhead whales in an area where feeding has been seen in the past but is not common. Whales remained in the same general area while seismic surveys were conducted 10-50 km east of them and bowheads were seen as close as 1.4 km from the source vessel. There was evidence of small-scale avoidance of the seismic operation, but one group of three whales tolerated received levels of seismic sounds approximately 180 dB re 1 μPa, three groups (five individuals) tolerated levels >170 dB re 1μPa, and at least 12 groups (19 individuals) tolerated levels 150 to 170 dB re 1μPa. These levels are much higher than the 120 to 130 dB re 1μPa levels that migrating bowhead whales avoided during seismic operations near the same location in 1996–1998. Thus, it appears that bowhead whales under some circumstances will tolerate much higher levels of seismic sounds (*i.e.*, when food sources are available than they will when food is not available).

Thode, Blackwell et al. (2020) reported:

> *Over 500,000 automated and manual acoustic localizations, measured over seven years between 2008 and 2014, were used to examine how natural wind-driven noise and anthropogenic seismic airgun survey noise influence bowhead whale call densities (calls/km^2/min) and source levels during their fall migration in the Alaskan Beaufort Sea. Noise masking effects, which confound measurements of behavioral changes, were removed using a modified point transect theory. The authors found that mean call densities generally rose with increasing continuous wind-driven noise levels. The occurrence of weak airgun pulse sounds also prompted an increase in call density equivalent to a 10–15 dB change in natural noise level, but call density then dropped substantially with increasing cumulative sound exposure level (cSEL) from received airgun pulses. At low in-band noise levels the mean source level of the acoustically-active population changed to nearly perfectly compensate for noise increases, but as noise levels increased further the mean source level failed to keep pace, reducing the population's communication space. An increase of >40 dB cSEL from seismic airgun activity led to an increase in [bowhead vocalization] source levels of just a few decibels. These results have implications for bowhead acoustic density estimation, and evaluations of the masking impacts of anthropogenic noise.*

NMFS (2016) stated that the absence of changes in the behavior of foraging bowhead whales should not be interpreted to mean that the whales were not affected by the noise. Short-term disturbance reactions to airgun noises that have been observed may not be indicative of long-term or biologically meaningful effects. Nonetheless, the net rate of increase of the Bering-Chukchi-Beaufort stock from 1978–2011 has been estimated as about 3.7% per year (95% CI 2.9%–4.6%) (IWC 2019) during a period of exposure to exploration activities in the Beaufort and Chukchi seas.

In addition to these behavioral or avoidance responses, whales alter their vocal communications when exposed to anthropogenic sounds. The effect of seismic airgun pulses on bowhead whale calling behavior has been extensively studied in the Alaskan Beaufort Sea. Some research has shown that bowheads continue calling in the presence of seismic survey sounds, and their calls can be heard between seismic pulses (Richardson, Greene Jr. et al. 1995). Data from 2007–2010 indicated that call detection rates dropped rapidly when cumulative sound exposure levels (cSELs), summed over 10 min, were greater than approximately 127 dB re 1 µPa2·s and whales were nearly silent at received levels close to 160 dB re 1µPa (Blackwell, Nations et al. 2015). The decrease could be caused by a decrease or lack of calling by individual whales, whales avoiding the seismic activity, or a combination of both (Richardson 2008); however, calling resumed near the seismic operations area shortly after operations ended. Blackwell, Nations et al. (2015) reported that the decrease could be caused by a decrease or lack of calling by individual whales, deflection of whales around the seismic activity, or a combination of both; however, calling resumed near the seismic operations area shortly after operations ended.

Increases in anthropogenic and natural (*i.e.*, wind) sounds have been shown to result in an increase in bowhead whale calls. Bowhead whale call source levels also increased with an increase in ambient noise with the exception, however, of airgun pulses (Thode, Blackwell et al. 2020). Blackwell, Nations et al. (2015) and Blackwell, Nations et al. (2017) noted that bowhead whale calling rates initially increased when exposed to certain industrial sounds including airgun pulses, vessel tones, and machinery; however, at higher received levels (*i.e.*, when those sound source levels increased), bowhead calling rates then decreased.

On-ice vibroseis occurs during winter months when sea ice thickness of at least 1.4 m supports safe operations (NMFS 2006), typically early January through mid-May. As described in Quakenbush and Citta (2019), almost all bowhead whales migrate to the Canadian Beaufort Sea in the spring, with an average arrival date around Point Barrow of May 26th during the period 2006–2018. There is evidence of a shift towards more use of the north-central Chukchi Sea during winter months due to less sea ice (Quakenbush and Citta 2019). However, given the requirement for sea ice of a certain thickness to conduct on-ice vibroseis, it is unlikely bowhead whales would be in the Beaufort Sea during those activities.

7.1.4.2. Behavioral Responses during Construction and Operation of Oil and Gas Facilities

Underwater sound levels from Northstar operations were measured both near the source and offshore near the southern edge of the migration corridor. Richardson (2008), Richardson (2011) summarized the series of monitoring reports for Northstar Development and provided detailed information on acoustic monitoring program designed to record whales that call as they migrate past a source of underwater sound, allowing for several complicating factors. The reports from the Northstar monitoring program provide insight on the potential indirect effects due to disturbance from noise due to construction and ongoing operations. The long-term studies demonstrate that localization using passive acoustics can document temporal variations in the positions of calling bowhead whales in the inshore part of their fall migration corridor offshore of Northstar Island. Notably, only whales that call can be detected by the DASARs (see Chapter 6 for a description of PAM). Whales that pass through the area that are silent are not detectable using passive acoustics, which could result in biases. In addition, the number of calls detected using PAM is not indicative of the number of whales in the area and whales may have higher or lower rates of calling during certain periods. There could also be different calling rates and varying distances offshore, irrespective of bowhead distribution. Finally, the occurrence of other activities in the area may also disturb bowhead whales (Richardson and Williams 2001).

Chapter 8 of (Richardson and Thomson 2002) acknowledged the variability from year-to-year of bowhead whale migration due to ice conditions and other environmental factors. During 2001, just after Northstar construction, the bowhead whale subsistence hunt was reported as difficult partly because of weather and ice, but whales were also described as “skittish”. If any change in distribution occurred, the report concludes it was attributable if not entirely to sound from vessels rather than the island itself.

Richardson (2008) reported:

> *There could be a change in the relative numbers of calls emitted and detected at different distances offshore even if there were no corresponding change in the distribution of whales. An actual displacement of some whales was predicted a priori based on observed avoidance reactions of bowhead (and other) whales to industrial activities in other situations (Richardson, Greene Jr. et al. 1995). However, an effect of Northstar sound on locations where calls were detected could be attributable, at least in part, to a Northstar sound effect on some aspect(s) of bowhead calling behavior such as calling rate or source level.*

As summarized in Chapter 5 of Richardson (2011), some variation is due to the change in methodology (*i.e.*, equipment or placement of equipment); however, the proximity of nearshore pack ice and mean wind speed were also two key factors. In addition, the southern edge of the call distribution was another 0.68 km closer to shore when received levels of airgun pulses from seismic exploration far to the east of Northstar were above background sound levels.

For each year during the Northstar program, percentile levels of broadband sound (95th, 50th, and 5th percentiles) as well as minimum and maximum levels were computed over the entire field season and are summarized in Table 2.2 of (Kim and Richardson 2020). Over the 17-year period presented, maximum broadband sounds (in dB re 1µPa) ranged from 131.1 in 2003 to 141.1 in 2008 (Kim and Richardson 2020).

Bowhead whale call data collected every year since 2001 at a location approximately 15 km offshore northeast of Northstar (known as C/EB) allow comparison of mean number of calls per day over the 20-year program. Figure 7-3 shows the daily number of bowhead calls detected by DASAR at location C/EB by date (A) 2001-2009 and (B) 2010-2018. Five years underlined in panels (A) and (B) were years with relatively low call counts as shown with a different scale in panel (C). In 2018, the call detection rate at location C/EB was the fifth highest for the multi-year program at 984 calls/day. The year with the highest number of recorded calls (92,516) was 2017. Analyses of the distribution of whale calls in years when a full array was deployed has revealed that in the shallow waters offshore of Northstar, bowhead calls appear directional, i.e., received levels of sound in front of the whales are higher than the received levels behind the whale (Richardson, McDonald et al. 2012).

Figure 7-4 shows an analysis of directional bearing of bowhead whale calls detected by DASARs at location C/EB for the period 2001–2018 (Kim and Richardson 2020). For each 10° sector, results for each year are expressed as a percentage of all bearings to bowhead whale calls collected at location C/EB. In 2010 and 2011, note the different scale for percentage of bearings. Approximate orientation of the Beaufort Sea coast is shown as a dashed line through each DASAR. Sample sizes varied widely, from 331 calls in 2006 (over 18 days) to 92,516 in 2017 (39 days) (Kim and Richardson 2020).

The location of calls do have varying precision around their direction due to a number of factors including water depth, depth of the whale, and other environmental conditions. Analyses of the distribution of whale calls in years when a full array was deployed has revealed that in the shallow waters offshore of Northstar, bowhead calls appear directional, i.e., received levels of sound in front of the whales are higher than the received levels behind the whale (Blackwell et al. 2012). DASAR C/EB is deployed on the seafloor at 20 m, a water depth which impedes the propagation of sounds below about 100-150 Hz, yet bowhead calls often include frequencies down to tens of Hz. Therefore, lower frequency calls would be weakened, and the more directional, higher frequency calls would likely be detected (and reflected forwards by the whale's anatomy). This apparent directionality helps explain the distribution of bearings in the polar plots shown in Figure 7-4. Bowhead whales are traveling westward during acoustic monitoring at Northstar. Therefore, it may appear that most years the number of calls detected east of DASAR C/EB is greater than the number of calls detected to the west. Finally, analyses of similar DASAR data from other studies has confirmed the lack of apparent directionality with deployments in deeper water (e.g., 40-50 m) (McDonald, Richardson et al. 2012).

The 2018 Northstar monitoring report also provides the percentage breakdown by call type 2001–2018. As shown in Figure 7-5, there was little differentiation among years in the percentages of each call type with the exception of 2009, when there was a higher number of complex calls (Kim and Richardson 2020). Simple calls (colored bars) include upsweeps, downsweeps, constant calls, and undulations, while complex calls are shown in black.

Assessing the biological significance of monitoring results proves challenging, as noted in several monitoring reports over the 20-year study period summarized in this report. For example, the 2008 comprehensive monitoring report for Northstar states:

> *Assuming that some of these correlations [between bowhead whale calls and industrial sounds] actually correspond to specific responses of the whales to Northstar sounds, assessing their biological significance is challenging as little is known about the functions of bowhead calls (Richardson 2008).*

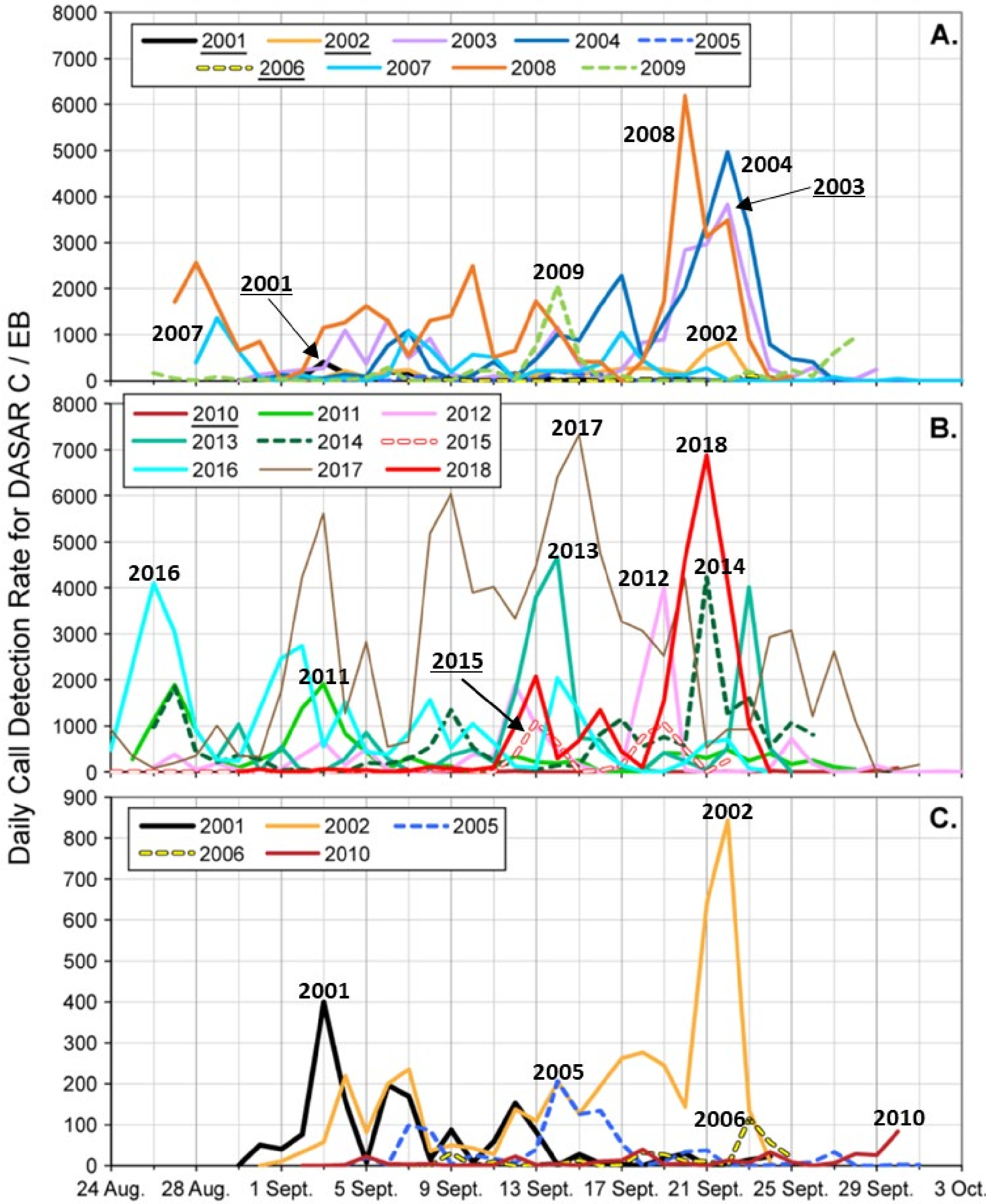

Figure 7-3. Daily No. of Bowhead Calls Detected by DASAR near Northstar at Location C/EB by Date 2001–2018

Source: Kim and Richardson (2020)

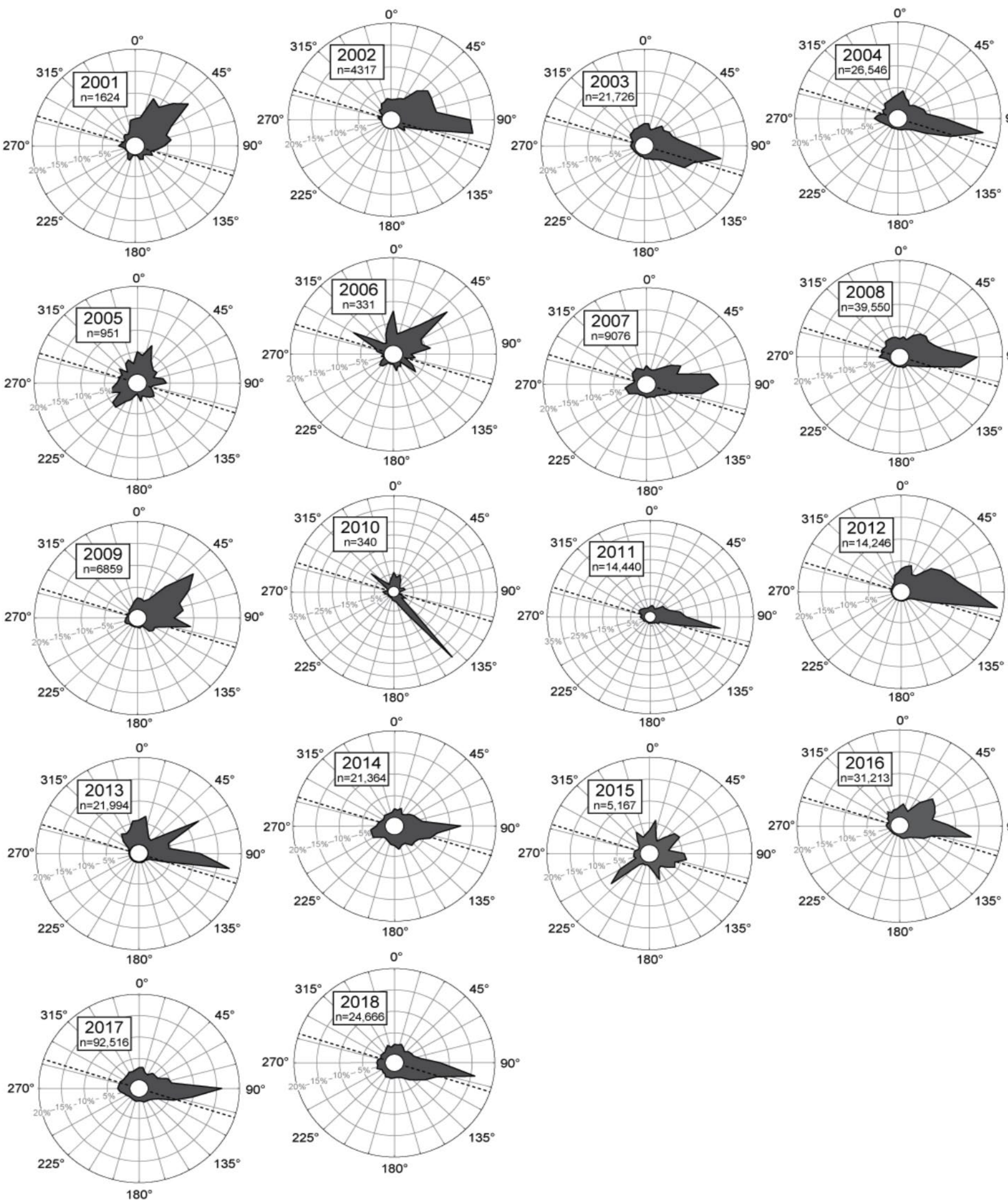

Figure 7-4. Directional Distribution of Bearings to Bowhead Whale Calls Detected by DASAR C/EB in 2001–2018

Source: Kim and Richardson (2020)

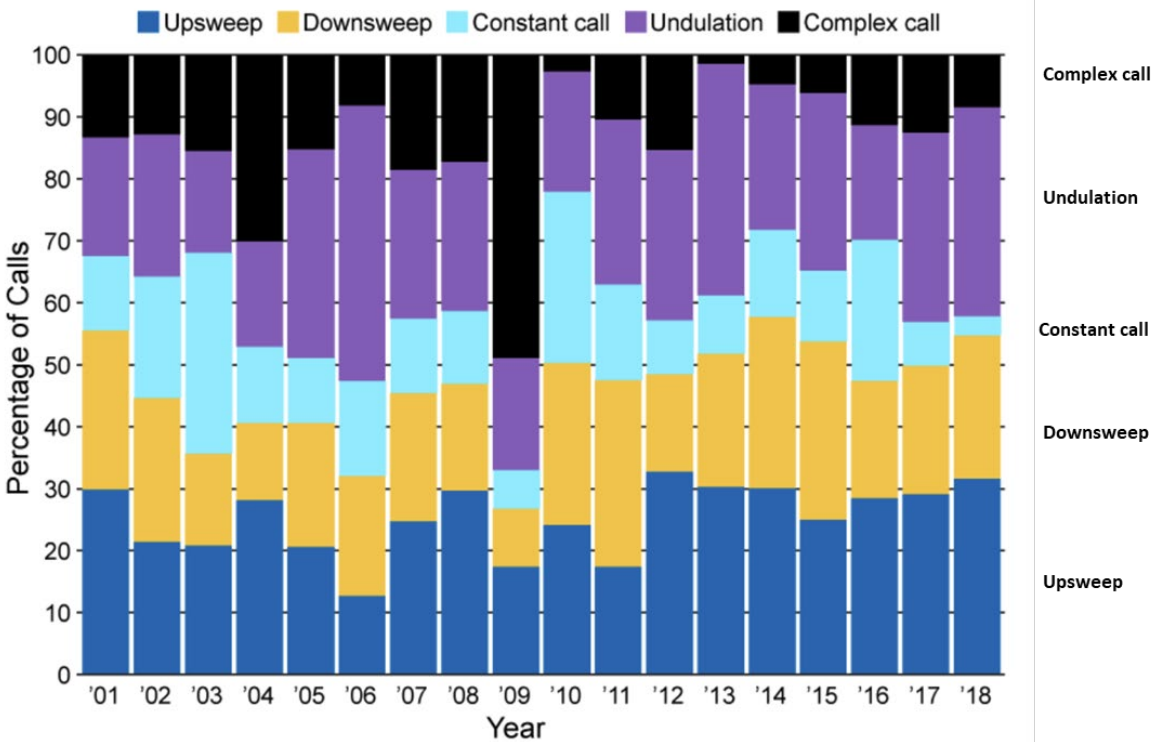

Figure 7-5. Percentage Breakdown by Call Type in 2001–2018 for Calls Detected by DASARs at Location C/EB

Source: Kim and Richardson (2020)

The 2014 long-term monitoring report prepared by BPXA (Bishop and Streever 2016) compared data collected on bowhead whale calls 2001–2014. This comparison showed that the highest call detection rate occurred in 2008 (1,337 calls per day), while the years 2003, 2004, 2013 and 2014 were similar in terms of an average number of calls per day (*i.e.*, approximately 684 in 2014). Heavy pack ice occurred in the offshore in 2005, 2006, and 2010 when the lowest number of bowhead whale calls were recorded. Studies conducted in the Chukchi Sea utilizing acoustic data from multiple DASAR arrays deployed in each of 8 years on behalf of Shell, an estimated median cue rate for the Bering-Chukchi-Beaufort population of bowheads during their westward fall migration was 1.3 calls/whale/hour (Blackwell, Nations et al. 2015).

McDonald, Richardson et al. (2012) described that analysis of passive acoustic monitoring data (25,176 bowhead calls) collected over 29 days in September 2003 detected a tendency for a portion (the 5^{th} quantile) of bowhead whale calls to be slightly further offshore (0.67km; 95% CI 0.31 to 1.05 km) when industrial sounds associated with Northstar (including vessels) were recorded in the 10–450Hz band 15 minutes prior to each call, even when received sound levels were low. Using block permutation, uncorrelated whale call clusters were assigned significance levels to coefficients in the quantile regression model due to potential dependencies in call locations. Allowing for natural within-season variation quantified by day–night changes, distance of the call east or west of Northstar, and the date, statistical modeling determined the anthropogenic sound measures most correlated with the 5^{th} quantile of offshore call distances (McDonald, Richardson et al. 2012).

Using the statistical approach described in McDonald, Richardson et al. (2012), Northstar acoustic monitoring data for four seasons (2001–2004) were further analyzed by Richardson, McDonald et al. (2012) to determine whether the closest detectable whale calls tended to be farther offshore when levels of underwater sound from Northstar (including support vessels) were above average. Weighted quantile regression was used to relate the 5th quantile of the offshore distances of bowhead calls to various measures of anthropogenic sound near Northstar after allowing for apparent effects of natural environmental covariates. Northstar sounds recorded by the nearshore (450 m) DASAR rarely exceeded 120–125 dB re 1 μPa, while received levels of Northstar sounds recorded by offshore DASARs rarely exceeded 105–110 dB re 1 μPa for the period 2001–2004. Richardson, McDonald et al. (2012) acknowledges that the acoustic data alone cannot distinguish whether the apparent shift in bowhead call locations was attributable to actual displacement of whales, noise-induced changes in bowhead calling behavior, or both.

Ireland, Bisson et al. (2016) stated that while the pre-drilling marine mammal monitoring effort during 2012 was less than monitoring efforts during drilling, bowhead whales appeared to show some level of avoidance of the area during drilling. For example, bowhead whales were sighted within 26.3 km of the drill site prior to drilling versus 40.2 km during drilling operations though given the difference in sighting effort as mentioned, the significance of this difference may be overstated. In addition, Ireland, Bisson et al. (2016) stated:

> *The direction (inshore or offshore) of that potential avoidance response is informed by the number of bowhead sightings recorded in 5 m (16.5 ft) depth bins. During the predrilling period, the distribution of sightings by depth was bi-model, with a first peak at 25–30 m and a second larger peak in sightings made in 35–45 m of water. On the other hand, the distribution of sightings by depth during drilling was unimodal, and those sightings occurred in a shallower and tighter range of water depths, between 20–40 m. This suggests that any avoidance response may have been towards shore rather than offshore; although, Brandon and Koski (2013) noted that the direction and speed of travel of whales observed during the drilling period suggested feeding opportunities may have been present in nearshore areas and that may have affected the location of bowhead sightings as much as a response to the drilling activities.*

Figure 7-6 presents aerial survey sightings and water depth of bowhead whales during Shell's exploratory drilling in the Beaufort Sea.

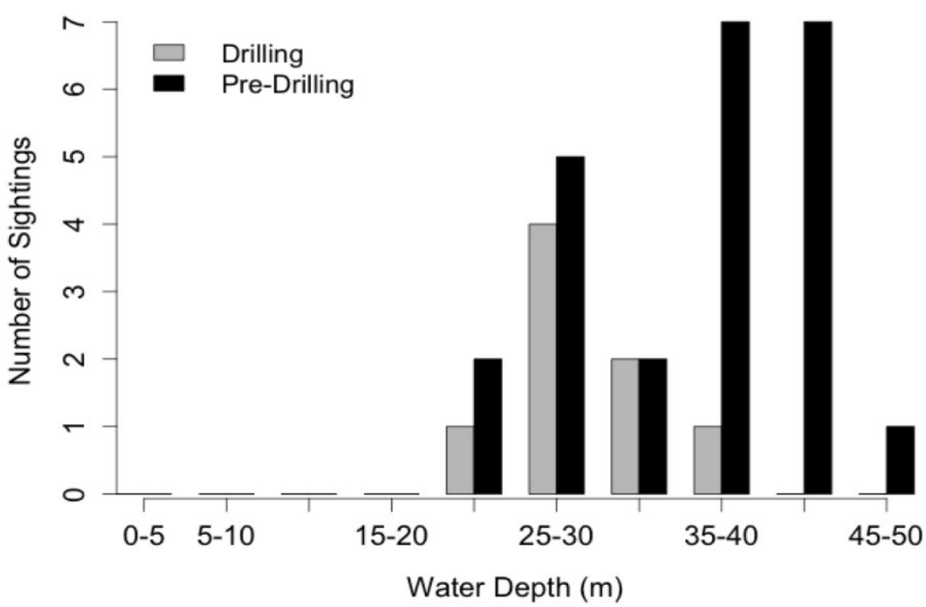

Figure 7-6. Aerial Survey Sightings of Bowhead Whale Sightings at 5-m Water Depth Intervals August 15 – November 3, 2012 during Shell Exploratory Drilling in the Beaufort Sea

Source: Ireland, Bisson et al. (2016)

Bowhead whale vessel-based sightings during drilling were higher (0.23 sightings/10 hours observation effort) in areas with received levels of ≥120 dB re 1 μPa rms SPL compared to areas with levels below 120 dB re 1 μPa rms SPL (0.13 sightings/10 hours). However, based on monitoring data, the mean closest point of approach of bowheads to project vessels where received sound levels were ≥120 dB re 1 μPa rms SPL was considerably greater (3,634 m) than where received sound levels were ≤120 dB re 1 μPa rms SPL (1,865 m) (Wilcoxon rank sum test; W=257.5, p=0.008). A broadscale comparison of sighting rates during periods of drilling activity versus non-activity appear to indicate some level of avoidance response by bowhead whales (Figure 7-7).

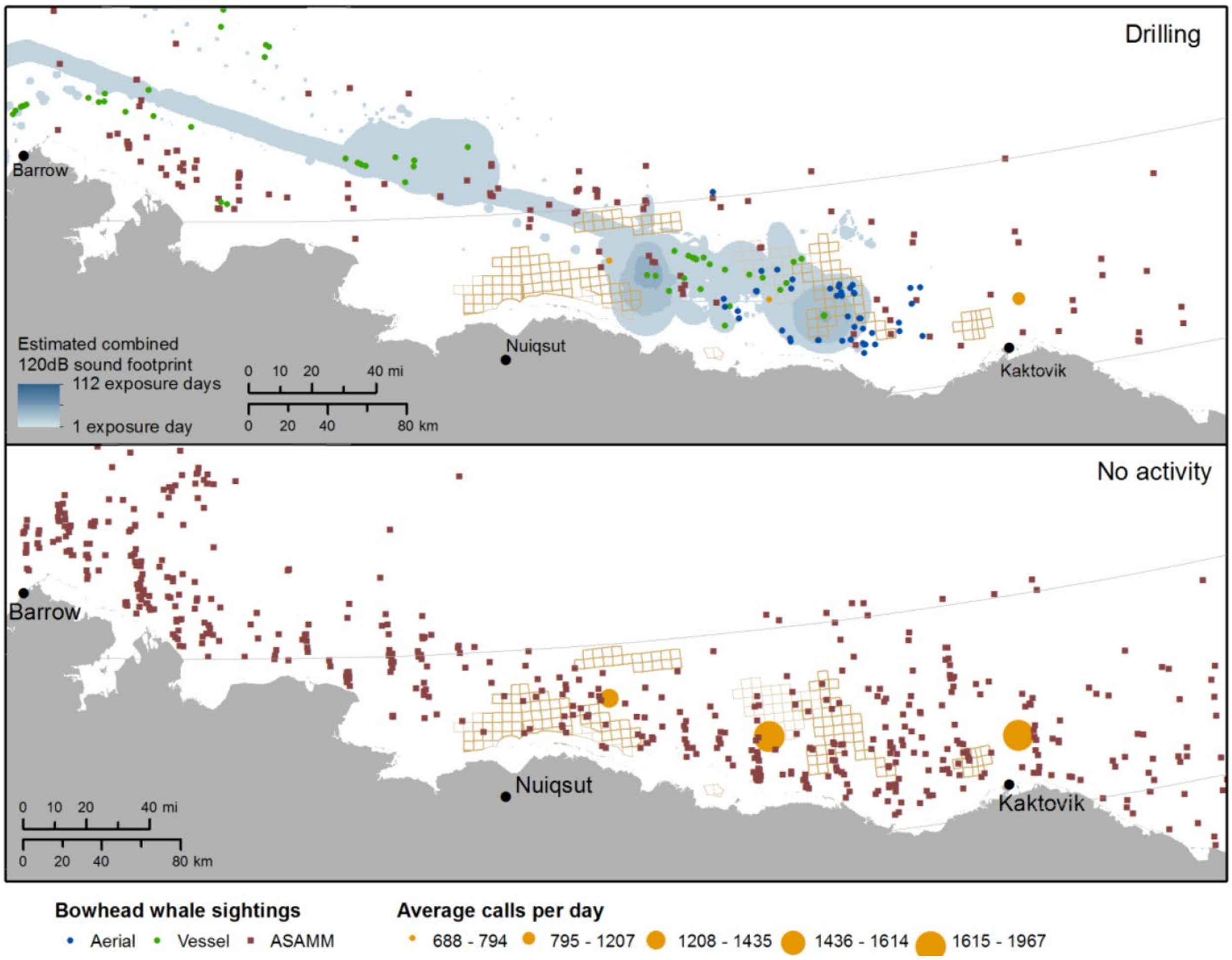

Figure 7-7. Bowhead Whale Sightings from Vessel and Aircraft, and Average Whale Calls Per Day in the Beaufort Sea during Oil and Gas Activities (Top Panel: 2012) Compared to No Activity (Bottom Panel: 2009, 2011, 2013-2014)

Source: Ireland, Bisson et al. (2016)

7.1.4.3. Behavioral Responses Due to Aircraft and Helicopters

Data on reactions of bowheads to helicopters are limited. Most bowheads showed no obvious response to helicopter overflights at altitudes above 150 m (Richardson and Greene Jr. 1993). Patenaude, Richardson et al. (2002) found that most reactions by bowhead whales to a Bell 212 helicopter occurred when the helicopter was at altitudes of ≤150 m and lateral distances of ≤250 m. Reactions were reported as "brief" and included abrupt dives, surfacing, and breaching. The majority of bowheads, however, showed no obvious reaction to single passes, even at those distances. Data were insufficient to analyze effects of repeated low-altitude passes (Patenaude, Richardson et al. 2002).

Fixed-wing aircraft flying at low altitude often cause bowheads to dive rapidly. Reactions to circling aircraft may be conspicuous at altitudes <300 m, uncommon at 460 m, and generally undetectable at 600 m. Repeated low-altitude overflights at 150 m during aerial photogrammetry studies of feeding bowheads sometimes elicited abrupt turns and quick dives (Richardson and Greene Jr. 1993). Aircraft on a direct course are audible only briefly, and whales are likely to resume their normal behavior within minutes after the plane passes (Richardson and Greene Jr. 1993). The effects from an encounter with aircraft are brief, and the whales generally resume their normal behavior within minutes.

7.1.5. Effects Due to Changes in Habitat

No critical habitat has been designated for the western Arctic stock of bowhead whales. Most assessments of potential effects of oil and gas on bowhead whale habitat is general, focusing primarily on the ambient acoustic environment. The results of long-term acoustic monitoring are described in Section 7.1.3 and 7.1.4. Therefore, this section presents available information on the effects of oil and gas on other aspects of bowhead habitat, which is limited.

Upon review of the more than 50 MMPA authorizations and associated BiOps for oil and gas activities that have been authorized in the Beaufort and Chukchi seas between 2000 and 2020, no significant adverse effects on bowhead whale habitat have been documented. For example, the 2013 MMPA final rule for new 5-year regulations for oil and gas operations at Northstar (the fourth rule since island construction in 1999 and 2000) stated that activities, as described and including proposed mitigation measures, would have a negligible impact on the affected species or stocks or their habitats, and no unmitigable adverse impact on subsistence.

Traditional knowledge has indicated that changes in sea ice (independent of any oil and gas activities) may affect the timing of bowhead whale migration. Quakenbush and Huntington (2010) noted that whalers from Wainwright have observed sea ice forming later in the fall (December instead of October) and when this occurs, there is less multi-year ice and ice is also generally thinner. This thinner ice then breaks up earlier than it has in the past (late March/early April rather than late April). Utqiaġvik whalers also noted the spring bowhead migration is earlier now (Huntington and Quakenbush 2009, as cited in (Quakenbush and Huntington 2010). For a more extensive discussion on subsistence user observations and traditional knowledge, please see Chapter 8.

Druckenmiller, Citta et al. (2018) reported changes in the number of open water days (OWD) between 1974 and 2014 along the western Beaufort Sea migratory route used by the Bering-Chukchi-Beaufort seas population of bowhead whales. The authors noted that: 1) ice cover in the northern extent of the core-use area decreased more than in the southern extent of the core-use area, 2) the number of OWD near Point Barrow increased by 13 days/decade and on the shelf and slope of the western Beaufort Sea by 20 and 25 days/decade, respectively, and 3) sea ice coverage in the winter core-use area has not changed notably. The authors speculated that bowhead whales will: 1) spend more time on summer and fall feeding grounds, 2) delay their arrival to the wintering grounds, 3) may start to overwinter in the southern Chukchi Sea, and 4) may display greater variability in the timing and movements of feeding in the summer and fall. Silber, Lettrich et al. (2017) also reported that changes in marine mammal distributions related to habitat changes caused by climate change over the past 40 years have been reported. Substantive additional changes in marine mammal distributions have been predicted based on models of future climate change. These changes are independent of any oil and gas activities.

Moore, George et al. (2021) have reported that with decreased sea ice in the U.S. Arctic, tagged bowhead whales have been observed lingering in the Chukchi Sea through December. Further, two tagged animals were reported to have overwintered in the Chukchi Sea. The authors also noted that in the nearly ice-free autumn of 2019, bowhead whales were not seen in the western Beaufort Sea, where they are usually common. The authors speculated that the prey base was likely insufficient in near-shore habitat to attract feeding bowhead whales, but they also commented that this short-term change in migratory behavior could have been related to elevated ocean temperatures or the presence of killer whales. Finally, Foote *et al.* (2013) forecast a 50% loss of bowhead habitat by 2100, which will also likely lead to changes in the migratory behavior of bowhead whales in the near future, especially when considered in the context of increased vessel traffic and changes in the timing of ecological processes.

It should also be noted that during certain open-water seasons, depending on the level of activity occurring year-to-year, some areas important to bowhead feeding or migration may be ensonified above 120 dB re 1μPa. At these sound levels, either masking of communication or reduced information transfer may occur within the seasonal migratory corridors mothers and calves pass through at least once within a year (Blackwell and Thode 2021). NMFS (2016) stated that some limited masking of low-frequency sounds (*e.g.*, whale calls) was a possibility during seismic surveys. However, NMFS stated 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 overall impact on bowhead whale communication behavior would be minor (NMFS 2016). Bowheads have been documented to continue calling in the presence of seismic survey sounds (Richardson, Greene *et al.*, 1995) and to increase their rate of calling and their call source level to adjust for increased noise (Thode, Blackwell et al. 2020).

A large oil spill (greater than or equal to 1,000 bbls) to marine waters during oil and gas activities has not occurred in the Chukchi or Beaufort seas in the U.S. Arctic. However, there is acknowledgement in MMPA authorization and ESA consultation documents that a very large oil spill (greater than or equal to 150,000 bbls) would pose the most meaningful threat to bowhead whale habitat (as well as all other marine mammals). As with previous BiOps, if a spill occurred during the open-water season, bowheads could be displaced from important feeding areas or from their migration route to and from the eastern Beaufort Sea. NMFS' 2008 BiOp for Chukchi and Beaufort oil and gas leasing stated the probability of a large oil spill was "likely remote during the first incremental step of exploration [but] the ability to prevent, contain, and remove spilled oil was a significant concern" (NMFS 2008). Nonetheless, to date there have been no effects of a large oil spill on bowhead whale habitat.

7.1.6. Effects Due to Changes in Acoustic Habitat

As described in Section 7.1.4.1, acoustically limiting the "communication space" of marine mammals may occur during certain oil and gas activities.

Bowheads are known to have sensitive hearing, and are capable of detecting sounds of icebreaker operations at a range of up to 50 km (Richardson, Greene Jr. et al. 1995). Whales likely use their sensitive hearing to navigate under the pack ice and to locate open-water polynyas where they surface (Ellison, Clark et al. 1987). Specific areas important to bowhead whales that may be ensonified above 120 dB re 1μPa due to oil and gas exploration (for example during airgun use), include seasonal migratory corridors where almost all mothers and calves pass through at least once within a year (Ellison, Clark et al. 1987). This could affect communication signals used by bowhead whales and other low-frequency mysticetes and thus, reduce their communication space (Ellison, Clark et al. 1987).

While some masking or loss of information content of low-frequency sounds (*e.g.*, whale calls) is possible during seismic surveys, the brief duration of these pulses and relatively longer silence between airgun shots (approximately 5-6 seconds) likely minimizes these potential effects to some degree because the intensity of the sound is greatly reduced. There is evidence of bowheads continuing to call in the presence of seismic survey sounds, with calls that can be heard between seismic pulses (Richardson, Würsig et al. 1986).

Bowhead whales have been shown to increase their rate of calling and their call source level to adjust for increased noise due to anthropogenic sources (Thode, Blackwell et al. 2020).

7.2. Other Baleen Whales

Other baleen whales that may be present in the U.S. Arctic and Cook Inlet where interactions with oil and gas may occur include gray, minke, fin, humpback, and North Pacific right whales. Of these species, the Eastern North Pacific (ENP) stock of gray whales are the most likely to occur in the Beaufort Sea; however, compared to bowhead whales, it would be considered infrequent. Subsistence hunters have identified humpback whales near Utqiaġvik (Hashagen, Green et al. 2009) and recent monitoring reports have documented sightings of humpback whales in the northeastern Chukchi Sea (Aerts, Hetrick et al. 2013). Minke whales are relatively common in the Bering and southern Chukchi seas and have recently also been sighted in the northeastern Chukchi Sea (Aerts, Hetrick et al. 2013). Fin whales are also occasionally sighted in the Chukchi Sea. North Pacific right whales are extremely rare in the U.S. Arctic, with known distribution only as far north as the Bering Sea (Muto, Helker et al. 2021).

Sightings of these other baleen whale species in the Chukchi Sea may indicate a change in distribution due to climate or oceanographic changes, however, based on available data it is not possible to know whether there is truly an increase in their presence in the U.S. Arctic or increased observations due to more human activity (Ireland, Bisson et al. 2016). The following subsections provide an overview on species' status and distribution, as well as available data regarding the potential effects of oil and gas activities on these species.

7.2.1. Current Status and Relevant Baseline Information

7.2.1.1. Gray Whales (*Eschrichtius robustus*)

Gray whales from the ENP stock are widely distributed along the U.S. West Coast (Figure 7-8). They feed in the Chukchi, Beaufort, and northwestern Bering seas during summer and fall months. The ENP stock migrates from wintering lagoons along coastal Baja California and Mexico northward to the summer foraging areas off northern Alaska (Bogoslovskaya 1981, as cited in (Rice, Wolman et al. 1984). Northbound migration typically begins in mid-February. Whales will travel through Umiak Pass into the southern Bering Sea, where they stay within relatively close proximity (1 km) to the coast. Pregnant females lead this migration, followed by anestrous females, adult males, immature males and finally, cows with calves are the last to head north (Rice, Wolman et al. 1984). Gray whales are more frequently seen in the Bering and Chukchi seas, with less frequency in the Beaufort Sea. During a 2D high-resolution shallow geohazard survey and seabed sonar mapping survey by BPXA July 16 - August 30, 2014 in the Beaufort Sea, no gray whales were sighted (Smultea, Lomac-MacNair et al. 2014). No gray whales were observed during a 3D ocean bottom seismic (OBS) survey in North Prudhoe Bay July–September of 2014.

BPXA also conducted a marine mammal monitoring survey during 3D ocean bottom sensor seismic operations in the North Prudhoe Bay area during the 2014 open-water season (beginning July to mid-September). No gray whales were seen during the survey (Lomac-MacNair, Smultea et al. 2015). Alternatively, gray whales were the most commonly sighted cetacean during marine mammal monitoring in the Chukchi Sea during the open water period in 2015 (Ireland, Bisson et al. 2016). Gray whales were sighted during aerial surveys in the Chukchi Sea from 2006–2015 at 15 times higher rates nearshore (<37 km) than offshore. A greater proportion of nearshore oil and gas activities occurred in 2013, which corresponded with higher vessel-based sighting rates of gray whales that year (Ireland, Bisson et al. 2016). In 2019, (Clarke, Brower et al. 2020) reported gray whale sightings in the northeastern Chukchi Sea in all months surveyed (July–October), with most sightings between 20 km and 120 km offshore, just south of Hannah Shoal. One gray whale was sighted in the central Alaskan Beaufort Sea in late September, while 15 gray whales were observed in the eastern Beaufort Sea (northwest of the Tuktoyaktuk Peninsula, Canada) in August (Clarke, Brower et al. 2020).

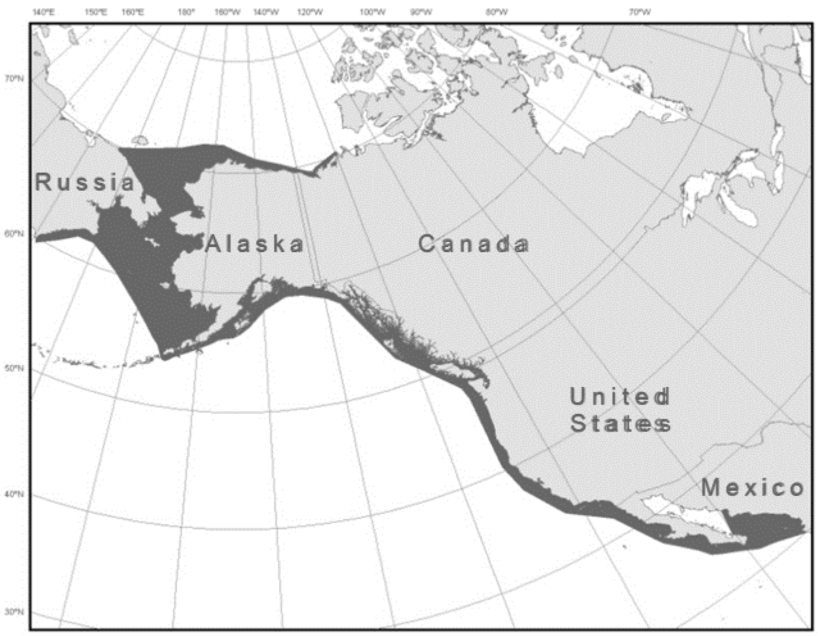

Figure 7-8. Approximate Distribution of ENP Stock of Gray Whales

Source: Carretta, Forney et al. (2021)

The most recent abundance estimate for the ENP stock is 26,960 (CV = 0.05) and the minimum population estimates (N_{min}) is 25,849 (Carretta, Forney et al. 2021). The population has likely had high calf production in recent years, based on a general population increase of approximately 22% over 2010 and 2011 (Perryman *et al.* 2017, as cited in (Carretta, Forney et al. 2021). An increase in ice-free habitat in the Arctic may also be contributing to favorable foraging opportunities resulting in higher numbers of whales (Moore 2016). The PBR for the ENP stock of gray whales is 801 animals per year. For the period 2014–2018, gray whales were most commonly entangled in unidentified fishing gear (n=21), net fisheries (n=16), pot/trap fisheries (n=14) and marine debris (n=2) (Carretta, Forney et al. 2021). Increased shipping congestion and industrialization along the U.S. Pacific coastline overlaps with gray whale migratory corridors, which may post increased risks for the species in terms of ship strike, exposure to pollutants and general habitat degradation. Summer habitat in the U.S. Arctic has expanded over the last decade for gray whales due to reduced ice extent (Carretta, Forney et al. 2021).

7.2.1.2. Minke Whales (*Balaenoptera acutorostrata*)

Minke whales are not listed under the ESA or designated as depleted under the MMPA. The Alaska stock of minke whales are relatively common in the Bering and Chukchi seas (Muto, Helker et al. 2020), with a few animals also occurring in Lower Cook Inlet (Fairweather Science 2020) (Figure 7-9). Visual and acoustic data from July, August, October, and November from the northeast Chukchi Sea documented the characteristic "boing" sounds minke whales make when calling (Clarke *et al.* 2013 and Delarue *et al.* 2013; both cited in (Muto, Helker et al. 2020). Data from surveys in 2002, 2008, and 2010 provided evidence that minke whales were scattered throughout oceanographic domains (*i.e.*, coastal, middle shelf, and outer shelf/slope). The highest minke whale abundance over these years occurred in 2008 and 2010 in the Bering Sea, when colder water temperatures were present in the surveyed areas (Friday *et al.* 2013, as cited in (Muto, Helker et al. 2020). Minke whales were recorded by vessel-based, aerial, and acoustic monitoring efforts during 2006–2015 Chukchi Sea oil and gas activities, with most sightings documented in mid- to late August (Ireland, Bisson et al. 2016). Gulf of Alaska minke whale surveys in 2009, 2013, and 2015 resulted in so few animals sighted that population estimates for this area could not be determined (Muto, Helker et al. 2020).

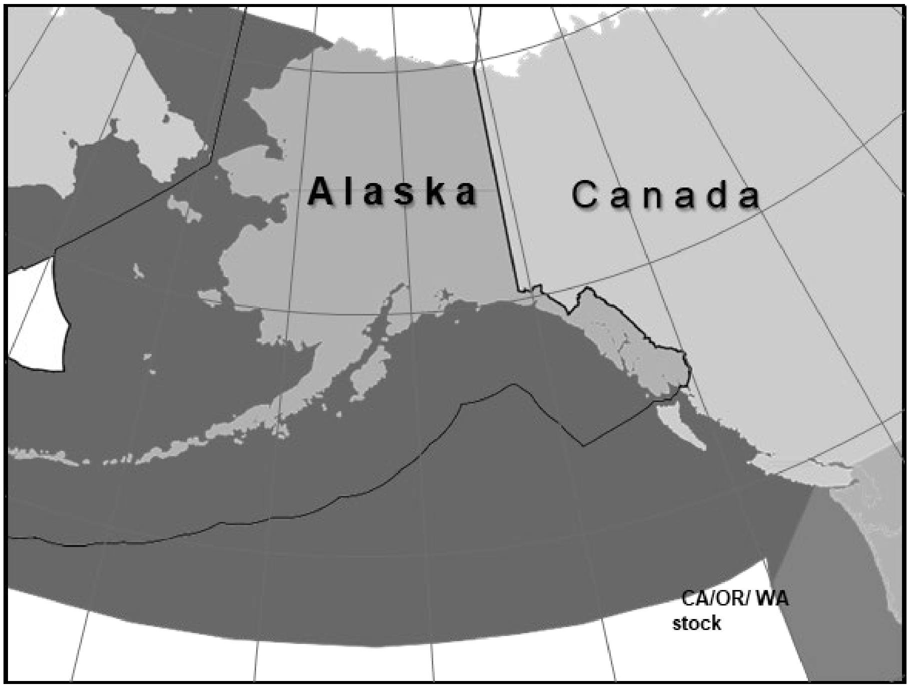

Figure 7-9. Approximate Distribution of Minke Whales in the North Pacific

Source: Muto, Helker et al. (2019)

Minke whale population estimates have not been made for the entire North Pacific; however, there are provisional estimates for specific areas of the Bering Sea for the years 2002 (389; CV = 0.52), 2008 (517; CV = 0.69), and 2010 (2,020; CV = 0.73). Specific abundance estimates are not available for Cook Inlet; however, line transect surveys in shelf and near-shelf waters from Kenai Fjords to the central Aleutian Islands for the period 2001–2003 supported an estimate of 1,233 (CV = 0.34) for this area (Zerbini *et al.* 2006, as cited in (Muto, Helker et al. 2020). There are inadequate data to estimate the abundance of minke whales in Alaskan waters. As such, PBR for this species is also unknown. For the period 2012–2016, total estimated human-caused mortality, serious injury, and non-serious injury of minke whales was zero. Increased vessel traffic, anthropogenic noise, and possible changes in prey distribution associated with climate changes are the primary habitat-related concerns for this species (Muto, Helker et al. 2020).

7.2.1.3. Fin Whales (*Balaenoptera physalus*)

Fin whales are distributed widely in every ocean except the Arctic Ocean, where they have only recently begun to appear (Figure 7-10). Individuals and small groups of fin whales have recently increased in the Chukchi Sea during summer, seasonally inhabiting areas within and near the Chukchi Sea Planning Area during the open water period (BOEMRE 2011). Based on observations and passive acoustic detection (Funk, Ireland et al. 2010, Hannay, Delarue et al. 2013), direct observations from monitoring and research projects of fin whales from industry (Funk *et al.* 2011 and Ireland *et al.* 2009, as cited in (NMFS 2016) and government agencies (Clarke, Christman et al. 2011), fin whales occur in very low densities but have become regular visitors to the Chukchi Sea.

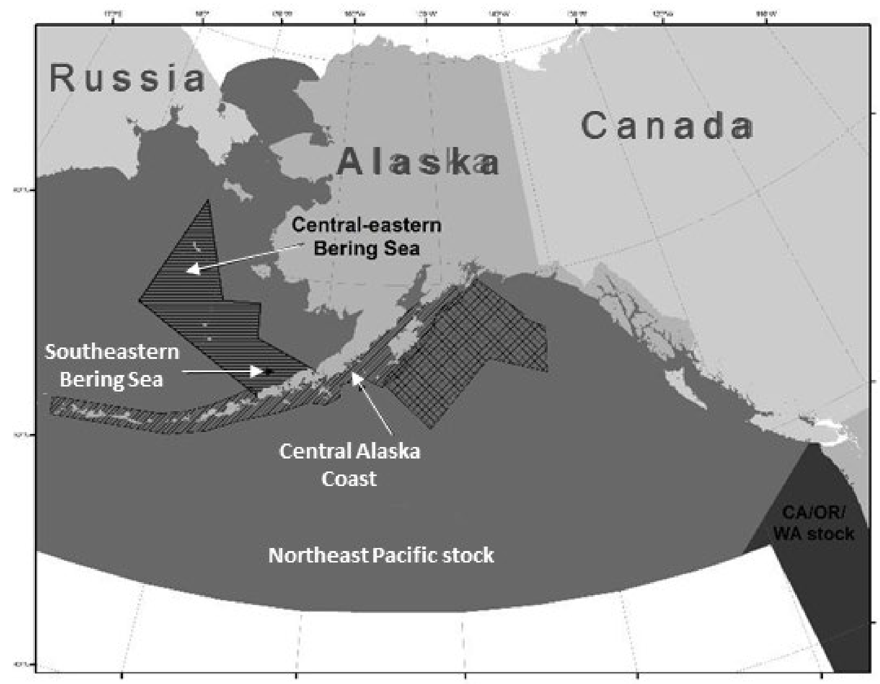

Figure 7-10. Approximate Distribution of Fin Whales in the Eastern North Pacific

Note: Striped areas indicate where vessel surveys occurred: horizontal stripes 1999-2010; diagonal stripes 2001-2003; and crosshatch 2015.
Source: Muto, Helker et al. (2019)

Offshore hydrophone arrays along the U.S. Pacific coast in the central North Pacific and western Aleutian Islands detected fin whales, with the highest calling rates noted August through February, suggesting these areas are important foraging habitat (multiple citations as listed in (Muto, Helker et al. 2020)). Between July and October, moored instruments in the northeastern Chukchi Sea also detected fin whale calls during periods between 2007 and 2010. Based on call data from the Bering Sea, fin whales may feed in that area (Delarue *et al.* 2013, as cited in (Muto, Helker et al. 2020). Vessel-based monitoring detected fin whales in the Chukchi Sea in 2008, 2012, and 2015, but were not observed during any of the industry-sponsored aerial surveys over the multi-year study period (Ireland, Bisson et al. 2016).

As indicated for minke whales, fin whale prey (*i.e.*, large copepods and euphausiids) favor colder water. Therefore, years with colder water distributed further north toward the Chukchi Sea coincide with years of higher fin whale encounter rates. For example, in 1999 (a cold year), fin whale encounter rates were 7 to 12 times higher than a warm year (2002) (Stabeno *et al.* 2012, as cited in (Muto, Helker et al. 2021). There are no reliable abundance estimates for fin whales in the Northeast Pacific. However, visual ship-based surveys during fisheries research in the Bering Sea along the eastern shelf in 1997, 1999, 2000, 2002, 2004, 2008 and 2010 support population estimates of 417 (CV = 0.33), 1,368 (CV = 0.34), and 1,061 (CV = 0.38) for the years 2002, 2008, and 2010, respectively (Friday *et al.* 2013, as cited in (Muto, Helker et al. 2021).

Surveys in 2013 and 2015 in the Gulf of Alaska recorded 171 and 38 sightings of fin whales, respectively. These surveys support an abundance estimate of 3,168 (CV = 0.26) and 916 (CV = 0.39), respectively, for 2013 and 2015 (Rone *et al.* 2017, as cited in (Muto, Helker et al. 2021). One fin whale was sighted in Lower Cook Inlet on May 31, 2016 between Anchor Point and Homer (Shelden, Hobbs et al. 2017). (Castellote, Stocker et al. 2020) reported acoustic detections of fin whales in Lower Cook Inlet during 3D seismic surveys in 2019. The 2019 PAM study summarized by (Castellote, Stocker et al. 2020) reported a greater amount of fin whale vocal activity during the 3D seismic survey than after the survey was complete, suggesting that fin whales may have responded to the acoustic disturbance by increasing calling rates.

The best provisional population estimate for this stock is 3,168 whales (CV = 0.26), while N_{min} is 2,554 whales. PBR is calculated to be 5.1 fin whales; however, this is likely biased low given that it is based on estimates from only a portion of the stock's range (Muto, Helker et al. 2020). Based on data from 2013–2017, mean annual fin whale mortality due to ship strikes in Alaska was 0.4 whales. Reductions in sea ice that may lead to concomitant increases in shipping or oil and gas activities in Alaska, as well as changes in prey distribution due to climate changes, are listed as primary habitat concerns for fin whales (Muto, Helker et al. 2021).

Fin whales are listed as endangered under the ESA and depleted under the MMPA. The Northeast Pacific stock of fin whales are found in the Bering Sea during summer months and further south off the North American coast. While this single stock is the only one currently recognized in the Bering Sea, there are key uncertainties in the assessment. Data suggest there may be multiple stocks that overlap in the Bering Sea (Muto, Helker et al. 2021).

7.2.1.4. North Pacific Right Whales (*Eubalaena japonica*)

North Atlantic and North Pacific right whales are listed as endangered under the ESA and depleted under the MMPA. In 2008, North Pacific right whales were relisted as a separate species from North Atlantic right whales (NMFS 2008). The summer range of the ENP stock of North Pacific right whales includes the Gulf of Alaska and Bering Sea. The approximate historical range of North Pacific right whales extended across the North Pacific and south as far as the Baja Peninsula (Figure 7-11). Striped areas shown in Figure 7-11 represent designated North Pacific right whale critical habitat.

Areas used for winter calving are currently unknown. Vessel-based, aerial, and acoustic monitoring provide records of this species being detected consistently since around 1996 in the southeastern Bering Sea. Given how extremely rare this species is today, sightings are relatively rare, typically consisting of a single individual. However, in 2017, the IWC's Pacific Ocean Whale and Ecosystem Research (POWER) survey reported 15 right whales in the southeastern Bering Sea using a combination of PAM and visual sightings (Matsuoka *et al.* 2017, as cited in (Muto, Helker et al. 2021). Three right whales were sighted in 2018, two of which were observed in right whale designated critical habitat (Matsuoka *et al*. 2018, as cited in (Muto, Helker et al. 2021) (Figure 7-12). No right whale observations were reported in the southeastern Bering Sea from January through April, supporting a theory that the whales migrate out of the Bering Sea during winter (Wright 2017, as cited in (Muto, Helker et al. 2021). Passive acoustic data from 2008–2016 detected North Pacific right whale calls in the northern Bering Sea, but it remains unknown whether this indicates reoccupation of a historic distribution or a northward shift in distribution (Muto, Helker et al. 2021). While right whale distribution is limited to the Bering Sea, marine transit routes between Dutch Harbor and the Chukchi or Beaufort seas are used by the oil and gas industry. Therefore, industry vessels may observe North Pacific right whales or transit near or through North Pacific right whale designated critical habitat, as shown in Figure 7-12 (see Section 6.13.2 for standard mitigation measures for transit routes). In the Gulf of Alaska, three surveys for right whales in 2013, 2015, and 2019 detected whales in Barnabus Trough off Kodiak Island with passive acoustics but no visual sightings were made.

North Pacific right whale abundance is critically low. The best available abundance estimate is based on mark-recapture analyses of photo-identification and genetic data through 2008. Two separate estimates of 31 (95% CL: 23-54) and 28 (95% CL: 24–42) were developed for the Bering Sea and Aleutian Islands, respectively (Wade, Kennedy et al. 2011). PBR for this stock is 0.05, equivalent to one take every 20 years (Muto, Helker et al. 2021). There appear to be more males than females in the population and calf production is very low. For the period 2014–2018, no human-caused mortality or serious injury was reported for North Pacific right whales. Potential threats to right whale habitat are primarily driven by commercial shipping and fishing vessel activity. Considerable fishing activity occurs within portions of critical habitat, increasing the risk of entanglement with gear. Unimak Pass, in the Aleutian Island chain, is a major shipping channel into the Bering Sea. The high density of vessels poses risks not only for ship strike but also potential oil spills if an accident occurs (Muto, Helker et al. 2020).

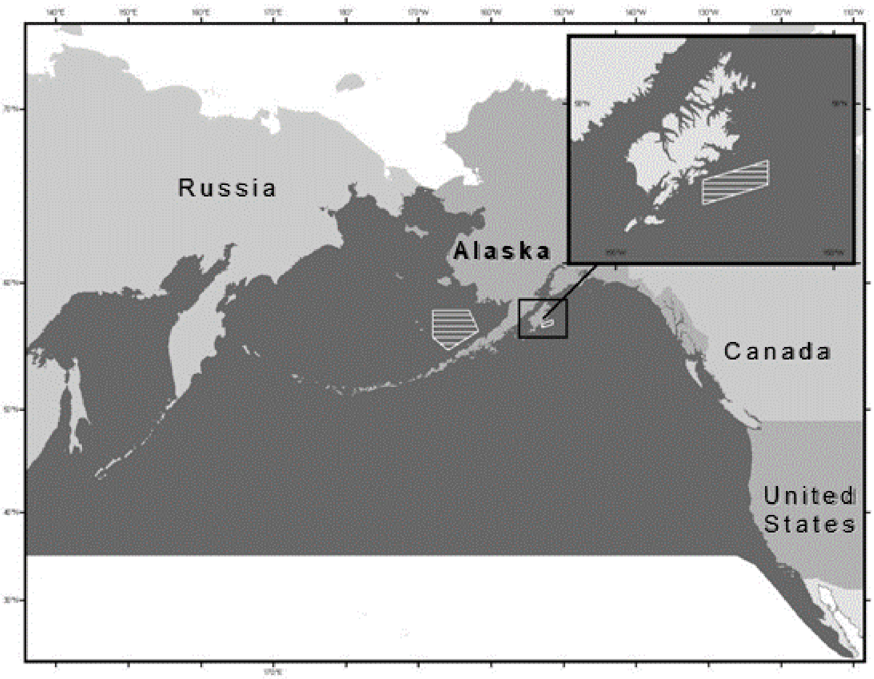

Figure 7-11. Approximate Historical Distribution of North Pacific Right Whales

Source: Muto, Helker et al. (2021)

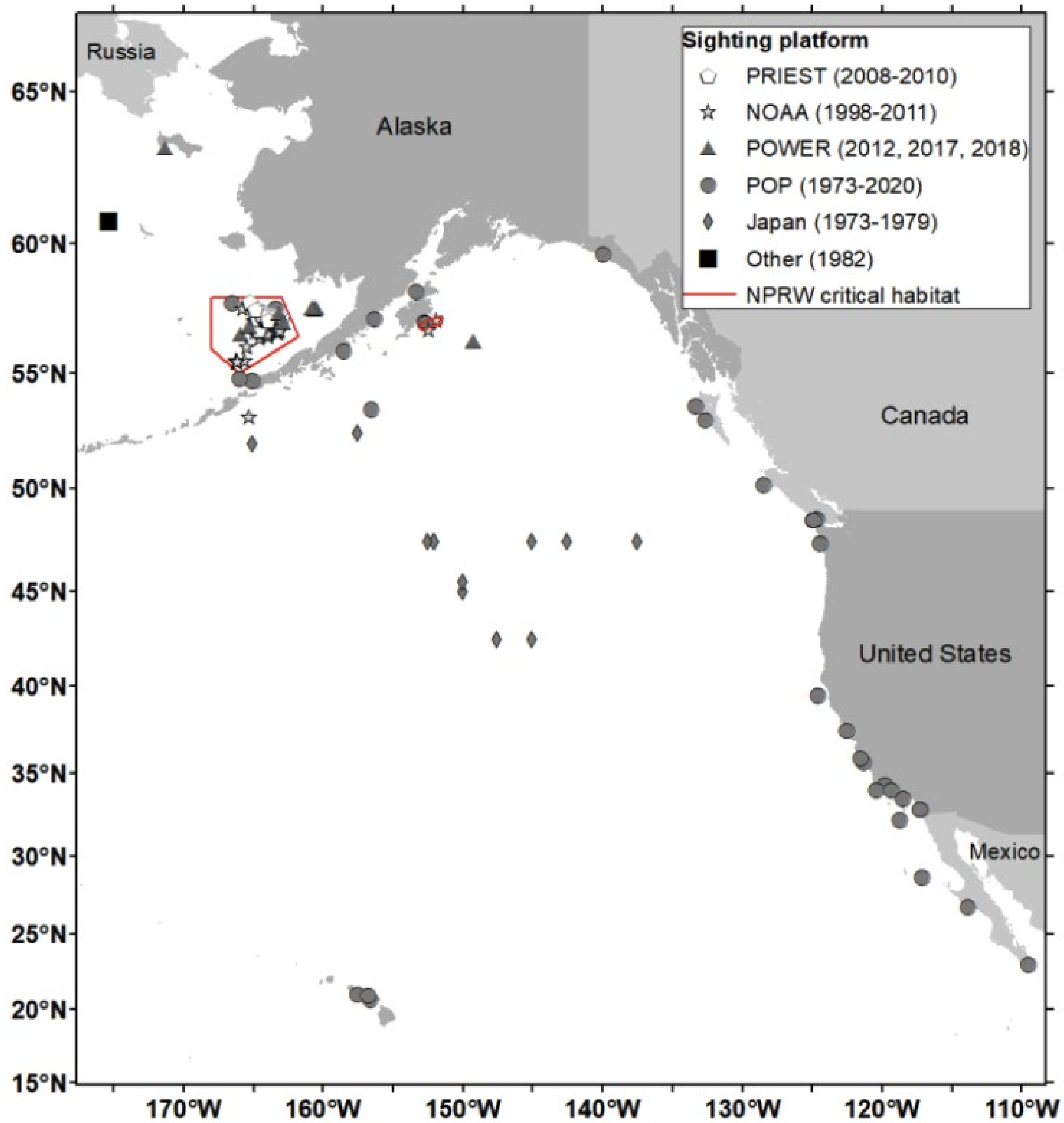

Figure 7-12. All Eastern North Pacific Right Whale Sightings in the North Pacific 1970–2018

Key: PRIEST = BOEM-NOAA (Pacific Right Whale Ecology Study) survey; NOAA = other NOAA surveys; POWER = IWC's POWER survey; POP = opportunistic sighting documented in the Marine Mammal Laboratory's Platforms of Opportunity database; Japan = Japanese sighting survey; Other = Bering Sea (Navarin Basin) survey.
Source: Brueggeman, Grotefendt et al. (1984)

7.2.1.5. Humpback Whales (*Balaenoptera novaeangliae*)

Humpback whales are distributed globally in all ocean basins. A large-scale study of humpback whales was undertaken between 2004 and 2006 (the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project) (Calambokidis, Barlow et al. 2017), resulting in new information on stocks, abundance, and distribution. Four of the 14 DPS of humpback whales inhabit the North Pacific. Historical summer feeding grounds for whales in the North Pacific range from Point Conception, California to the Gulf of Alaska and Bering Sea, and west into the Aleutians and further into Asia (Figure 7-13).

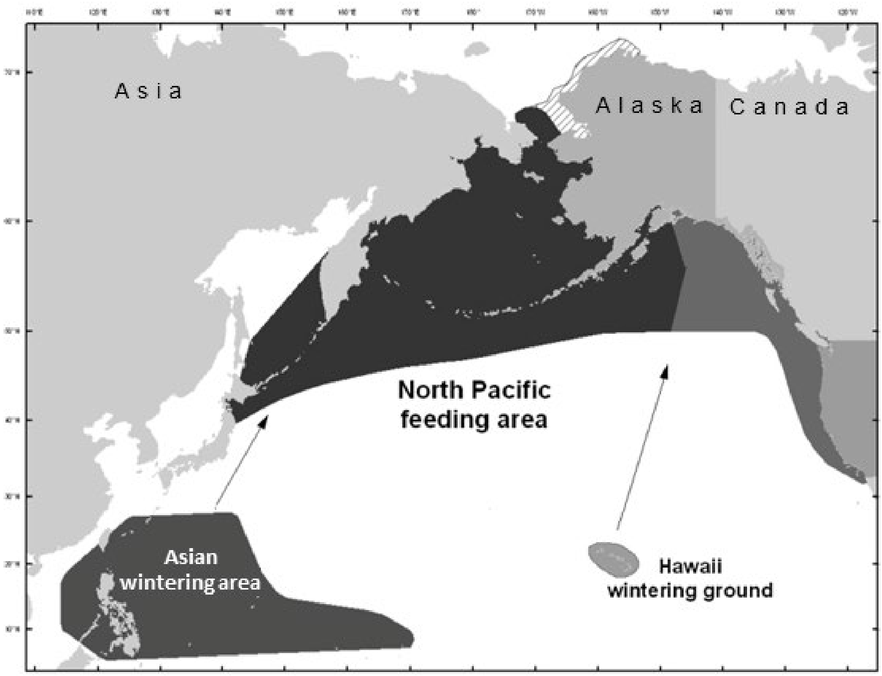

Figure 7-13. Approx. Feeding and Wintering Grounds of Humpback Whales in the North Pacific

Source: Muto, Helker et al. (2021)

Humpback whales have been sighted as far north as the Beaufort Sea during summer (Hashagen, Green et al. 2009). In August 2007, a mother-calf pair of humpback whales was sighted from a barge approximately 87 km east of Utqiaġvik in the Beaufort Sea (Hashagen, Green et al. 2009). Additionally, Ireland, Koski et al. (2009) reported three humpback sightings in 2007 and one in 2008 during surveys of the eastern Chukchi Sea. Humpback whales have been seen and heard with some regularity in recent years (2009-2011) in the southern Chukchi Sea, often feeding and in very close association with feeding gray whales (Clarke, Christman et al. 2011). Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback whales are present earlier than September (Hashagen, Green et al. 2009). A single humpback was observed between Icy Cape and Wainwright feeding near a group of gray whales during aerial surveys of the northeastern Chukchi Sea in July 2009 as part of COMIDA (Clarke, Christman et al. 2011). This may be a recent phenomenon as no humpback whales were sighted during the previous COMIDA surveys in the Chukchi Sea from 1982 through 1991 (Clarke, Christman et al. 2011). Additional sightings of four humpback whales occurred in 2009 south of Point Hope, while transiting to Nome (Brueggeman 2009).

The Western North Pacific stock consists mostly of populations that occur off Asia, which migrate to Russia and the Bering Sea/Aleutian Islands. The Western North Pacific stock of humpback whales may occasionally be sighted in the Chukchi Sea and less frequently in the Beaufort Sea. The migratory route of the Western North Pacific stock of humpback whales is not completely understood. Only one sighting of two individual humpback whales likely from the Western North Pacific stock were documented during oil and gas associated monitoring 2015 (Ireland, Bisson et al. 2016).

The Central North Pacific stock migrates between summer and winter feeding grounds primarily to northern British Columbia/Southeast Alaska and Gulf of Alaska to the Bering Sea/Aleutian Islands. Some of these whales may occur in Lower or Middle Cook Inlet, where they have been infrequently observed (Muto, Helker et al. 2018). In 2016, NMFS published a final decision that changed the status of humpback whales under the ESA (81 FR 62259). The decision recognized the existence of 14 DPSs, three of which occur in the waters off Alaska: the endangered Western North Pacific DPS; the threatened Mexico DPS; and the Hawaii DPS, which does not require protection under the ESA (NMFS 2021). According to (NMFS 2021) humpback whales that use summer feeding areas in the Gulf of Alaska, and may travel to Cook Inlet waters, have an 89% probability of belonging to the non-listed Hawaii DPS. Therefore, humpback whales that occur infrequently in Lower or Middle Cook Inlet are likely from the unlisted Hawaii DPS.

Whales from these stocks are also likely to mix within summer feeding grounds in the Bering Sea, Gulf of Alaska, and British Columbia (Muto, Helker et al. 2020). Using SPLASH data (Calambokidis, Barlow et al. 2017), the N_{min} for the Western North Pacific stock is 865 (Muto, Helker et al. 2021) and PBR is 3 whales annually. The Central North Pacific stock N_{min} estimate is based on data from Hawaii and is 10,103 whales with a calculated PBR of 83 based on Hawaii data (Muto, Helker et al. 2021). Stock structure for humpback whales is currently under review.

Annual estimated human-caused mortality for the Western North Pacific stock is 2.8 whales and for the Central North Pacific stock, 26 whales, most (9.8) of which were associated with U.S. commercial fisheries. A sharp decline in sightings of humpback whales in the Central North Pacific stock between 2013 and 2018 suggests that humpbacks may be vulnerable to environmental changes due to harmful algal blooms, changes in prey distribution due to changing ocean conditions or increased levels of anthropogenic sounds (Muto, Helker et al. 2021). Overall, however, populations of humpback whales are increasing globally.

Recent monitoring for marine mammals during the Lower Cook Inlet seismic surveys in 2019 documented sightings of humpback whales (as well as other marine mammals including Cook Inlet belugas, Dall's porpoise, harbor porpoise, harbor seals, killer whales, sea otters, and Steller sea lions) (Figure 7-14). Table 7-1 provides total counts of animals by species during the 2019 seismic survey in Lower Cook Inlet, while Figure 7-15 shows locations of all marine mammals observed during aerial surveys.

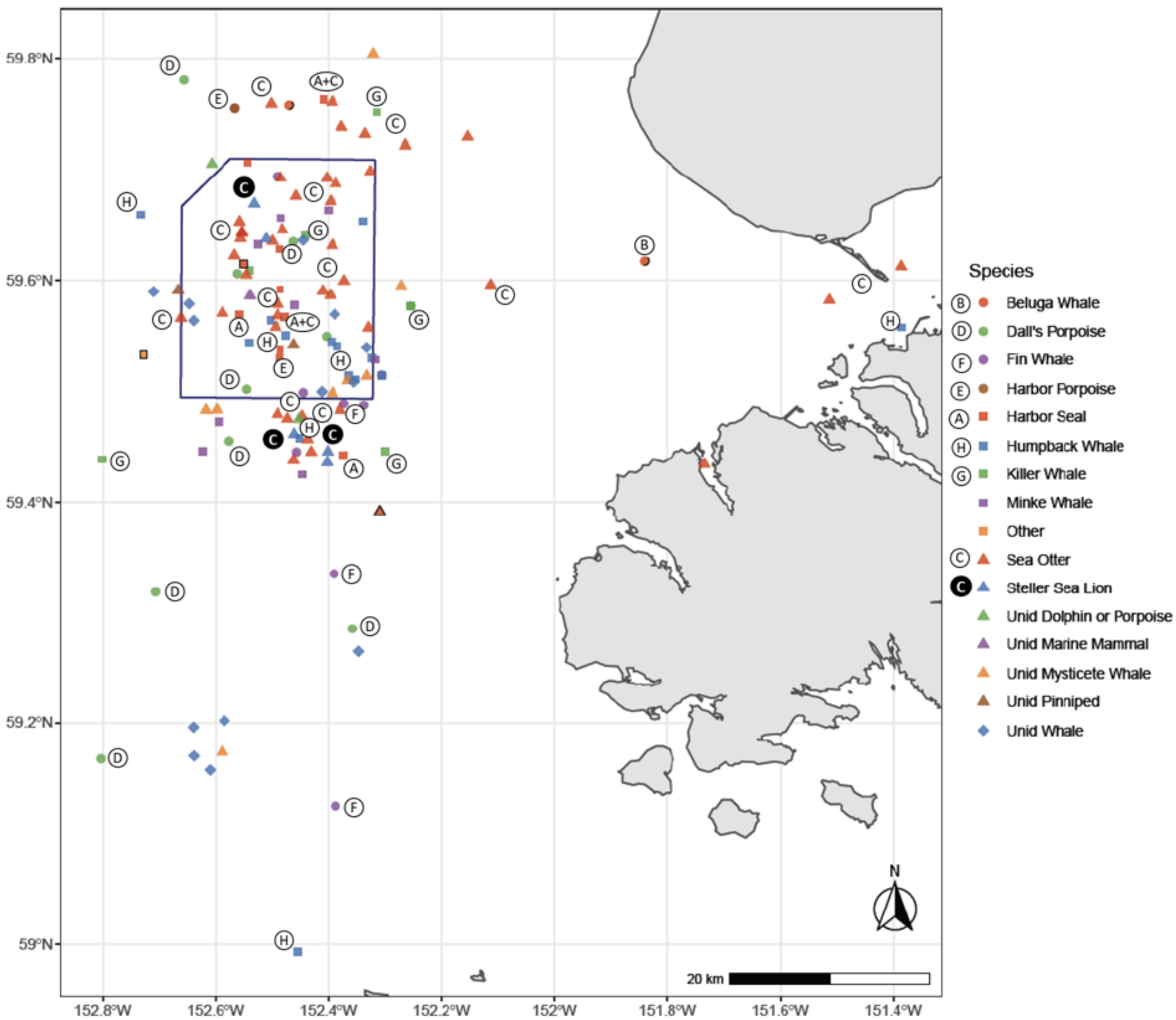

Figure 7-14. Total Vessel-Based Marine Mammal Sightings during 2019 Lower Cook Inlet 3D Seismic Surveys

Notes: Symbols with Black borders represent dead animals.
Source: Fairweather Science (2020)

Table 7-1. Total Marine Mammal Sightings and Estimated Individual Counts per Vessel during 2019 Lower Cook Inlet 3D Seismic Surveys

	Source Vessel (*Polarcus Alima*)		Mitigation Vessel (R/V *Q105*)		Total	
Species	**No. of Sightings[1]**	**Estimated No. of Individuals[2]**	**No. of Sightings[1]**	**Estimated No. of Individuals[2]**	**Sightings**	**Individuals**
Beluga Whales	1	1	1	1	2	2
Dall's Porpoise	9	28	1	2	10	30
Fin Whales	6	21	2	2	8	23
Harbor Porpoise	0	0	2	3	2	3
Harbor Seal	6	6	4	4	10	10
Humpback Whales	13	35	1	3	14	38
Killer Whales	5	16	1	5	6	21
Minke Whales	6	6	2	2	8	8
Other	0	0	1	1	1	1
Sea Otters	21	23	21	37	42	60
Steller Sea Lions	4	4	1	1	5	5
Unidentified Dolphin or Porpoise	1	3	1	1	2	4
Unidentified Marine Mammal	0	0	1	1	1	1
Unidentified Mysticete Whales	3	3	5	5	8	8
Unidentified Pinniped	2	2	0	0	2	2
Unidentified Whales	3	5	10	11	13	16
TOTAL	80	153	54	79	134	232

Source: Fairweather Science (2020)
[1] One sighting equals one group.
[2] Totals do not include individuals from re-sightings.

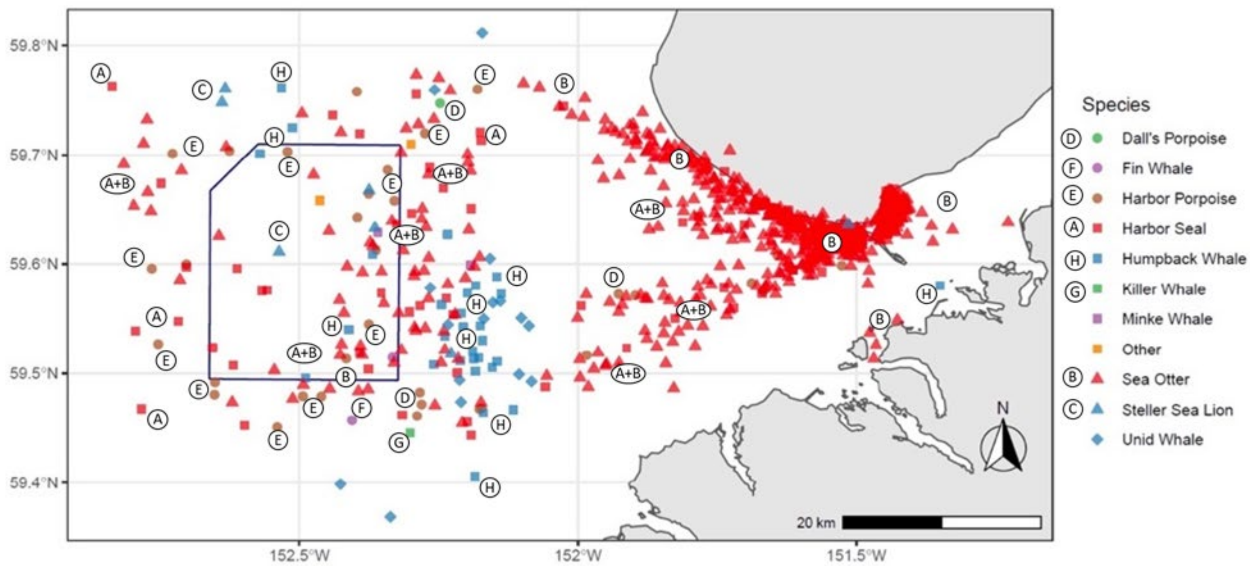

Figure 7-15. Total Marine Mammal Sightings Based on Aerial Surveys during the LCI Seismic Project

Note: The rectangle shows the area of seismic study tracks.
Source: Fairweather Science (2020)

7.2.2. Mortality and Serious Injury

Based on a comprehensive review of monitoring reports (Richardson and Williams 2000, Richardson 2008, Funk, Ireland et al. 2010, Aerts, Hetrick et al. 2013, Fairweather Science 2020)and published literature for the period 2000–2020, no mortality or serious injury of other baleen whales has been documented as a result of interactions with oil and gas activities in the U.S. Arctic or Cook Inlet.

7.2.3. Behavioral Response Due to Disturbance

The 2008 Supplement to the 2006 Biological Evaluation for MMS Oil and Gas Lease Sales in the Chukchi and Beaufort seas stated that fin and humpback whales were increasing in the Chukchi Sea but were not likely to be exposed to or adversely affected by noise, disturbance, discharges, or oil spills associated with seismic survey activities (MMS 2008).

As cited in (NMFS 2013):

> *…16 approach trials carried out in Exmouth Gulf, off Australia, McCauley et al. (2000) reported that pods of humpback whales with resting females consistently avoided a single (20 in^3) operating airgun at an average range of 1.3 km. Standoff ranges were 1.22-4.4 km. McCauley et al. (2000) also reported a single a startle response. As this information pertains to whales in general, however, these distances are similar to those observed by Richardson and Malme (1993) during vessel-disturbance experiments in the Canadian Beaufort Sea.*

7.2.3.1. Behavioral Responses during Seismic Surveys and Exploration Drilling

Chukchi Sea marine mammal monitoring during Shell's exploration drilling program in 2015 reported that approximately 54% of all cetacean sightings were observed by PSOs on four different vessels that frequently transited off the coast of Wainwright in areas of low received sound levels under water (Ireland, Bisson et al. 2016). Importantly, the primary duty of PSOs during monitoring was to implement mitigation measures to avoid and minimize potential exposure of marine mammals to harassment associated with underwater noise rather than collect extensive behavioral data. Nevertheless, behavioral data collected by PSOs included estimated closest observed point of approach (CPA), direction of movement relative to the vessel, initial behavior of the animal, reaction of the animal to the vessel presence or activity, and duration of the sighting. The following observations were made based on the 2015 monitoring effort:

> *Cetaceans observed from moving and stationary vessels were most often recorded as having no observable reaction (94%, n=89, and 98%, n=96, respectively). Observable reactions for cetaceans from moving vessels included change of direction (4%), increase in speed (1%), and splash (1%). The only observable reaction for cetaceans from stationary vessels was change of direction (2%).*

Ireland, Bisson et al. (2016) also reported that overall mean CPA distances of cetaceans observed from moving vessels in areas where received sound levels were >120 dB re 1 µPa rms SPL (1,151 m) were not significantly different compared with areas where received sound levels were <120 dB re 1 µPa rms SPL (1,121 m) (Wilcoxon rank sum test; W = 752, p = 0.8142).

Frankel and Stein (2020) reported behavioral responses of gray whales during exposure to sonar off the California coast. The sonar had a maximum source level of 215 dB re 1 µPa m, where the frequency ranged from 21–25 kHz. Change in behavior was measured as a function of swimming speed and relative orientation, as well as distance offshore; 532 whale groups were tracked over 119.7 hours of observation. One key finding was that migrating gray whales moved inshore during periods of sonar transmission relative to control periods. In addition, the authors noted a slight, but noticeable decrease in swimming speed when the sonar was broadcasting relative to the control. Regarding orientation, whales avoided the source vessel during periods of transmission. These data suggest that gray whales may have functional hearing sensitivity to at least 21 kHz. Although (Frankel and Stein 2020) reported no visual observation of responses by gray whales to these sonar transmissions, statistical analysis of tracking data indicated that gray whales deflected at ranges of 1-2 km at a received level of 148 dB re 1 µPa.

Airgun arrays are the most common source of seismic-survey noise and would be employed for most exploratory activities. Research has shown that airguns can interrupt feeding behavior in gray whales (Gordon, Gillespie et al. 2003). Malme, Würsig et al. (1986) studied the responses of feeding eastern gray whales to pulses from a single 100-in^3 airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 µPa, and that 10% of feeding whales interrupted feeding at received levels of 163 dB re 1µPa. However, findings in Russia and British Columbia have shown that gray whales have no apparent change in feeding patterns resulting from seismic surveys (Bain and Williams 2006). In contrast to the general trend of avoidance, minke whales have occasionally been observed to approach active airgun arrays where received sound levels were estimated to be near 170–180 dB re 1 µPa (NMFS 2010). However, Moulton and Holst (2010) reported that humpback and minke whales exhibited similar movement patterns during seismic operations in Canada, with both species significantly more likely to swim away and less likely to swim towards and mill during airgun operations (humpbacks: $X^2 = 17.81$, $df = 4$, $p = 0.0001$; minkes: $X^2 = 11.02$, $df = 3$, $p = 0.026$). Fin and blue whale movements did not differ significantly during period of airgun vs. no airguns ($p > 0.10$ for all X^2 tests) (Moulton and Holst 2010).

Fin whales have also been shown to demonstrate very little behavioral change resulting from exposure to noise from seismic surveys. Sightings by observers on seismic vessels during many large-source seismic surveys off the U.K. from 1997 to 2000 suggest that, during times of good visibility, sighting rates for fin and sei whales were similar when large arrays of airguns were shooting versus when they were silent (Stone and Tasker 2006). However, the whales did exhibit localized avoidance, remaining farther from the airgun array during seismic operations compared with non-seismic periods and were more likely to swim away from the vessel than in any other direction while shooting (Stone and Tasker 2006). In addition, fin and sei whales were less likely to remain submerged during periods of seismic shooting (Stone and Tasker 2006).

The 2019 marine mammal monitoring effort during Lower Cook Inlet seismic surveys provide information on cetacean behavioral response including: blow; travel; mill; swim; breach; splash; bowride/wakeride; and other (see Table 7-2). The following cetacean species were observed: humpback, fin, minke, and killer whales; and Dall's and harbor porpoises.

Table 7-2. Vessel-Based Monitoring of Cetacean Behavior during 2019 Lower Cook Inlet 3D Seismic Surveys

Cetacean Initial Behavior	Percent of Sightings	Number of Sightings
Blow	47.2	34
Travel	19.4	14
Mill	11.1	8
Swim	8.3	6
Breach	4.2	3
Splash	5.6	4
Bowride/Wakeride	2.8	2
Other	1.4	1
TOTAL	100	72

Source: Fairweather Science (2020)

7.2.3.2. Behavioral Responses to Vessels

In 2012, seven gray whales were sighted where sounds from industry vessels were ≤110 median SPL [dB re 1 µPa (rms)], two gray whales were sighted during active drilling in locations where industrial sounds were ≤105 median SPL [dB re 1 µPa (rms)], and two gray whale sightings occurred during ice management activities in locations where vessel sounds were <105 median SPL [dB re 1 µPa (rms)] (LGL Alaska Research Associates Inc., JASCO Applied Sciences Inc. et al. 2014). During the 2018 Cook Inlet Pipeline Installation Project (Sitkiewicz, Hetrick et al. 2018) near Tyonek in Middle Cook Inlet, a total of two sightings of three individual humpback whales were documented, although behavioral responses to project vessels were not possible to determine. The 2017 monitoring report for the Quintillion subsea cable project (not oil and gas), observed two individual fin whales, three individual minke whales and 14 individual humpback whales during activities involving support vessels (Green, Blees et al. 2018). PSOs recorded animal behaviors when it was possible to discern, including observations such as a blow sighting, breaching, diving, thrashing, or fluking. These recorded behaviors, combined, accounted for 27.5% of the recorded behaviors for all cetaceans observed (Green, Blees et al. 2018).

7.2.4. Effects Due to Changes in Habitat including Acoustic Habitat

Data on impacts to baleen whale habitat due to oil and gas activities in the U.S. Arctic and Cook Inlet are primarily focused on bowhead whales (see Sections 7.1.5 and 7.1.6). Given the similar hearing sensitivity and prey base, it is a reasonable assumption that similar effects to other baleen whale species could occur as a result of oil and gas activities. However, broader scale changes in habitat associated with oceanographic and climatic changes are more likely to result in long-term effects on baleen whale habitat than oil and gas activities.

As described in Section 7.1.5, independent of any changes in habitat due to oil and gas activities, Silber, Lettrich et al. (2017) reported that changes in marine mammal distributions related to habitat changes caused by climate change over the past 40 years have been reported. Substantive additional changes in marine mammal distributions have been predicted based on models of future climate change (Moore 2016).

Upon review of the more than 50 MMPA authorizations and associated BiOps for oil and gas activities authorized in the Beaufort and Chukchi seas between 2000 and 2020, no meaningful adverse effects on bowhead whale habitat were documented and as such, one might assume similar conclusions for other baleen whales. Moore, George et al. (2021) reported that with decreased sea ice in the Arctic, observations of tagged bowhead whales lingering in the Chukchi Sea through December have been noted. Again, the distribution and movements of other baleen whales as relative to prey and oceanographic conditions would likely be similar. A large oil spill to marine waters during oil and gas activities has not occurred in the Chukchi or Beaufort seas in the U.S. Arctic though if one occurs, it would pose a major threat to baleen whale habitat and prey.

As described in Section 7.1.6, increased anthropogenic noise, including but not limited to oil and gas activities, may affect the acoustic habitat available to baleen whales by limiting their "communication space" (Blackwell and Thode 2021).

7.3. Beluga Whales (*Delphinapterus leucas*)

There are five distinct stocks of beluga whales in Alaska: Cook Inlet, Eastern Chukchi Sea, Beaufort Sea, Eastern Bering Sea, and Bristol Bay (Figure 7-16). Oil and gas activities have historically overlapped with the Cook Inlet population (see Section 7.3.1) and the Eastern Chukchi and Beaufort Sea populations (see Section 7.3.2).

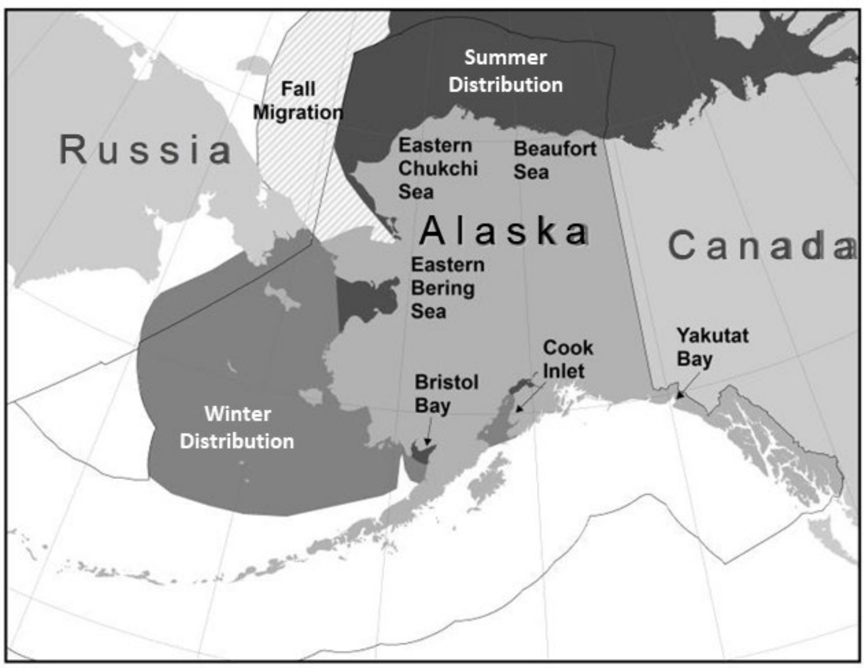

Figure 7-16. Approximate Distribution of Alaska Beluga Stocks

Source: Muto, Helker et al. (2021)

7.3.1. Cook Inlet Beluga Whales

Cook Inlet beluga whales are geographically and genetically isolated from other beluga whale stocks in Alaska (Muto, Helker et al. 2018). Beluga whales found in Cook Inlet remain in the inlet year-round but show seasonal shifts in distribution (Hobbs, Laidre et al. 2005, Goetz, Montgomery et al. 2012, Shelden, Rugh et al. 2013, Shelden, Hobbs et al. 2017). During the summer and fall, beluga whales are found in shallow coastal waters concentrated near the mouth of the Susitna River, and within Knik Arm, Turnagain Arm, and Chickaloon Bay. During the winter, the whales disperse throughout the mid-inlet deeper waters to Kalgin Island, and to the shallow waters along the west shore of Cook Inlet to Kamishak Bay (Nemeth *et al.* 2007, as cited in NMFS (2019).

The Cook Inlet beluga DPS was listed as endangered in 2008 (73 FR 62919). The Cook Inlet Beluga Recovery Plan identified potential impacts on the species from oil and gas development including increased noise from seismic activity, vessel traffic, air traffic, and drilling; discharge of wastewater and drilling muds; habitat loss from the construction of oil and gas facilities; and contaminated food sources or injury resulting from an oil spill or natural gas blowout (NMFS 2016). Critical habitat for Cook Inlet belugas is discussed in Section 7.3.1.5.

7.3.1.1. Current Status and Relevant Baseline Information

The best historical abundance estimate of the Cook Inlet beluga population is derived from a 1979 survey, which estimated the total population to be 1,293 belugas (Calkins 1989, as cited in (NMFS 2019). In 1993, NMFS began conducting comprehensive, systematic aerial surveys of the Cook Inlet beluga population; these surveys documented a decline in abundance from 653 belugas in 1994 to 347 belugas in 1998 (NMFS 2019). In response to this nearly 50% decline, in 2000 NMFS designated the Cook Inlet beluga population as depleted under the MMPA (65 FR 34590). Due to a continued lack of growth, NMFS listed the Cook Inlet beluga population as endangered under the ESA on October 22, 2008 (73 FR 62919).

The 2020 Draft Alaska Marine Mammal Stock Assessment Report (Muto, Helker et al. 2021) defines the best estimate of current abundance for the Cook Inlet beluga population in 2018 as 279 (CV = 0.061, 95% PI: 250 to 317). This is based on a weighted average from three most recent annual abundance estimates (2014, 2016, and 2018). As shown in Figure 7-17, the population declined steadily while hunting was unregulated, with peak hunting mortality occurring in 1996 (123 whales). Only five whales were reported killed from hunting from 1999 to 2005 but the population continued to decline until about 2004. It then showed an increase from 2005 to 2010 but has declined again since 2010. During the most recent 10-year time period (2008-2018), the population of Cook Inlet belugas has experienced a decline of about 2.3% per year (95% PI: -4.1% to -0.6%) (Wade, Boyd et al. 2019). Due to the continued decline, the PBR for this stock is calculated as only 0.53 beluga whales per year (Muto, Helker et al. 2021).

In Cook Inlet, the oil and gas industry, the Port of Alaska (formerly Port of Anchorage), and others have conducted acoustic studies, marine mammal monitoring projects, and impact assessments for nearly two decades (Blackwell and Greene Jr. 2003, HDR Alaska Inc., LGL Alaska et al. 2006, Prevel Ramos, Markowitz et al. 2006, URS 2007, Scientific Fishery Systems and Alaska Native Technologies 2008, Integrated Concepts & Research Corporation 2009, Integrated Concepts & Research Corporation 2010, Integrated Concepts & Research Corporation 2012, SAExploration 2012, Corporation 2013, Lammers, Castellote et al. 2013, CH2M Engineers Inc. 2016, Fairweather Science LLC 2018, Sitkiewicz, Hetrick et al. 2018, Castellote 2019, Castellote, Thayre et al. 2019, 61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020). For example, during Apache's 3D seismic study in Cook Inlet in 2012, it was estimated that 660 beluga individuals were observed during 57 sightings (SAExploration 2012). More recently, Sitkiewicz, Hetrick et al. (2018) conducted marine mammal monitoring during Hilcorp's Cross Inlet Pipeline (CIPL) Project. Over the period May 9 to September 15, 2018 (more than 3,000 hours of monitoring time) over 1,000 marine mammal sightings were recorded, including 143 sightings of beluga whales, but no live beluga whales were sighted during the 2019 Lower Cook Inlet (LCI) seismic survey (Fairweather Science 2020).

Recently, Castellote, Thayre et al. (2019) analyzed more than 8,700 hours of acoustic recordings from different locations in the inlet. Nine sources of anthropogenic noise were identified including ships, aircrafts, dredging, pile-driving, and sub-bottom profilers. Anthropogenic noise was high and variable throughout the inlet, but was loudest and most common in the vicinity of the Port of Alaska and lower Knik Arm. This area is an important passageway for belugas moving into Knik Arm to seasonally forage.

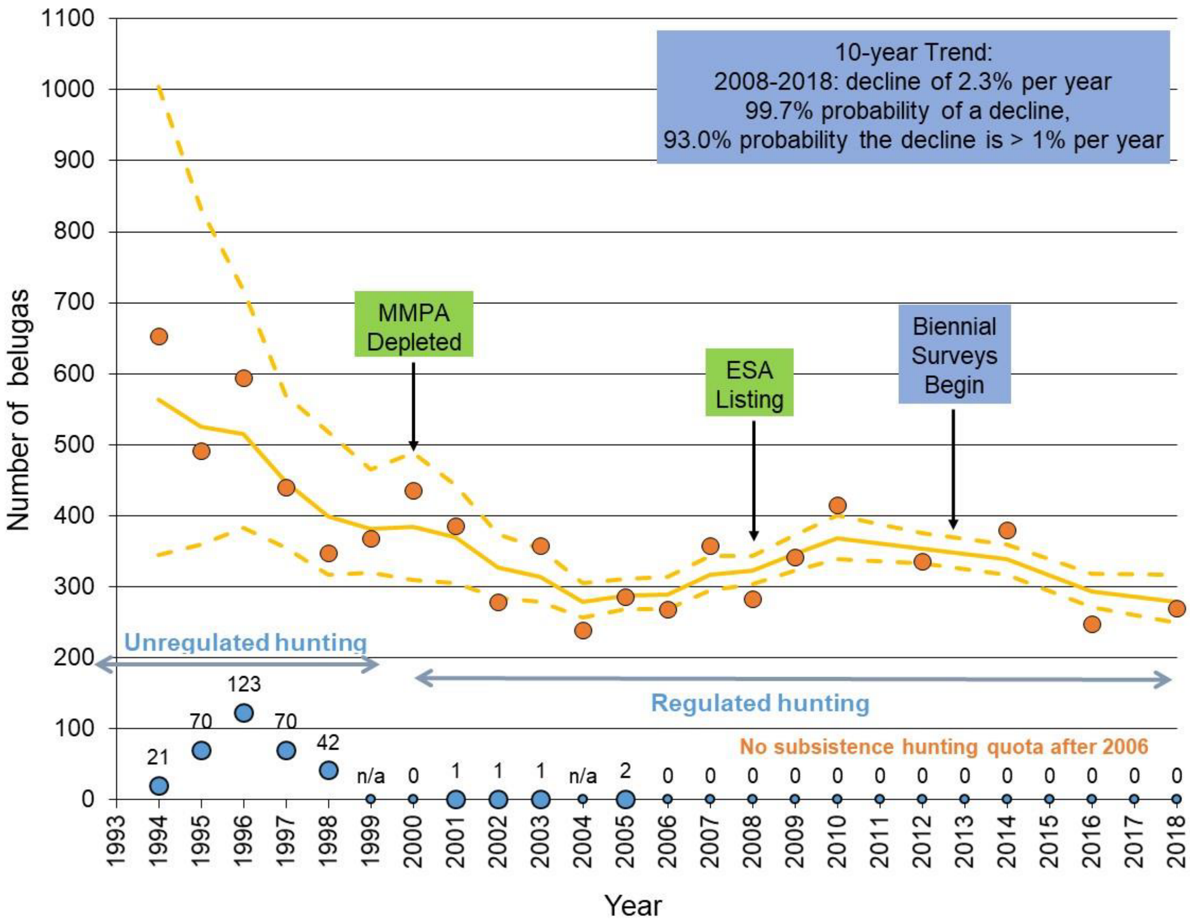

Figure 7-17. Annual Cook Inlet Beluga Abundance Estimates 1994–2018

Note: Orange circles show annual abundance, blue circles show reported removals (landed plus struck and lost) during the period of harvest. The solid line is a weighted moving average of the abundance estimates that represents the smoothed population trend over time. Dashed lines are the 95% probability intervals around the smoothed trend line.
Source: Muto, Helker et al. (2021)

7.3.1.2. Mortality and Serious Injury

The most recent information shows there was no human-caused mortality or serious injury of Cook Inlet beluga whales between 2014 and 2018 (Muto, Helker et al. 2021). Because the abundance remains below 350 whales, an Alaska Native subsistence harvest is not allowed for the period 2018-2022. Reports from the NMFS Alaska Region marine mammal stranding network provide additional information on beluga whale mortality. Between 2014 and 2018, 79 beluga whales were involved in three known live stranding events and one suspected live stranding event with two associated deaths (Muto, Helker et al. 2021). Cook Inlet beluga whales are probably predisposed to stranding because they breed, feed, and molt in the shallow waters of Upper Cook Inlet where extreme tidal fluctuations occur (NMFS 2019).

Cook Inlet beluga whales may be susceptible to vessel strike mortality. However, to date only one whale death in October 2007, has been attributed to a potential vessel strike based on bruising consistent with blunt force injuries (NMFS unpublished data, as cited in (NMFS 2019). Beluga whales may be more susceptible to strikes from commercial and recreational fishing vessels (as opposed to cargo ships, oil tankers and barges), as both belugas and fishing activities occur where salmon and eulachon congregate (NMFS 2019).

Cook Inlet belugas may be exposed to noise associated with oil and gas activities, but mortality or permanent injury to hearing ability is unlikely. There have been no documented mortalities or serious injuries to Cook Inlet beluga whales attributable to oil and gas activities in the area. One unidentifiable marine mammal carcass was observed and reported during monitoring for the CIPL Project; the marine mammal's death was not due to CIPL project activities (Sitkiewicz, Hetrick et al. 2018). Marine mammal monitoring conducted during a recent (2019) 3D seismic survey did document two dead stranded belugas, which were reported following protocols required under the MMPA. The cause of death was not known (Fairweather Science 2020).

7.3.1.3. Physiological Effects (Threshold Shifts)

The highest noise levels from oil drilling platforms have frequencies generally below 10 kHz. Noise from the platform itself is thought to be very weak because the majority of the machinery is on the deck of the platform, which is above the water. However, noise can be carried down the legs of the platform. Blackwell and Greene Jr. (2002) recorded underwater noise produced at an oil platform (now the Tyonek platform; Figure 3-9) at distances ranging from 0.3 to 19 km. The highest recorded sound level was 119 dB re 1μPa at a distance of 1.2 km. Sounds at frequencies between 2 and 10 kHz were measured as high as 85 dB re 1μPa at 19 kilometers from the source. Beluga whales are in the mid-frequency hearing group with a generalized hearing range of 150 Hz to 160 kHz (Southall, Bowles et al. 2007). This noise is audible to beluga whales, but unlikely to cause TTS (NMFS 2017, NMFS 2019).

NMFS (2019) identified the noise sources from oil and gas activity with the greatest potential to cause Level A or Level B acoustic harassment (Table 7-3).

Table 7-3. Noise Sources from Oil and Gas Activity in Cook Inlet

Activity	Sound Pressure Levels (dB re 1 μP)	Frequency
2D and 3D Seismic Surveys ($2,400\ in^3$ airgun)	217 dB peak at 100 m 185 dB SEL at 100 m 197 dB rms at 100 m	<300 Hz
Geohazard Surveys	210- dB rms at 1 m	High-resolution sub-bottom profiler: 2–24 kHz Low-resolution sub-bottom profiler: 1–4 kHz
Drive Pipe Installation	195 dB rms at 55 m	<500 Hz
Vertical Seismic Profiling (VSP)	227 dB rms at 1 m	<500 Hz
Vibratory Sheet Pile Driving	175 dB peak at 10 m 160 dB SEL at 10 m 160 dB rms at 10 m	<100–2,500 Hz
Water Jet	176 dB rms at 1 m	500 Hz–2 kHz

Source: NMFS (2019)

It is difficult to predict beluga whale response to seismic programs; their most likely response to noise from seismic surveys is expected to be short-term, localized avoidance (NMFS 2019). A single airgun pulse would need to have a received level of approximately 196 to 201 dB re 1μPa to produce brief, mild TTS in belugas (NMFS 2019). Exposure to several strong seismic pulses, each with a received level near 190 dB rms (175 to 180 dB SEL), could result in the cumulative exposure of approximately 186 dB SEL, and thus, slight TTS in a beluga (NMFS 2019). Beluga whales exposed to low-frequency sound from airguns are likely to respond to exposures between 150 Hz and 30 kHz (NMFS 2017). However, because whales are not likely to communicate at source levels that would damage the tissues of other members of their species, this evidence suggests that received levels of up to 192 dB re 1μPa are not likely to damage the tissues of beluga, fin, or humpback whales (Thompson *et al.* 1986, Au *et al.* 1987, Clark and Gagnon 2004; all cited in (NMFS 2017).

Beluga whales that may be exposed to received levels ≥160 dB re 1μPa during marine seismic surveys are likely to reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming direction to avoid seismic operations, change their respiration rates, increase dive times, reduce feeding behavior or alter vocalizations and social interactions (Richardson, Würsig et al. 1986, Funk, Ireland et al. 2010). These kind of responses could be expected at distances between 0 and 9.5 km for the largest 2,400 in^3 seismic array, and 4 km for VSP (Austin *et al.* 2015, as cited in (NMFS 2017).

7.3.1.4. Behavioral Response Due to Disturbance

Generally, the most frequent behavioral response of Cook Inlet belugas to oil and gas activities has been avoidance, or minor changes in movements or behaviors (NMFS 2019). Scientific studies and opportunistic sightings suggest that beluga whales are tolerant of many types of in-water noise (NMFS 2017, NMFS 2019). Cook Inlet beluga whales use habitat in Knik Arm despite disturbance and underwater noise from many sources including: maritime operations; maintenance dredging; aircraft operations; and pile-driving. This beluga whale behavior may, however, be taken as evidence for extreme motivation to reach important habitats in Knik Arm, rather than an indication that noise does not bother the whales (NMFS 2017, NMFS 2019). Some beluga whales repeatedly exposed to noise may habituate to the sounds and, upon subsequent exposures, may not change their behavior or distribution when exposed to those sounds; therefore, seismic activities may not have substantial effects on animals that habituate to these or to similar sounds (NMFS 2019).

Since 2003, NMFS has conducted numerous Section 7 consultations and harassment authorizations regarding beluga whales and oil and gas or construction activities in Cook Inlet (NMFS 2003, NMFS 2007, NMFS 2007, NMFS 2012, NMFS 2012, NMFS 2012, NMFS 2013, NMFS 2013, NMFS 2016, NMFS 2017, NMFS 2017, NMFS 2017, NMFS 2018, NMFS 2018, NMFS 2019, NMFS 2019, NMFS 2019, NMFS 2020, NMFS 2020, NMFS 2020). The analyses and findings of the Section 7 process and MMPA processes indicate that oil and gas activities in Cook Inlet are not responsible for the current endangered status of Cook Inlet belugas or the observed lack of recovery. Mitigation and monitoring efforts conducted by the industry have contributed to a better understanding of Cook Inlet beluga whale distribution throughout the inlet. Appendix A provides a comprehensive list of literature supporting these authorizations and analyses.

7.3.1.5. Effects Due to Changes in Habitat

NMFS designated critical habitat for Cook Inlet beluga whales on April 8, 2011 (Figure 7-18; 76 FR 20180). Critical habitat includes two areas: Critical Habitat Area 1 and Area 2 that together encompass 7,800 km^2 of marine and estuarine habitat (76 FR 20180). Critical Habitat Area 1 contains shallow tidal flats or mudflats and mouths of rivers that provide important areas for foraging, calving, molting, and escape from predation. High concentrations of beluga whales are often observed in these areas from spring through fall. Critical Habitat Area 2 lies south of Area 1 and includes nearshore areas along western Cook Inlet and Kachemak Bay. Area 2 is known fall and winter foraging and transit habitat for beluga whales as well as spring and summer habitat for smaller concentrations of beluga whales. Oil and gas platforms and activity (as shown in Figure 3-9) overlap with these critical habitat areas. Timing and area restrictions on exploration drilling in beluga whale critical habitat have reduced impacts on beluga whales (NMFS 2017). However, Castellote, Thayre et al. (2019) found that noise from current activities in Cook Inlet (such as shipping and dredging) often exceed thresholds for behavioral harassment levels throughout a large portion of critical habitat and particularly in the lower region of Knik Arm.

The quality of Cook Inlet beluga critical habitat would almost certainly be affected by oil spills. A large accidental discharge could render areas of designated critical habitat unsuitable for use (NMFS 2017). Individual belugas and their primary prey species could become contaminated, experience mortality, or be otherwise adversely affected by spilled oil.

On February 7, 2017, Hilcorp discovered a natural gas leak (methane gas) from an 8-in. pipeline serving platforms in Cook Inlet's Middle Ground Shoals region. Hilcorp promptly reported the incident to the National Response Center, the Alaska Department of Environmental Conservation (ADEC) and other regulatory agencies. Under regulations 18 AAC 75.300(d), 18 AAC 75.335(b)(2)(B), and 18 AAC 75.300(f)(12), ADEC required Hilcorp to undertake a mitigation and monitoring program until the leak could be repaired in spring when ice in Cook Inlet did not present human safety concerns for repair personnel. Hilcorp's mitigation and monitoring program included fish and wildlife monitoring, water quality sampling and acoustic monitoring. The results of the program are not currently publicly available. The pipeline leak was shut down on April 3, 2017. A more detailed timeline of events as well as links to Hilcorp's monitoring reports are available at: https://dec.alaska.gov/spar/ppr/spill-information/response/2017/04-hilcorp/; Accessed November 19, 2021. The monitoring reports generally indicated the natural gas quickly volatilizes and based on wildlife monitoring as of May 2017, did not appear to result in adverse effects to species or their environments, including beluga whales, although the ADEC webpage states the evaluation of results is ongoing.

Regarding potential effects to Cook Inlet beluga whale critical habitat, the effects of noise on beluga whale prey species must also be considered. Popper, Hawkins et al. (2019) summarized relevant data from 2005 to mid-2018 on the effects of sounds on fishes. The authors conclude that fish exposed to pile-driving sounds may show alarm responses, including an increase in swimming speed and changes in ventilation and heart rate. These transient startle responses are unlikely to result in adverse impacts because the fish often rapidly return to normal behavior. However, stronger more sustained behavioral responses to longer duration sounds may place an energetic load on the fish by generating oxygen debt as ventilation rates increase. In addition, anthropogenic noise may interfere with fishes' ability to detect, locate, and identify predator threats. Signals from seismic airguns are similar to those of pile driving in terms of frequency energy range, duration of impulse, and rapid rise time. Therefore, fish could experience temporary behavioral reactions due to noise from seismic airguns, but at this stage there are few data that can be applied to develop guidelines (Popper, Hawkins et al. 2019).

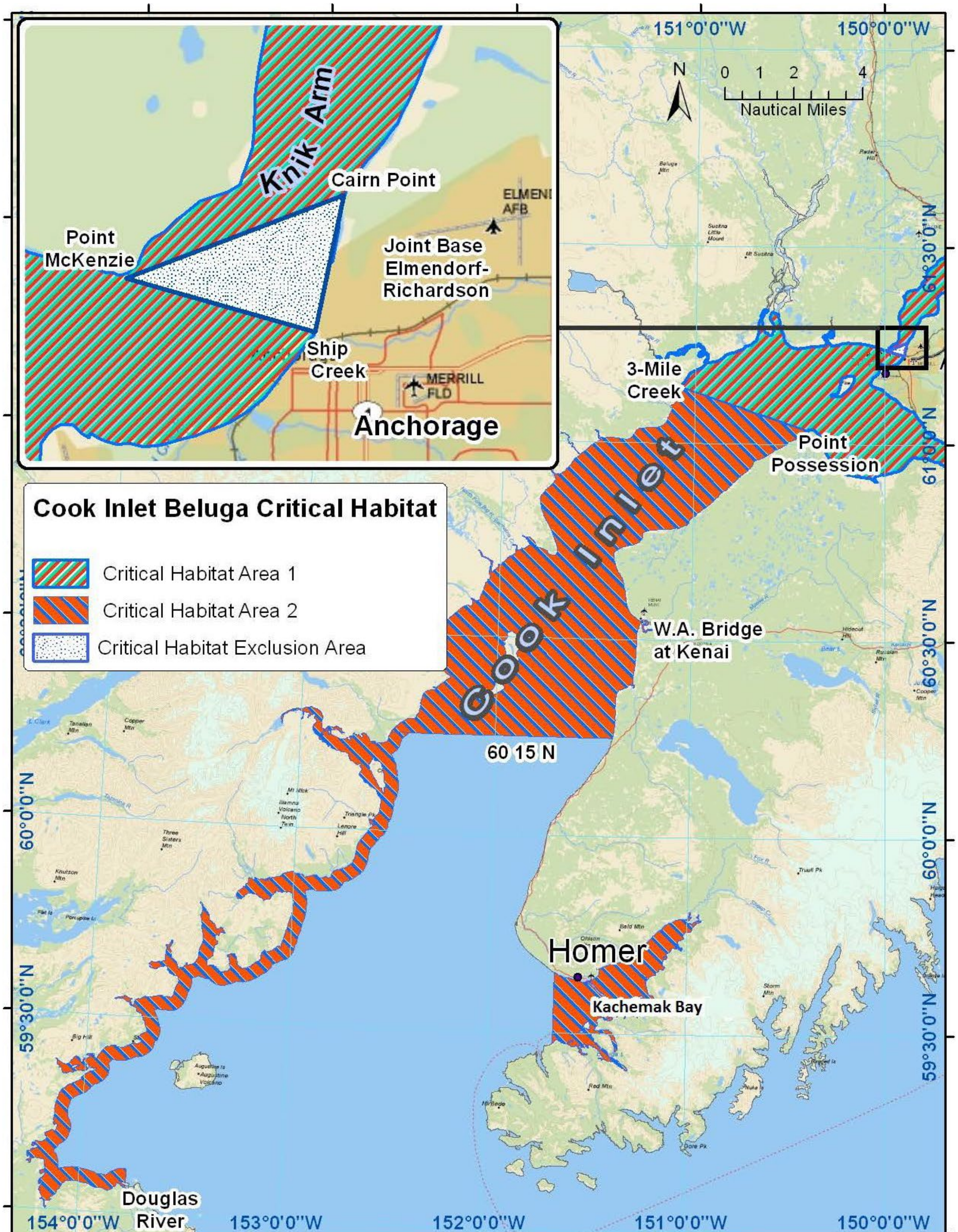

Figure 7-18. Cook Inlet Beluga Critical Habitat

Source: 76 FR 20180 and NMFS (2016)

7.3.2. Beaufort and Eastern Chukchi Sea Beluga Whales

The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas (Muto, Helker et al. 2020, Muto, Helker et al. 2021). Beaufort Sea beluga whales depart from the Bering Sea in early spring moving through the Chukchi Sea and into the Canadian waters of the Beaufort Sea where they remain in the summer and fall, returning to the Bering Sea in late fall. Eastern Chukchi Sea beluga whales migrate out of the Bering Sea in late spring and early summer moving into the Chukchi Sea and western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall. The Eastern Bering Sea stock remains in the Bering Sea but moves south near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser *et al.* 2014, Citta *et al.* 2017, as cited in Muto, Helker et al. (2021) and (Lowry, Citta et al. 2019).

Data from satellite tagged beluga whales from the Beaufort and Eastern Chukchi Sea stocks identify relatively distinct month-to-month ranges for each stock's summering areas and autumn migratory routes (Lowry, Citta et al. 2019, Muto, Helker et al. 2021). The data also show that while whales from these summering areas do overwinter in the Bering Sea, they do not overlap in space and time while in the Bering Sea (Lowry, Citta et al. 2019, Muto, Helker et al. 2021). Recent genetic analyses combined with new telemetry data show that the demographically distinct summering aggregations return to discrete wintering areas and do not appear to interbreed extensively (O'Corry-Crowe, Suydam et al. 2018).

7.3.2.1. Current Status and Relevant Baseline Information

7.3.2.1.1. Beaufort Sea Stock Status

An aerial survey for Beaufort Sea beluga whales was conducted in July 1992; the stock was estimated at 19,629 beluga whales (CV = 0.229) (Harwood *et al.* 1996, as cited in (Muto, Helker et al. 2020). Duval (1993, as cited in (Muto, Helker et al. 2020) recommended a correction factor of 2 to account for availability bias for the Beaufort Sea beluga whale stock, resulting in a population estimate of 39,258 whales (19,629 × 2). However, this correction factor is considered to be negatively biased considering that aerial survey correction factors for this stock have been estimated by others to be between 2.5 and 3.27 (Frost and Lowry 1995). Additionally, the 1992 surveys are negatively biased because they did not encompass the entire summer range of Beaufort Sea beluga whales (Richard, Martin et al. 2001).

Independent aerial, line-transect surveys to better define bowhead whale abundance were conducted in the eastern Beaufort Sea as a joint effort by U.S. and Canada researchers. Those data are also being analyzed to derive abundance estimates for the Beaufort Sea stock of beluga whales. Lowry, Kingsley et al. (2017) accessed a dataset of 119 transects covering 10,608 km in the Beaufort Sea and estimated the number of surface visible belugas in the study area during the survey period as 11,703. However, when some statistically anomalous sightings that occurred on one day at the northern ends of two neighboring transects were removed from the dataset, the estimate was reduced to 5,547 surface-visible belugas.

Due to the lack of recent population data, the current population trend of the Beaufort Sea stock of beluga whales and PBR for this stock are unknown (Muto, Helker et al. 2020).

7.3.2.1.2. Eastern Chukchi Sea Stock Status

A geographically stratified line-transect analysis based on the assumption that the Beaufort Sea and Eastern Chukchi Sea stocks are geographically segregated from mid-July through August estimated that the population of Eastern Chukchi Sea beluga whales range from 6,456 (CV=0.48) to 16,598 (CV=0.49) over the period 2012 to 2017 in the study area (Givens, Ferguson et al. 2020). These estimates incorporate a correction factor of 1.85 to account for submerged whales not visible to the aerial observers (Lowry, Kingsley et al. 2017). The data from this study show no statistically significant trends in abundance of this stock inside the study area over 2012-2017 (Givens, Ferguson et al. 2020), and the interannual variation among the abundance estimates and the estimated CVs are both large. However, the stock is not considered to be decreasing, and PBR was determined to be 178 whales (Muto, Helker et al. 2020).

7.3.2.1.3. Monitoring of the Effects of Oil and Gas Activities

For over two decades, the oil and gas industry has conducted monitoring of marine mammals and the acoustic environment in the Beaufort Sea (Richardson and Williams 2000, Richardson and Williams 2001, Richardson and Williams 2002, Richardson and Williams 2003, Blackwell, Greene Jr. et al. 2004, Blackwell, Norman et al. 2004, Richardson and Williams 2004, Richardson and Williams 2005, Blackwell and Greene Jr. 2006, Aerts, Blees et al. 2008, Aerts and Richardson 2008, Aerts and Richardson 2009, Aerts and Richardson 2010, Beland and Ireland 2010, Richardson and Kim 2012, Aerts, Hetrick et al. 2013, HDR Alaska Inc. 2013, Richardson and Kim 2013, Richardson and Kim 2014, Smultea, Lomac-MacNair et al. 2014, Cate, Blees et al. 2015, Richardson and Kim 2015, Bishop and Streever 2016, Greeneridge Sciences Inc. 2017, Frouin-Mouy, Mouy et al. 2019) and Chukchi Sea (Patterson, Blackwell et al. 2007, Funk, Ireland et al. 2010, Reiser, Funk et al. 2010, Statoil 2010, Hartin, Bisson et al. 2011, Aerts, Hetrick et al. 2013, LGL Alaska Research Associates Inc., JASCO Applied Sciences Inc. et al. 2014, Shell Gulf of Mexico Inc. 2014, Ireland, Bisson et al. 2016). Many of these studies are related to the Northstar development in the Beaufort Sea and Shell's exploratory drilling efforts in the Chukchi Sea.

Ireland, Bisson et al. (2016) summarized the results of marine mammal monitoring and mitigation related to oil and gas activities in the Beaufort and Chukchi seas for the period 2006 to 2014. The authors concluded that:

> *There is no evidence that oil and gas exploration activities in this area have resulted in population-level effects to any species. Intensive monitoring of recent exploration activities in the Arctic OCS has suggested that impacts to marine mammals were limited to localized and short-term effects (Funk et al. 2007, 2010a,b, 2011; Ireland et al. 2009; LGL et al. 2014).*

Much of the construction of oil and gas projects in the U.S. Arctic region is planned for winter months to avoid disturbance and impacts to marine mammals such as belugas, which are absent from the Beaufort Sea and Eastern Chukchi Sea during the winter and spring months (USACE 1999, MMS 2004, USACE 2012, BOEM 2018). Some work, such as pile-driving, dredging, and open-water seismic surveys, are conducted during periods when belugas may be present in the area. Effects due to these activities are discussed in Sections 7.3.2.3 and 7.2.3.4.

7.3.2.2. Mortality and Serious Injury

Direct mortality or serious injury of a beluga whale due to oil and gas activities in the U.S. Arctic has never been reported. However, there is a potential for oil spills or other types of discharges to occur from oil industry activities, such as support vessels. Beluga whales concentrate along the continental shelf break, which is offshore of current oil and gas activities, thereby reducing the potential that belugas would contact spilled oil (BOEM 2018).

7.3.2.3. Physiological Effects (Threshold Shifts)

Physiological effects to belugas can occur from exposure to noise produced during seismic surveys, construction activities, drilling, and production. As described in Section 7.1.3, the only likely direct impact from seismic airgun activities is the possibility of auditory injury or PTS. Whales are highly mobile and can avoid the acoustic footprint of a slow-moving sound source, thereby potentially avoiding exposure to injurious sound levels. For example, small-toothed whales such as belugas tend to move away or maintain a greater distance from a seismic survey vessel when a large airgun array is operating (Stone and Tasker 2006, Weir 2008).

BOEM (2018) describes how sheet pile and pipe driving may impact beluga whales in the vicinity of the Liberty Development in Foggy Island Bay:

> *Pile-driving noise would attenuate in the shallow environment of Foggy Island Bay, reaching ambient background levels within several miles. Belugas near the LDPI would be exposed to noise up to 148 dB RMS in the 5 to 55 Hz range, from impact or vibratory sheet-/pile-driving during construction and would likely respond by avoiding the area.*

Responses of beluga whales to drilling operations are described in Richardson, Greene Jr. et al. (1995) and summarized here. In the Mackenzie Estuary during summer, belugas were observed regularly within 99.9 m to 149.9 m of artificial drilling islands (Fraker 1977a, 1977b; Fraker and Fraker 1979, as cited in BOEM (2018) suggesting that animals were not overtly disturbed by noise produced during drilling operations. In spring, migrating belugas showed no obvious reaction to recorded drilling noise (less than 350 Hz) until within 199.9 m to 399.8 m of the source, even though the sounds were measurable up to 4.9 km away (Richardson *et al.* 1991, as cited in BOEM (2018). However, during another drilling noise playback study, belugas showed increased swimming speed or reversal of direction of travel within about 50 to 300 m of the noise (Stewart *et al.* 1983, as cited in BOEM (2018).

Production-related activities focus on the operation and maintenance of facilities and equipment. In a 2012 environmental assessment for ongoing production operations at Northstar, NMFS determined routine production activities would have minimal impact on belugas (NMFS 2012).

Survey protocols and mitigation measures, such as exclusion and safety zones monitored by PSOs, and procedures to enact power down, shutdown, ramp up, and soft start measures, as described in Sections 6.7 through 6.10, are meant to reduce the potential for Level A and Level B exposures during seismic surveys and construction activities.

7.3.2.4. Behavioral Response Due to Disturbance

Disturbance to beluga whales can occur due to use of vessels and aircraft during seismic surveys and oil and gas construction and operations. Belugas may display strong avoidance reactions to vessels particularly if they belong to a hunted population (Richardson, Greene Jr. et al. 1995). Beluga reactions to vessels are mixed and may vary with location. Some belugas in the Gulf of St. Lawrence seasonally habituate to boats, while others in Arctic Canada show strong escape reactions from vessels and icebreaking (Richardson, Greene Jr. et al. 1995). Beluga whales have exhibited greater responses to a moving sound source (*e.g.*, airgun activity on a moving vessel) than to a stationary sound source (NMFS 2015, as cited in (BOEM 2018). They have been shown to exhibit changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran, Schlundt et al. 2002). However, the animals tolerated high received levels of sound (peak–peak level >200 dB re 1 µPa) before exhibiting aversive behaviors (Richardson, Greene Jr. et al. 1995).

Based on observations collected during 2 years of seismic studies in the Beaufort Sea, Miller, Moulton et al. (2005) reported that beluga whale sightings were unexpectedly high 20–30 km (from the seismic vessel) but were substantially lower 10–20 km from the vessel, indicating that whales may be avoiding seismic operations by 10–20 km. Most of the energy from airgun arrays is below 100 Hz, which is below the frequencies of calling and best hearing of beluga whales; however, behavioral observations indicate that they are not insensitive to sounds produced by these activities.

Lesage, Barrette et al. (1999) reported that beluga whales changed their call type and call frequency when exposed to vessel noise. Beluga whales have been documented swimming rapidly away from ships and icebreakers in the Beaufort Sea when a ship approached to within 35 to 50 km and received levels ranged from 94 to 105 dB re 1 µPa in the 20 to 1,000 Hz band, and they may travel up to 80 km from the vessel's track (Finley, Miller et al. 1990). In addition to avoidance, changes in dive behavior and pod integrity were also noted.

Beluga whales are reported to be extremely sensitive to icebreaking. While not many studies have been conducted to evaluate the potential interference of icebreaking noise with marine mammal vocalizations, a few studies have looked specifically at icebreaking noise and beluga whales. Erbe and Farmer (2000) reported that the Canadian Coast Guard ship, *Henry Larsen*, ramming ice in the Beaufort Sea, masked recordings of beluga vocalizations at a signal-to-noise ratio of 18 dB. At least 6 of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson, Greene Jr. et al. 1995). Finley *et al.* (1990) also reported beluga avoidance of icebreaker activities in the Canadian High Arctic at distances of 35 to 50 km.

Helicopter noise may be a source of disturbance to beluga whales, particularly during exploratory drilling crew transfers. During spring migration in the Beaufort Sea, beluga whales reacted to helicopter noise more frequently and at greater distances than did bowhead whales (Patenaude, Richardson et al. 2002). Most belugas do not visibly respond to occasional single passes by low-flying helicopters at altitudes above 152.4 m (Richardson and Malme 1993, as cited in BOEM (2018). Patenaude, Richardson et al. (2002) recorded reactions of bowhead and beluga whales to a Bell 212 helicopter and Twin Otter fixed-wing aircraft during four spring seasons (1989 through 1991, and 1994) in the western Beaufort Sea. Responses were more common to the helicopter than to the fixed-wing aircraft and included immediate dives, changes in heading, changes in behavioral state, and apparent displacement of belugas (Patenaude, Richardson et al. 2002). Similar but weaker reactions to fixed-wing aircraft were observed by the authors. Most reactions occurred when the helicopter was at altitudes ≤150 m and at lateral distances ≤250 m (Nowacek, Thorne et al. 2007).

7.3.2.5. Effects Due to Changes in Habitat

As described in Section 7.1.5, assessments of impacts due to oil and gas activities on marine mammal U.S. Arctic habitat are general and focus on the ambient acoustic environment. Offshore drilling islands such as the existing Northstar Island and proposed Liberty Island, and the footprints of these and other structures such as docks, remove or alter beluga habitat; however, the amount of habitat removed or altered is a very small fraction of available potential beluga whale habitat in the Beaufort and Chukchi seas. Other impacts on whale habitat due to noise effects on prey species, changes in sea ice, and impacts from oil spills are described in Sections 7.1.5 and 7.3.1.5.

7.4. Other Cetaceans

Other cetacean species that could be encountered in the U.S. Arctic OCS, in Cook Inlet, and along the marine transit route include killer whales, Dall's porpoise, and harbor porpoise. Sperm whales are considered extralimital in the U.S. Arctic and Cook Inlet but may be encountered in the marine transit route by oil and gas industry vessels transitioning between Dutch Harbor and the Beaufort or Chukchi seas.

7.4.1. Current Status and Relevant Baseline Information

7.4.1.1. Killer Whales (*Orcinus orca*)

Eight killer whale stocks are now recognized within the Pacific U.S. Exclusive Economic Zone (EEZ) (Muto, Helker et al. 2021). Killer whales observed in the Chukchi and Beaufort seas and in Cook Inlet waters belong to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock, while killer whales in Cook Inlet waters belong to either the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock or the Alaska Resident stock (Muto, Helker et al. 2017). Figures 7-19 and 7-20 show the ranges of the transient and resident stocks, respectively. For the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale stock, a total of 587 individual whales have been identified in photographic catalogues, and PBR for the stock is 5.9 animals (Muto, Helker et al. 2021). Combining the counts of known resident whales gives a minimum number of 2,347 killer whales belonging to the Alaska Resident stock, with a PBR of 24 animals (Muto, Helker et al. 2017).

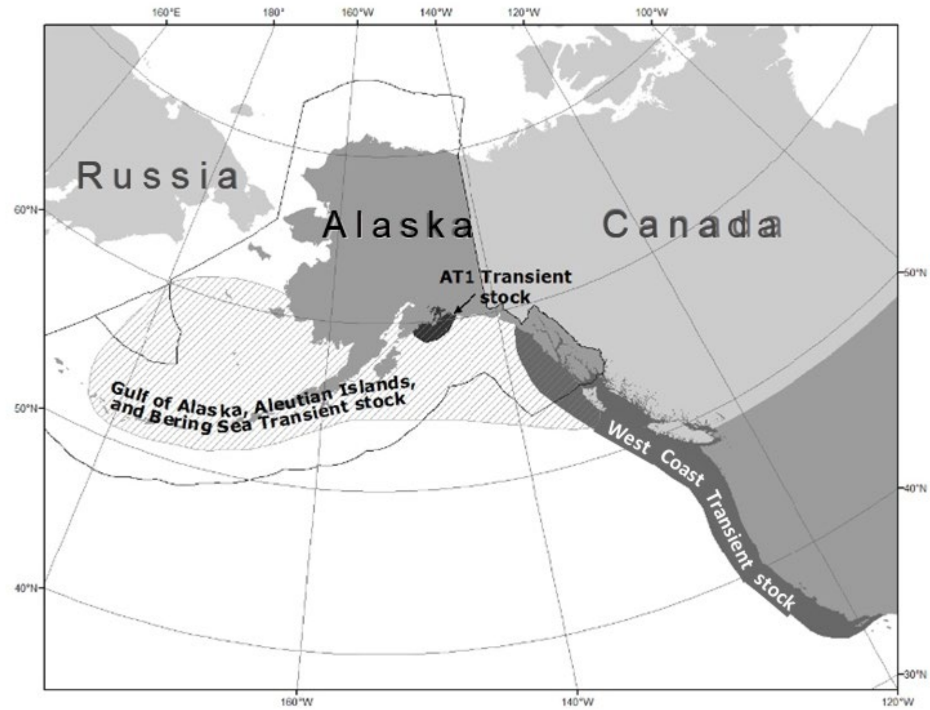

Figure 7-19. Ranges of Killer Whale Transient Stocks in Alaska

Source: Muto, Helker et al. (2021)

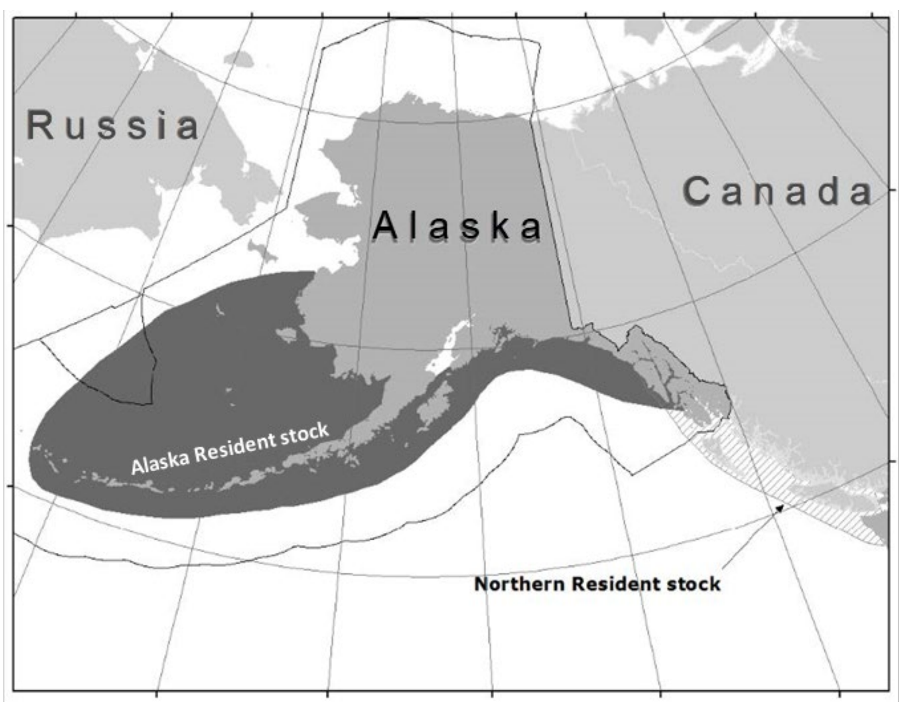

Figure 7-20. Ranges of Resident Stocks of Killer Whales in Alaska

Source: Muto, Helker et al. (2017)

PSOs aboard industry vessels in the Chukchi Sea recorded killer whale sightings in 2006, 2007, 2008, 2010, 2012, and 2015 (Ireland, Broker et al. 2016). Killer whales were sighted annually between 2008 and 2012 by observers aboard the Chukchi Sea Environmental Studies Program (CSESP) cruises (Aerts, Hetrick et al. 2013) and in 2012 by aerial observers (Clarke, Stafford et al. 2013). Killer whales inhabit the northeastern Chukchi Sea during the summer and autumn sea ice-free season in the U.S. Pacific Arctic (Willoughby, Ferguson et al. 2020). They have been sighted annually adjacent to Utqiaġvik, Alaska, and are seen by Iñupiaq hunters who hunt along the shoreline and on the water (George, Philo et al. 1994). There is a general consensus that killer whales will utilize sub-Arctic and Arctic marine habitat, as sea ice continues to recede associated with global warming (Moore and Huntington 2008).

Killer whales are occasionally observed in Lower Cook Inlet, especially near Homer and Port Graham (Shelden, Rugh et al. 2003). One group consisting of two individual killer whales was observed during the 2015 SAExploration seismic program near the North Forelands (Kendall *et al.* 2015, as cited in (NMFS 2019). During the LCI seismic project in Lower Cook Inlet in 2019, 21 individual killer whales were sighted in six separate groups (Fairweather Science 2020). During this monitoring, killer whales were observed either as solitary animals (33%), or in groups of approximately 4 to 5 individuals (67%). Juvenile killer whales were observed with two of the sightings, which were swimming and traveling in groups of 5 and 4, respectively (Fairweather Science 2020). Figure 7-15 shows the locations of marine mammal observations during aerial surveys for the LCI seismic survey. However, no killer whales were observed during monitoring for the 2018 CIPL Project in Upper Cook Inlet (Sitkiewicz, Hetrick et al. 2018).

7.4.1.2. Sperm Whales (*Physeter macrocephalus*)

During summer, male sperm whales are found in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988, Mizroch and Rice 2013, Ivashchenko *et al.* 2014; all cited in (Muto, Helker et al. 2021). Mizroch and Rice (2013, as cited in (Muto, Helker et al. 2021) also showed movements by females into the Gulf of Alaska and western Aleutians. While Figure 7-21 shows the overall geographic distribution of the North Pacific stock of sperm whales, sighting surveys conducted by the Marine Mammal Laboratory (MML) in the summer months between 2001 and 2010 found sperm whales to most frequently sighted in the coastal waters around the central and western Aleutian Islands (MML unpublished data, as cited in (Muto, Helker et al. 2021). Acoustic surveys, from fixed autonomous hydrophones, detected the presence of sperm whales year-round in the Gulf of Alaska, although they appear to be approximately two times as common in summer than in winter (Mellinger *et al.* 2004, as cited in (Muto, Helker et al. 2021). This seasonality of detections is consistent with the hypothesis that sperm whales generally move to higher latitudes in summer and to lower latitudes in winter (Whitehead and Arnbom 1987, as cited in (Muto, Helker et al. 2021). Based on this information, they are not expected to be encountered in the Beaufort or Chukchi seas or in Cook Inlet but may be present in the marine transit route.

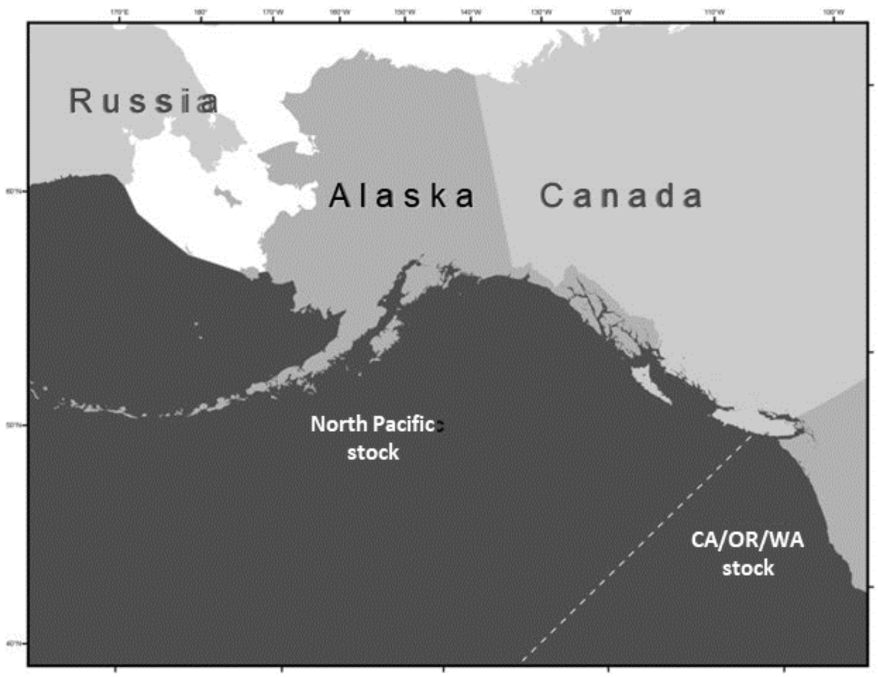

Figure 7-21. Distribution of Sperm Whales in the North Pacific Ocean

Source: Muto, Helker et al. (2021)

Current and historical abundance estimates of sperm whales in the North Pacific are based on limited data and are considered unreliable (Muto, Helker et al. 2021). For example, Kato and Miyashita (1998, as cited in (Muto, Helker et al. 2021) reported 102,112 sperm whales in the western North Pacific, with the caveat that their estimate is likely positively biased. Surveys in the Gulf of Alaska, Rone *et al.* (2017, as cited in (Muto, Helker et al. 2021) estimated 129 and 345 sperm whales in 2009 and 2015, respectively, in a smaller area. Because the data used in estimating the abundance of sperm whales in the entire North Pacific are more than 8 years old, a reliable estimate of abundance and PBR for the stock is considered unreliable (Muto, Helker et al. 2021). Sperm whales were listed as endangered throughout its range in 1970 (35 FR 18319). Critical habitat for sperm whales has not been designated.

7.4.1.3. Harbor Porpoise

In Alaskan waters, three stocks of harbor porpoises are currently recognized for management purposes: Southeast Alaska, Gulf of Alaska, and Bering Sea Stocks (Figure 7-22) (Muto, Helker et al. 2017). Porpoises found in Cook Inlet belong to the Gulf of Alaska Stock, which is distributed from Cape Suckling to Unimak Pass and most recently was estimated to number 31,046 individuals. The abundance estimate for the Bering Sea stock was estimated to be 5,713 using data from 2008 (Muto, Helker et al. 2020). PBR for both for these stocks is undetermined because abundance estimates are more than 8 years old (Muto, Helker et al. 2020).

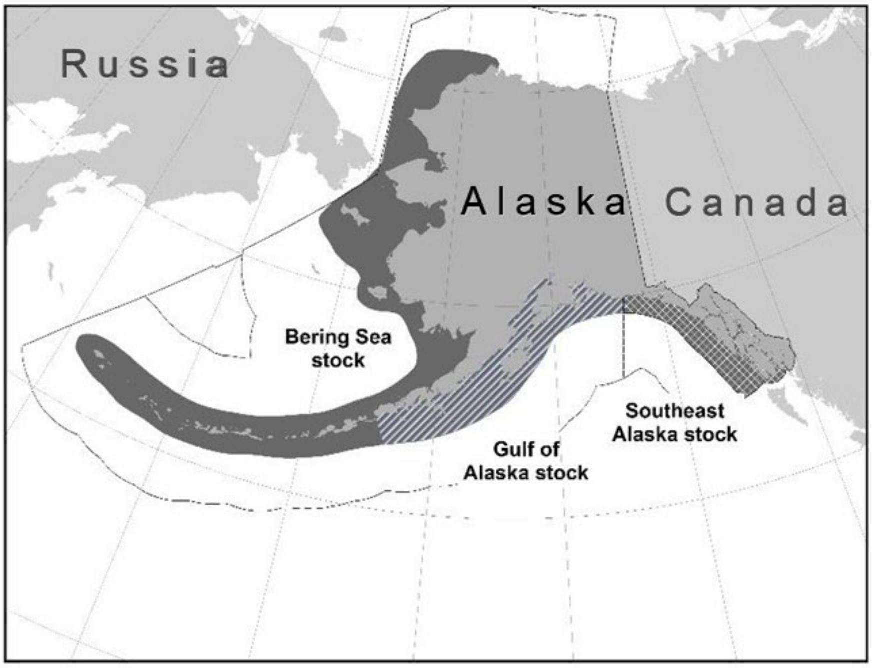

Figure 7-22. Ranges of Harbor Porpoise Stocks in Alaska

Source: Muto, Helker et al. (2020)

The Bering Sea stock includes those animals occurring in the Chukchi Sea, although recent records provide data on sightings in the Beaufort Sea. Harbor porpoises have been commonly encountered in the Chukchi Sea. Suydam and George (1992, as cited in Aerts, Hetrick et al. (2013) reported nine records in the Utqiaġvik area in 1985–1991. More recently, during the summer and fall of 2006–2008, observers recorded harbor porpoises in the Chukchi Sea (Haley *et al.* 2010, as cited in Aerts, Hetrick et al. (2013). Aerts, Hetrick et al. (2013) recorded observation of harbor porpoise over the period 2008–2012 in the Chukchi and Beaufort seas. Four animals were seen in the Beaufort Sea northwest of Utqiaġvik, 28 animals in the northeastern Chukchi Sea, and 10 animals south of Point Hope. Six of the 11 harbor porpoise sightings reported by Funk, Ireland et al. (2010) were in the Beaufort Sea.

Harbor porpoise are frequently observed during summer aerial surveys of Cook Inlet, with most sightings of individuals concentrated at Chinitna and Tuxedni Bays on the west side of Lower Cook Inlet (Rugh *et al.* 2005, as cited in NMFS (2019). Harbor porpoises have been consistently reported in Upper Cook Inlet between April and October. During Apache's 2012 seismic program, 137 sightings (190 individuals) were recorded between May and August (Lomac-MacNair, Smultea et al. 2014). (Lomac-MacNair, Smultea et al. 2014) also identified 13 groups of harbor porpoise totaling 77 individuals during Apache's 2014 seismic survey, both from vessels and aircraft, during the month of May. During SAExploration's 2015 seismic survey, 52 sightings (65 individuals) were observed north of the Forelands (NMFS 2019). In 2018, monitors for the CIPL Project in Upper Cook Inlet recorded 29 sightings (approximately 44 individuals) (Sitkiewicz, Hetrick et al. 2018). Most recently, during the 2019 LCI seismic project, only three harbor porpoise were observed during aerial surveys (Fairweather Science 2020). Figure 7-15 in Section 7.2.1.5 shows the location of harbor porpoise recorded during this monitoring.

7.4.1.4. Dall's Porpoise

Dall's porpoise are widely distributed across the North Pacific, but there is a distribution gap in Upper Cook Inlet (Figure 7-23). As reported in Muto, Helker et al. (2020) a corrected population estimate from 1987–

1991 for the Alaska Stock is 83,400 animals. However, because the surveys are more than 8 years old, there are no reliable abundance estimates for the entire Alaska stock of Dall's porpoise and PBR is considered to be undetermined (Muto, Helker et al. 2020).

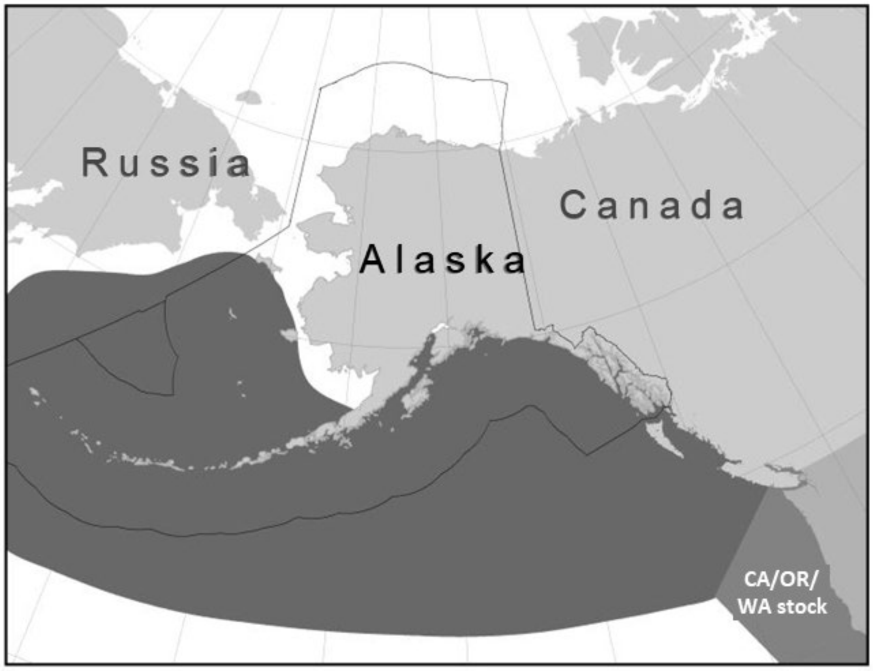

Figure 7-23. Distribution of Dall's Porpoise in Alaska

Source: Muto, Helker et al. (2020)

Dall's porpoise have been observed in Lower Cook Inlet, around Kachemak Bay, and rarely near Anchor Point (Owl Ridge 2014; BOEM 2015, as cited in (NMFS 2019). These porpoises were observed (two groups, three individuals) during Apache's 2014 seismic survey, which occurred in the summer months (Lomac-MacNair, Smultea et al. 2014). During the month of June, Shelden, Rugh et al. (2013) observed 3 Dall's porpoises in Iniskin Bay, 27 near Barren Island, 15 near Elizabeth Island, and 5 in Kamishak Bay. One Dall's porpoise was observed in August north of Nikiski in the middle of the inlet during SAExploration's 2015 seismic program (Kendall *et al.* 2015, as cited in NMFS (2019). As expected, no Dall's porpoises were observed during the CIPL project monitoring program in Upper Cook Inlet in 2018 (Sitkiewicz, Hetrick et al. 2018), but during the LCI seismic project in Lower Cook Inlet in 2019, 30 individual Dall's porpoise were sighted in 10 separate groups (Fairweather Science 2020). Figure 7-15 in Section 7.2.1.5 shows the locations of marine mammals sighted during aerial surveys for the LCI seismic work.

Although considered extralimital in the Chukchi Sea, Ireland, Bisson et al. (2016) reported sightings of a single Dall's porpoise in each of the 2008, 2012, and 2015 open-water seasons. Dall's porpoises were recorded in 2 of the 7 years of CSESP vessel-based surveys and these were located in the southern and northeastern Chukchi Sea (Christman *et al.* 2015, as cited in Ireland, Bisson et al. (2016). There have been no reported observations of Dall's porpoises in the northeastern Chukchi Sea from aerial monitoring programs (Ireland, Bisson et al. 2016).

7.4.1.5. Pacific White-Sided Dolphins

The North Pacific stock of Pacific white-sided dolphins ranges from British Columbia north into the southern Bering Sea. The species is common on the high seas and along continental margins and may occasionally enter inshore passes in Alaska such as Cook Inlet (Muto, Helker et al. 2020). Marine mammal sighting data from 1987–1990 provide the basis for a population abundance estimate that is likely representative of two stocks (North Pacific and California/Washington/Oregon) of 931,000 dolphins (CV = 0.90) (Muto, Helker et al. 2020). No reliable data are available to determine population trends for the North Pacific stock.

Passive acoustic monitoring during 3D seismic surveys in 2019 documented whistles from Pacific white-sided dolphins near Iniskin and the southwest corner of lower Cook Inlet (Castellote, Stocker et al. 2020). Simultaneous visual monitoring during the 3D surveys did not detect Pacific white-sided dolphins, though sightings of unidentified dolphins were reported (Fairweather Science 2020).

7.4.2. Mortality and Serious Injury

No incidences of serious injury or mortality of these species due to oil and gas operations have been recorded. Also there have been no recorded mortality or serious injury collisions between industry vessels using the marine transit route and any of these cetacean species. One unidentifiable marine mammal carcass was observed and reported during monitoring for the CIPL project; the marine mammal's death was not due to CIPL project activities (Sitkiewicz, Hetrick et al. 2018).

7.4.3. Behavioral Response Due to Disturbance

As described in Sections 7.4.1.1, 7.4.1.3, and 7.4.1.4, a few killer whales, harbor porpoise and Dall's porpoise have been observed during monitoring for seismic surveys and exploratory drilling programs in the Chukchi and Beaufort seas. The majority of these reports do not ascribe any behavioral response of these species due to noise from oil and gas activities or presence of vessels. However, during monitoring for Shell's 2012 exploration drilling program, Bisson, Reider et al. (2013) recorded no exposure of continuous sound levels over 120 dB re 1μPa for killer whales, and one exposure for harbor porpoise. Reactions to the exposures were not recorded.

Toothed cetaceans typically display similar behavior to baleen whales in response to noise generated from seismic surveys. Various studies have shown that toothed whales head away or maintain a somewhat greater distance from the vessel, and stay farther away from seismic sources, during periods of airgun operation versus silent periods (Stone and Tasker 2006, Weir 2008). Observers' records suggested that fewer cetaceans were feeding and fewer were interacting with the survey vessel (*e.g.*, bow-riding) during periods with airguns operating, and small odontocetes tended to swim faster during periods of shooting (Stone and Tasker 2006).

7.4.3.1. Behavioral Responses Due to Seismic Surveys

Porpoises show variable reactions to seismic operations and reactions depend on species. Limited available data suggest that harbor porpoises show stronger avoidance of seismic operations than Dall's porpoises (Bain and Williams 2006). Similar to baleen whales, it is plausible that toothed cetaceans would avoid 2D/3D seismic surveys due to increased sound levels.

Observed behavior of harbor porpoise during the CIPL project in Cook Inlet included swimming as the initial behavior and diving as secondary behavior (Sitkiewicz, Hetrick et al. 2018). There was no observed reaction. Twenty-eight sightings of 43 individual harbor porpoises were observed during periods of no work. Observed behavior consisted of swimming (39%) and traveling (61%) with only one reaction of avoidance, likely in response to vessel presence, and there was no observed reactions to the remaining 27 sightings (Sitkiewicz, Hetrick et al. 2018).

During monitoring for the LCI seismic survey, Fairweather Science (2020) noted:

> *50% of killer whale sightings were observed during periods of no seismic activity, and 50% of killer whale sightings were detected during seismic activity that included full array, and PSOs reported that no visible reactions occurred. During the same monitoring program, harbor porpoises were observed in groups of one or two animals, and 100% of harbor porpoise sightings were recorded during periods of no seismic activity. Harbor porpoise sightings were observed an average of ~400 m from PSOs, and no observable reactions were recorded.*

Dall's porpoises performed most (60%) behaviors at a vigorous pace. Approximately 50% of Dall's porpoise sightings occurred during periods of non-seismic activity and 50% were recorded during seismic operations including ramp up and operation of the full airgun array. Two reactions, bowride and splash, were described during gun testing and seismic activity, respectively (Fairweather Science 2020).

Pirotta, Brookes et al. (2014) showed that the probability of recording a harbor porpoise "buzz" (inter-click interval associated with attempted prey captures or social communication) declined by 15% in the ensonified area of a 2D seismic operation. The probability of occurrence of buzzes increased with distance from the seismic source. This indicates that the likelihood of buzzing was dependent upon received noise intensity. Observed changes in buzzing occurrence could reflect disruption of either foraging or social activities. These effects may result from prey reactions to noise, leading to reduced porpoise foraging efficiencies. Alternatively, foraging effort may change if porpoises adjust time budgets or diving behavior to avoid noise (Pirotta, Brookes et al. 2014). However, as described above, harbor porpoise observed during the LCI seismic survey showed no observable reaction.

7.4.3.2. Effects within the Marine Transit Route

Potential effects from oil and gas related vessel traffic on these other cetaceans includes auditory and visual disturbance from vessels using the marine transit route. Aerts, Blees et al. (2008) recorded sighting 10 Dall's porpoise, 8 killer whales, and 19 harbor porpoise during the 24-day transit from the Port of Alaska to West Dock, Prudhoe Bay. These were all observed in the Gulf of Alaska or Bering Sea and occurred at distances of 5 to 1,187 m. The monitoring report does not state whether course changes or speed reductions were enacted.

As described in the BiOp for the Liberty Development and Production Project in the Beaufort Sea (NMFS 2019), as oil and gas project vessels transit between Dutch Harbor and the Alaska North Slope, they are only present for a short duration in the Bering Sea and around the Aleutians where sperm whales may be found. The number of oil and gas related vessel trips along the marine transit route each year is small in comparison to the existing level of other vessel traffic in the area. Over the period 1978–2011, there has been only one ship strike (not identified as an oil and gas-related vessel) of an identified whale in the Bering Sea (Neilson, Gabriele et al. 2012) (Figure 7-24).

Based on the limited annual number of vessel trips between Dutch Harbor and the Alaska North Slope, the transitory nature of this vessel traffic, mitigation measures in place to minimize or avoid effects of transiting vessels on cetaceans and decades of vessels transiting in the Bering and Chukchi seas with only a single report of a ship strike, impacts on sperm whales or North Pacific right whales from oil and gas vessels in the transit route are discountable (NMFS 2019).

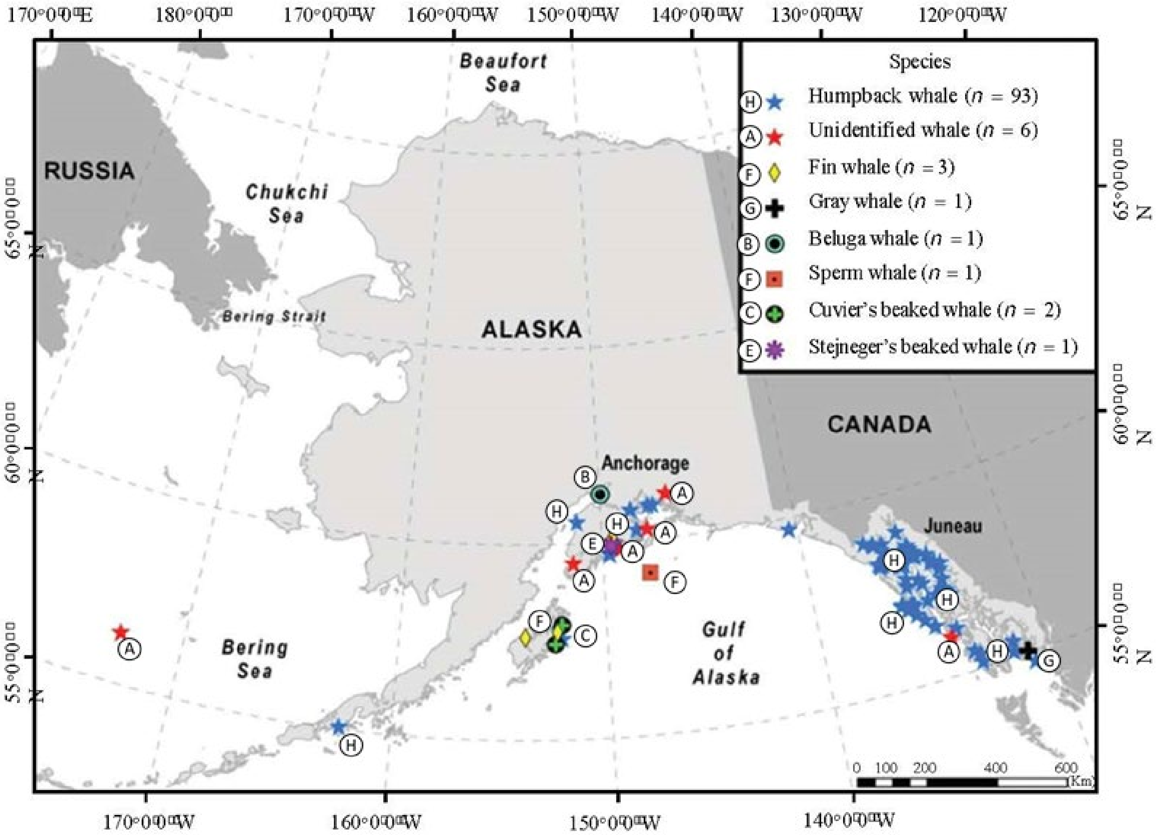

Figure 7-24. Location of Whale-Vessel Collisions 1978–2011

Source: Neilson, Gabriele et al. (2012)

7.4.4. Effects Due to Changes in Habitat

As described in Section 7.1.5, assessments of impacts due to oil and gas activities on marine mammal U.S. Arctic habitat are general and focus on the ambient acoustic environment. Other impacts on Arctic whale habitat due to noise effects on prey species, changes in sea ice, and impacts from oil spills are described in Sections 7.1.5, and 7.3.1.5.

Impacts to Cook Inlet habitat from oil and gas activities for these species would be similar to those described for beluga whales (see Section 7.3.1.5). Timing restrictions on exploration drilling in beluga whale critical habitat (NMFS 2017) may also have reduced impacts on killer whales, harbor porpoise and Dall's porpoise.

7.5. Ice Seals

This section discusses the potential direct and indirect effects on four species often collectively called "ice seals", which includes ringed seals; spotted seals; ribbon seals; and bearded seals. These species are all highly dependent on sea ice for critical life functions, and their seasonal distributions are heavily influenced by seasonal ice movement in Arctic waters. They are treated collectively because they share many similar characteristics, which are correlated with potential impacts from offshore oil and gas exploration activities. Where unique effects or susceptibilities exist, individual species are discussed separately.

7.5.1. Current Status and Relevant Baseline Information

Four species of ice seals occur in the Chukchi and Beaufort seas. Ringed seals are the species most frequently observed in nearshore areas of the Beaufort Sea coast where oil and gas activities occur. Bearded seals are less common, preferring pack ice further offshore (but over the continental shelf), while spotted and ribbon seals generally inhabit areas in the Chukchi Sea and Bering Sea, respectively.

To support analyses (*i.e.*, MMPA take estimates) of potential effects of anthropogenic activities on ice seals, the proportion of three of the four species that may occur in the U.S. Arctic have been estimated based on sighting data. Of all the pinniped sightings during monitoring surveys in 1996 (Harris, Miller et al. 2001), 2008 (Aerts, Blees et al. 2008, Hauser, Moulton et al. 2008), and 2012 (HDR Alaska Inc. 2013), 63% were ringed seals, 17% were bearded seals, and 20% were spotted seals. (Funk, Ireland et al. 2010) reported sighting data from vessel-based surveys in the Chukchi Sea 2006–2008, stating that ringed seals were the most common species (804 sightings), followed by bearded seals (363 sightings), spotted seals (220 sightings), and two ribbon seals.

The following subsections summarize recent data on seal distribution, estimated abundance, industry observation data (where available), PBR, and current threats to these populations. Following the four seal species descriptions, the potential effects of oil and gas activities, such as mortality and serious injury, behavioral effects due to disturbance, and potential effects due to changes in seal habitats, are summarized for all species together, though most monitoring data focuses on ringed seals based on available monitoring reports and literature.

7.5.1.1. Ringed Seals (*Phoca hispida*)

In the U.S., ringed seals are managed as a single stock (the Arctic stock) that occurs within the U.S. EEZ. However, ringed seals have a circumpolar distribution and are found in all seasonally ice-covered seas of the Northern Hemisphere (Muto, Helker et al. 2020, Lang, Boveng et al. 2021). Five subspecies of ringed seals are currently recognized, with only the Arctic stock (*Phoca hispida hispida)* occurring in U.S. waters in the Arctic Ocean and Bering Sea (Rice and Society for Marine Mammalogy 1998). Figure 7-25 shows the approximate winter distribution of the Arctic stock of ringed seals around Alaska.

Ringed seals are adapted to the use of shorefast and pack ice. Landfast ice is the best habitat for pupping (Kelly 1988). However, ringed seals cannot overwinter in ice-covered waters shallower than 3–5 m because of ice freezing to the seafloor or poor prey availability resulting from a limited water supply (NMFS 2020). Moulton, Richardson et al. (2002) found the highest concentration of ringed seals occurred on stable, shorefast ice over water depths of about 10–20 m in winter and spring. Therefore, it is reasonable to assume that waters less than 5 m deep are not preferred wintering areas for ringed seals (Moulton, Richardson et al. 2002, Frost, Lowry et al. 2004).

Ringed seals are abundant in the winter and spring in the northern Bering Sea, Norton Sound, Kotzebue Sound, Chukchi Sea, and Beaufort Sea, where they utilize sea ice for pupping and nursing, as well as resting. In the summer months, sea ice is used as a platform for molting and resting, although ringed seals can remain pelagic in productive foraging areas for long periods of time. In the fall, ringed seals utilize sea ice as a platform for resting. Ringed seals rarely haulout on terrestrial habitats. A summary of their life history can be found in (Frost 1985, Frost and Burns 1989, Kelly, Bengtson et al. 2010, Muto, Helker et al. 2020). Ringed seals predominantly forage on pelagic fish (Crain, Karpovich et al. 2021).

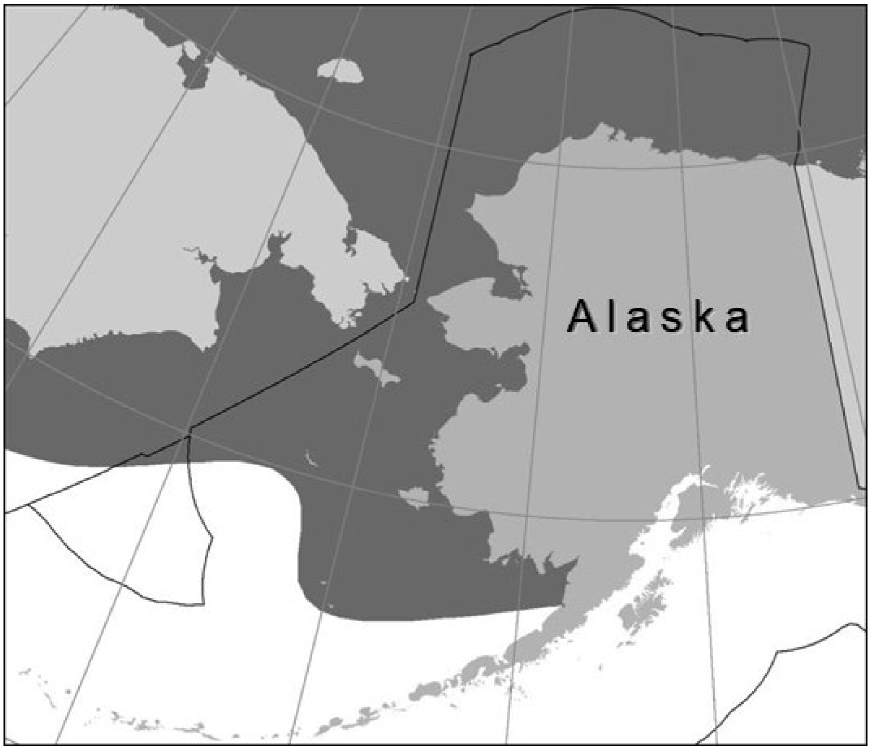

Figure 7-25. Approximate Winter Distribution of Ringed Seals around Alaska

Source: Muto, Helker et al. (2021)

A reliable population estimate for the stock of ringed seals that occupies U.S. waters is currently not available. A conservative estimate of minimum abundance for this stock was published by Conn *et al.* (2020) but is based on surveys conducted only in the Bering Sea, and which were not corrected for availability bias. Reliable information on trends in abundance are currently not available. As well, a reliable estimate of the maximum net productivity rate is currently not available, although for management purposes NMFS uses an annual rate of 12% per year, which is the default value for the maximum net productivity rate for pinniped stocks in general. The published PBR level published in Muto, Helker et al. (2020) pertains only to ringed seals in the Bering Sea (*i.e.*, 4,755 seals).

Ringed seals are an important subsistence resource for Alaskan communities. Subsistence use data for ringed seals was reported from 12 communities from 2013 to 2017 (Delean, Helker et al. 2020).

> *The minimum estimated mean annual level of human-caused mortality and serious injury for Alaska ringed seals between 2013 and 2017 is 700 seals: 2.4 in U.S. commercial fisheries, 697 in the Alaska Native subsistence harvest, 0.2 in marine debris, and 0.4 due to other causes (incidental to [MMPA]-authorized research). This is a minimum estimate of the Alaska Native subsistence harvest because only a small proportion of the communities that harvest ice seals are surveyed each year (Muto, Helker et al. 2020).*

The reported average annual removal level is considered a minimum estimate, as not all communities that hunt ringed seals were surveyed. See Section 8.1.4 for detailed information on subsistence hunting of ice seals. Other sources of human-caused mortality and serious injury are relatively minor compared to removals due to subsistence hunting.

NMFS considers vessel discharges of oil related to at-sea accidents to be a substantial threat to the status of this stock in the near term due to increased vessel traffic in U.S. Arctic waters. Finally, NMFS listed this stock of ringed seals as threatened under the ESA in 2012 based on the following rationale from Kelly, Bengtson et al. (2010).

> *The primary concern for this population is the ongoing and anticipated loss of sea ice and snow cover stemming from climate change, which is expected to pose a significant threat to the persistence of these seals in the foreseeable future (based on projections through the end of the 21st century).*

Monitoring and research on ringed seals in U.S. waters dates back to the 1980s and before, with distribution and abundance surveys along the Beaufort Sea coast prior to the develop of Northstar beginning in 1999 (Green and Johnson 1983, Frost and Lowry 1999). On-ice seismic surveys in the eastern Alaska Beaufort Sea also initiated specific monitoring programs for ringed seals (MacLean 1998). The annual and comprehensive monitoring reports for Northstar beginning in 2000 (Richardson and Williams 2000) and which continue today (for example, Kim and Richardson (2020) provide comprehensive data on ringed seals relative abundance, distribution, and behavior along the Beaufort Sea coast of Alaska). The Northstar monitoring program provides observation data on ringed seals dating back to 1999 (Richardson and Williams 2000, Moulton, Richardson et al. 2003, Williams, Nations et al. 2006, Richardson 2008). The effects of oil and gas activities on the Arctic DPS of ringed seals have been evaluated in more than 40 ESA consultations including BiOps requests for concurrence (*i.e.*, Letters of Concurrence) by NMFS beginning with the Northstar BiOp (NMFS 2002) and most recently the MMPA rule for sea ice roads, pads and trails along Alaska's North Slope (NMFS 2020).

In 2011, NMFS and USFWS declared an Unusual Mortality Event (UME) for pinnipeds in the Bering and Chukchi seas including ringed, bearded, spotted, and ribbon seals, from May 1, 2011 to December 2016. An investigation of the UME concluded that skin lesions and patchy baldness indicated a molt abnormality; however, no infectious disease agent or environmental cause for the UME was identified. Elevated numbers of ice seal strandings have been reported since 2018, and as of July 31, 2020, 298 ice seals of all age classes were reported stranded (Muto, Helker et al. 2021). Section 10.3.1 provides additional information on marine mammal UMEs in Alaska.

7.5.1.2. Bearded Seals (*Erignathus barbatus nauticus*)

In the U.S., bearded seals are managed as a single stock that occurs in the U.S. EEZ in Arctic waters (Cameron, Bengtson et al. 2011, Muto, Helker et al. 2020). Worldwide, two subspecies of bearded seals are recognized, the Beringia and Okhotsk DPS. While bearded seals inhabit the seasonally ice-covered waters of the Northern Hemisphere, the Beringia DPS is the subspecies that occurs off the U.S. Arctic coast and is the subject of this section. The distribution of bearded seals in Alaskan waters is very similar to that of ringed seals (Figure 7-26), but they are not found as far offshore in the Arctic as ringed seals.

Bearded seals are predominantly observed to haul out on pack ice, where they whelp and rear their pups and molt. In waters off Alaska, bearded seals are more abundant in nearshore waters (*i.e.*, 35–150 km from the shore) than in coastal waters (*i.e.*, within 35 km of the shore) with some exceptions (Bengtson, Hiruki-Raring et al. 2005, Quakenbush, Citta et al. 2011, Huntington, Nelson et al. 2016, Abadi, Tolstoy et al. 2017). During winter months, bearded seals occur mainly in the Bering Sea (Kelly 1988). Because of their preference for the pack ice habitat (Moulton, Elliott et al. 2002, Moulton, Elliott et al. 2003), many bearded seals winter in the Bering Sea and then move north in the spring and summer to the Chukchi Sea (Gryba, Wiese et al. 2019, Olnes, Crawford et al. 2020). Bearded seals, like ringed seals, rarely haulout on land.

Figure 7-26. Depiction of Drifting Pack Ice versus Landfast Ice

Source: Mahoney (2018)

Landfast ice that is connected to the shoreline is not preferred habitat for bearded seals. Mahoney (2018) distinguishes drifting pack ice from landfast ice by the attachment of landfast ice to the coast. Figure 7-26 from *NOAA's Arctic Report Card: Update for 2018* shows this distinction.

Based on annual aerial surveys for the period 2000–2003, only 29 bearded seals were observed during open-water (Richardson 2008) in the Beaufort Sea around Northstar. Acoustic records of bearded seal calls were reported in Aerts and Richardson (2010) during the 2009 monitoring season, with only two visually observed. No bearded seals were observed around Northstar during winter seasons 2000–2010. Bearded seals are considered infrequent along the Beaufort Sea coast with more observations typically recorded during aerial or vessel-based surveys in the Chukchi Sea (Funk, Ireland et al. 2010, Reiser, Funk et al. 2010, Aerts, Hetrick et al. 2013, LGL Alaska Research Associates Inc., JASCO Applied Sciences Inc. et al. 2014, Ireland, Bisson et al. 2016, Boveng, Cameron et al. 2017). Aerts, Hetrick et al. (2013) reported that "…trophic interactions (*i.e.*, competition for food and walrus predation), might play a role in the distribution pattern of bearded seals study areas" [in the Chukchi Sea].

Seasonal occurrence of bearded seals in the northeast Chukchi Sea was highly variable during the study period (2008–2012) (Aerts, Hetrick et al. 2013). During the ice-free summer months, the most favorable bearded seal habitat is found in the central or northern Chukchi Sea along the margin of the pack ice (Bengtson, Hiruki-Raring et al. 2005).

A reliable population estimate for the stock of bearded seals that occupies U.S. waters is currently not available (Muto, Helker et al. 2020). A conservative estimate of minimum abundance for this stock was published by Conn, Ver Hoef et al. (2014), but is based on surveys conducted only in the Bering Sea, and which were not corrected for availability bias. Reliable information on trends in abundance are currently not available. As well, a reliable estimate of the maximum net productivity rate is currently not available, although for management purposes NMFS uses an annual rate of 12% per year, which is the default value for the maximum net productivity rate for pinniped stocks. The published PBR level published in Muto, Helker et al. (2020) pertains only to bearded seals in the Bering Sea (*i.e.*, 8,210 seals). Muto, Helker et al. (2020) estimated the minimum mean annual level of human-caused mortality and serious injury for Alaska bearded seals between 2013 and 2017 was 551 seals. The amount of the subsistence harvest of bearded seals is considered a minimum estimate. See Section 8.1.4 for additional information on subsistence hunting of ice seals.

Like ringed seals, the Beringia DPS of bearded seals was listed as threatened under the ESA in 2012. Bearded seals require pack ice for successful molting, and therefore, this stage of their life history could become compromised with the loss of sea ice in the Arctic (NMFS 2021). Essential features for bearded seal habitat suitable as a platform for molting are defined as "areas with waters 200 m or less in depth containing pack ice of at least 15 percent concentration and providing bearded seals access to those waters from the ice" (NMFS 2021). According to Cameron, Bengtson et al. (2011), the main concern regarding the risk of becoming endangered stems from the likelihood that a warming climate will reduce the amount of available preferred sea ice habitats. That is, because pack ice is considered a requirement for successful whelping in the spring, and given forecasts for the loss of sea ice in fall, winter, and spring months, the recruitment of young bearded seals into the population is likely to be measurably reduced. Further, bearded seals require pack ice to rest between foraging bouts. Unlike the pelagic feeding habits of a ringed seal, bearded seals forage primarily on benthic organisms (both invertebrates and demersal fish (Kelly 1988, Crain, Karpovich et al. 2021). It is generally believed that suitable habitat for bearded seals is more limited in the Beaufort Sea, where the continental shelf is narrower and the pack ice edge frequently occurs seaward of the shelf and over water too deep for seals to forage (Kelly, Bengtson et al. 2010, Muto, Helker et al. 2020).

From Cameron, Frost et al. (2018):

> *The close association of young bearded seals to the ice edge in the Bering Sea is important, given the likely effects of climate warming on the extent of sea-ice and subsequent changes in ice edge habitat.*

From Burns and Frost (1979):

> *…they favor drifting pack ice with natural openings and areas of open water, such as leads, fractures, and polynyas, for breathing, hauling out on the ice, and access to the water for foraging.*

In terms of additional threats to the persistence of this stock, NMFS considers the following human-related activities (Cameron, Bengtson et al. 2011, Muto, Helker et al. 2020):

1. Disturbance associated with increased vessel noise due to increased vessel traffic in the U.S. Arctic;
2. Disturbance associated with an increase in the number and duration of seismic surveys;
3. The potential for oil spills; and
4. Cascading trophic effects related to global warming and ocean acidification.

See Sections 7.5.1.1 and 10.3.1 for additional descriptions of recent UMEs that have occurred in the Bering and Chukchi Sea involving bearded seals. See Section 8.1.4 for detailed information on subsistence hunting of ice seals.

7.5.1.3. Spotted Seals (*Phoca largha*)

Spotted seals are most numerous in the Bering and Chukchi seas (Quakenbush, Citta et al. 2009), although small numbers do range into the Beaufort Sea during summer (Rugh, Shelden et al. 1997). The Bering DPS of spotted seals is one of three DPS identified for this species and inhabit the offshore areas of the Bering, Chukchi, and Beaufort seas in the U.S. EEZ (Allen and Angliss 2015). Spotted seals are often mistaken for Pacific harbor seals (*Phoca vitulina richardii*) as the two species are closely related; however, harbor seals generally occur in more southern portions of the Bering Sea. The distribution and characteristics of seasonal sea ice from late fall through spring directly affects spotted seal habitat use. The ice provides a dry platform away from land predators during the whelping, nursing, breeding, and molting periods. In the Bering Sea, whelping typically occurs from late March to the end of April with most pups being born during early to mid-April, coinciding with the average period of maximum extent and stability of the seasonal sea ice. Adult spotted seals begin molting immediately after breeding (Burns 2002, as cited in Boveng, Bengtson et al. (2009). In response to a petition to list spotted seals under the ESA, based on the 2009 status review (Boveng, Bengtson et al. 2009), NMFS determined to not list the Bering DPS of spotted seals because they are currently not in danger of extinction or likely to become endangered in the foreseeable future. However, given their dependence on sea ice, habitat loss due to a warming climate is a primary concern for this species (Boveng, Bengtson et al. 2009).

Herds of spotted seals break up when the usable sea ice disappears in early summer and the animals move toward ice-free coastal waters from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. Unlike other ice seals, they use coastal haulouts for at least part of the summer. When sea ice begins to form in the fall, spotted seals move southward along the ice edge in the Bering Sea (Quakenbush, Citta et al. 2009).

A small number of spotted seal haulouts have been documented in the deltas of the Colville River in years prior to the 1990s, and while historically the sand spits and small river islands supported as many as 400 to 600 spotted seals, opportunistic aerial surveys conducted in the late 1990s documented only a few seals (n=4) at such locations (Johnson, Lawhead et al. 1999). Considering the low densities of spotted seals in the Beaufort Sea, none were observed or positively identified during Northstar monitoring 2000–2018 based on monitoring reports such as Richardson (2008) or Kim and Richardson (2020). A total of 12 spotted seals were positively identified near the source-vessel during open-water seismic programs in the central Alaskan Beaufort Sea, generally occurring near Northstar from 1996 to 2001 (Moulton and Lawson 2002). The number of spotted seals observed per year ranged from zero (in 1998 and 2000) to four (in 1999).

During a seismic survey in Foggy Island Bay, only 1 out of 18 pinnipeds observed by PSOs was confirmed as a spotted seal (Aerts, Blees et al. 2008). A small number of spotted seals were observed by PSOs during Hilcorp's geohazard surveys in July–August 2014 (Smultea, Lomac-MacNair et al. 2014) and in July 2015 (Cate, Blees et al. 2015).

Aerial surveys in the central and eastern Bering Sea in 2007 were analyzed to develop a population estimate of 141,479 spotted seals. Subsequent aerial surveys in 2012 and 2013 of ice-covered portions of the Bering Sea provide an estimate of approximately 69,000–101,000 spotted seals in the eastern Bering Sea during spring and Chukchi Sea during summer open-water. However, weather constraints in 2012 result in substantial uncertainty in this estimate because the southwest portion of the study area at the ice edge could not be surveyed (Boveng, Cameron et al. 2017). Conn *et al.* (2014, as cited in (Boveng, Cameron et al. 2017), estimated 461,625 spotted seals (95% CI: 388,732–560,348) based on a sub-sample of the data collected from the U.S. portion of the Bering Sea during the 2012 surveys.

Reliable information on population trends for spotted seals is not available. The published PBR level for the U.S. portion of spotted seals is 25,394. The minimum estimated mean annual level of human-caused mortality of spotted seals between 2014 and 2018 was 5,254 seals (Muto, Helker et al. 2021) and there are approximately 64 coastal communities between Bristol Bay north to the Beaufort Sea that harvest this species (Muto, Helker et al. 2021). For additional information on subsistence hunting of spotted seals, see Section 8.1.4. See also Sections 7.5.1.1 and 10.3.1 for additional information on recent UMEs that have occurred in the Bering and Chukchi seas involving spotted seals.

7.5.1.4. Ribbon Seals (*Histriophoca fasciata*)

Ribbon seals are found in the North Pacific Ocean and parts of the Arctic Ocean, most often along the pack ice (Allen and Angliss 2014). Ribbon seals inhabit the Bering Sea ice front from late March to early May and as ice retreats (typically July), the seals move further north in the Bering Sea to haulout on receding ice. Based on satellite tagging 2007–2010 of 72 ribbon seals, it seems most ribbon seals remain south of the Bering Strait with only 21 (29%) of tagged seals moving north into the Chukchi Sea during those years (Boveng, Bengtson et al. 2013).

Ribbon seals have been sighted in very low numbers in the northeastern Chukchi Sea (Aerts, Hetrick et al. 2013). No ribbon seals were reported as part of the Bowhead Whale Aerial Survey Project surveys conducted in the Beaufort Sea or during seismic survey program monitoring, although three animals were reported during a vessel-based marine mammal monitoring program near Prudhoe Bay in 2008 (Funk, Ireland et al. 2010). Frouin-Mouy, Mouy et al. (2019) reported that PAM in August to mid-November detected ribbon seal calls in the Chukchi Sea as well as the western Beaufort Sea.

In spring 2012 and 2013, aerial surveys were conducted by Russian researchers over ice-covered portions of the Bering Sea and Sea of Okhotsk. Based on these surveys, an estimated abundance of 184,697 (95% CI: 139,617–240,225) was calculated using a sub-sample of data from the U.S. portion of the Bering Sea (Conn *et al.* 2014, as cited in Boveng, Cameron et al. (2017). The N_{min} is 163,086 ribbon seals in the U.S. Bering Sea in the spring. The PBR for ribbon seals in the U.S. is 9,785. Population trends for the U.S. portion of the ribbon seal stock are not available. The annual rate of incidental mortality in U.S. commercial fisheries occurring in the Bering Sea and Aleutian Islands was 0.9 seals (Muto, Helker et al. 2021).

During the period 2014–2018, a mean of 162 ribbon seals were hunted annually for Alaska Native subsistence. See Section 8.1.4 for more detailed information on subsistence hunting of ice seals(Muto, Helker et al. 2021). As for other ice seal species, the presence of sea ice is a primary habitat feature ribbon seals depend on for molting, reproduction, whelping, and nursing. Molting is believed to be promoted by skin temperature, meaning that elevated skin temperature achieved when hauled out on the ice may accelerate the molt. Long-term habitat loss and modification of sea ice associated with a warmer climate is considered a main concern for ribbon seals (Muto, Helker et al. 2021). Ocean acidification from increased carbon dioxide emissions may also change prey populations on which ribbon seals depend though the specific effects on seal survival and recruitment is complex (Boveng, Bengtson et al. 2013). See Sections 7.5.1.1 and 10.3.1 for additional information on recent UMEs that have occurred in the Bering and Chukchi seas involving ribbon seals.

7.5.2. Mortality and Serious Injury (All Ice Seals)

There are no documented mortalities or serious injuries of bearded, ribbon, or spotted seals associated with oil and gas activities. As stated in the 2020 final rule for ice road construction, operation, and maintenance (NMFS 2020):

> *Based on a review of literature and monitoring reports from Northstar and other North Slope projects, there is documentation of one seal mortality associated with a vibroseis program outside the barrier islands east of Bullen Point in the eastern Beaufort Sea*

(MacLean 1998). During a 1999 NMFS workshop to review on-ice monitoring and research, Dr. Brendan Kelly (then of the University of Alaska), also indicated that a dead ringed seal pup was found during his research using trained dogs to locate seal structures in the ice. The dead ringed seal pup was located approximately 1.5 km (0.9 mi) from the Northstar ice road. No data on the age of the pup, date of death, necropsy results, or cause of death are available.

No other mortality or serious injury of ringed seals has been documented during oil and gas activity monitoring. Upon review of monitoring reports since 2000, there has not been another mortality observed that is attributable to oil and gas activities in the Beaufort or Chukchi seas.

Beginning with the 2000 final rule for Northstar (and subsequent LOAs over the 5-year period), NMFS (2000) states:

Although the potential impacts to the several marine mammal species known to occur in these areas is expected to be limited to harassment, a small number of marine mammals may incur lethal and serious injury. Most effects, however, are expected to be limited to temporary changes in behavior or displacement from a relatively small area near the construction site and will involve only small numbers of animals relative to the size of the populations.

A small number of takes for serious injury or mortality have been authorized each year in subsequent rules for Northstar; however, no lethal takes or serious injuries to seals have been known to occur due to oil and gas activities. The 2020 final rule and LOA for ice road, trail and pad construction, and operation and maintenance (NMFS 2020) also authorized a small number of takes for serious injury or mortality (a total of 12 for the 5-year period). In 2020, there were no reports of serious injury or mortality of any seals.

Mortality and serious injury of bearded and ringed seals has been evaluated for on-ice seismic activities in several MMPA authorizations. For example, an IHA issued by NMFS to ConocoPhillips evaluated on-ice seismic activities in 2003 (NMFS 2003) concluding that while pup mortality could occur if any seals were nursing and displaced during seismic work, the likelihood of this happening was very low considering: 1) seismic survey placement is required to avoid known seal lairs; 2) seismic activities would generally occur prior to the pupping season beginning mid-March; and 3) any seismic work planned after March 20th would require pre-seismic seal surveys to identify any active seal lairs/holes or lair habitats so they could be avoided; if trained dogs were not available for such surveys, a trained biologist would conduct surveys. The 2003 IHA states:

In the event that seismic surveys can be completed in that portion of the activity area ≥ 3 m (9.8 ft) before mid-March, no field surveys would be conducted of seal structures. Under this scenario, surveys would be completed before pups are born and disturbance would be negligible.

For open-water seismic activities, mortality or serious injury are not anticipated for seals due to the premise that seals would avoid areas where seismic activities occur and, in some cases, projects implement specific shutdown zones to protect seals from serious injury such as PTS.

7.5.3. Behavioral Response Due to Disturbance (All Ice Seals)

Evidence from more than three decades of ringed seal monitoring provide some of the best available data on the presence/absence and behavioral response of seals within proximity to oil and gas activities. Most available data on seal response are from ringed seal monitoring, with a few reports of bearded and spotted seals during Chukchi Sea marine mammal monitoring for oil and gas. Given how rare ribbon seals are in the U.S. Arctic, there is a paucity of data on the behavioral response of this species to oil and gas activities.

Generally, based on the available literature, behavioral effects of oil and gas activities have been considered negligible to the overall health and reproductive potential of the ringed seal population. However, while local presence/absence surveys are undertaken during oil and gas projects, species-specific information on overall abundance, density, and population trends are still needed. Similar conclusions have also been stated in BiOps, MMPA authorizations, and monitoring reports regarding bearded, spotted, and ribbon seals.

7.5.3.1. Behavioral Responses Due to Seismic Surveys, and Vibroseis

During an open-water seismic survey in the Chukchi Sea by Shell in 2007, Patterson, Blackwell et al. (2007) reported:

> *Sighting rates for bearded, spotted, and unidentified seals were greater during non-seismic than seismic periods, and, for most species, post-seismic sighting rates were also greater than those during seismic periods. No ringed seals were sighted during non-seismic periods for comparisons. Considering all species combined, the seal sighting rate for non-seismic periods (67.1 seals/1000 h of "daylight effort") was significantly greater than the seismic rate (~31.1 seals/1000 h of "daylight effort" χ^2 =13.22, df = 1, p <0.005.*

The 2016 Comprehensive Report of Marine Mammal Monitoring and Mitigation 2006–2015 reported that sighting rates in the Chukchi and Beaufort seas were nearly twice as high during non-seismic vessel activity as compared with sighting rates during seismic vessel activity (Ireland, Bisson et al. 2016)(Figure 7-27):

> *Lower sighting rates from source vessels during seismic periods compared to non-seismic periods and higher sighting rates from monitoring vessels than source vessels during seismic periods suggests that some seals may have avoided areas close to operating seismic sources. (Ireland, Bisson et al. 2016)*

Movement and reaction behaviors were also analyzed during the Chukchi and Beaufort seas seismic programs 2006–2013, as shown in Figures 7-27, 7-28, and 7-29.

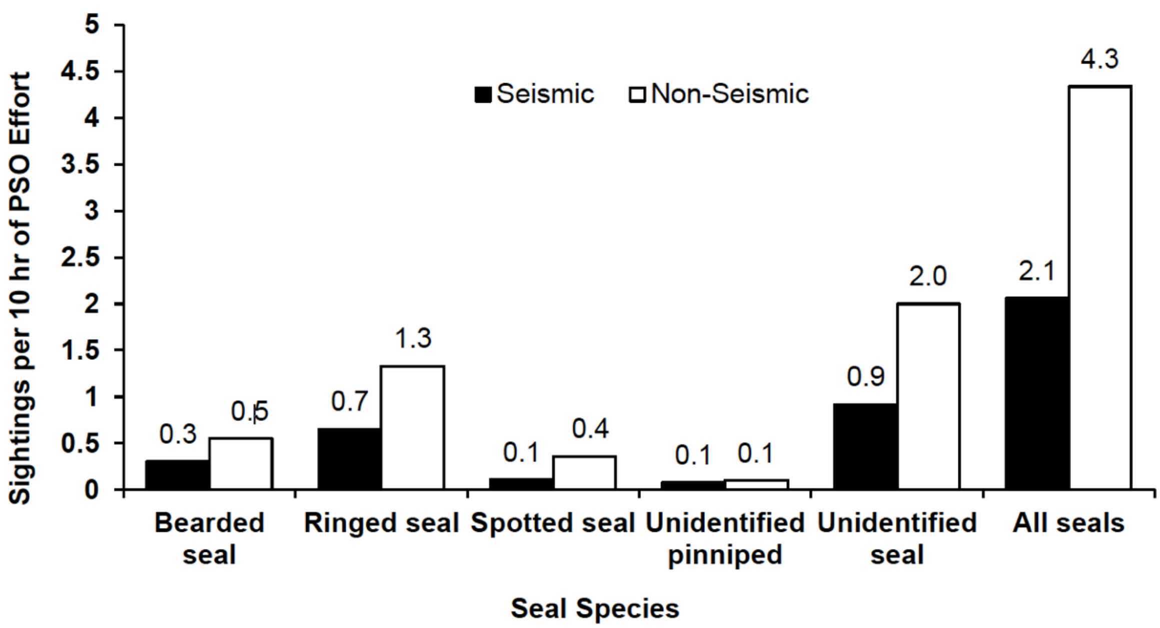

Figure 7-27. Sighting Rates by Seal Species in the Chukchi and Beaufort Seas

Note: Sightings are per 10 Hours of PSO Effort Based Observation during Seismic and Non-Seismic Periods
Source: Ireland, Bisson et al. (2016)

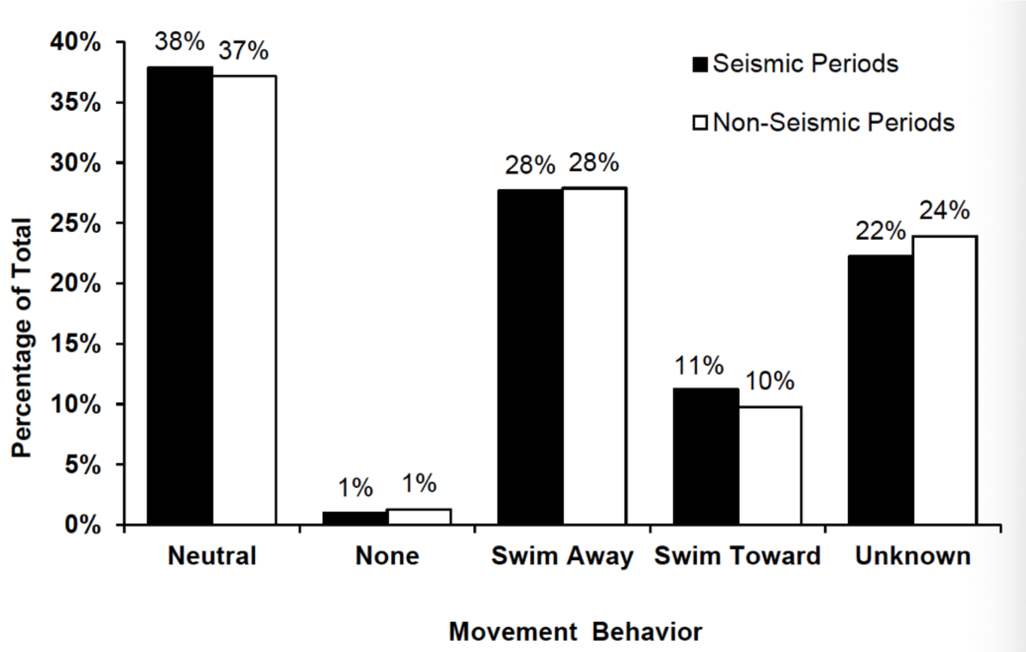

Figure 7-28. Seal Movement Behaviors during Seismic and Non-Seismic Periods in the Chukchi and Beaufort Seas

Note: Data recorded as a percentage of total sightings, 2006-2013
Source: Ireland, Bisson et al. (2016)

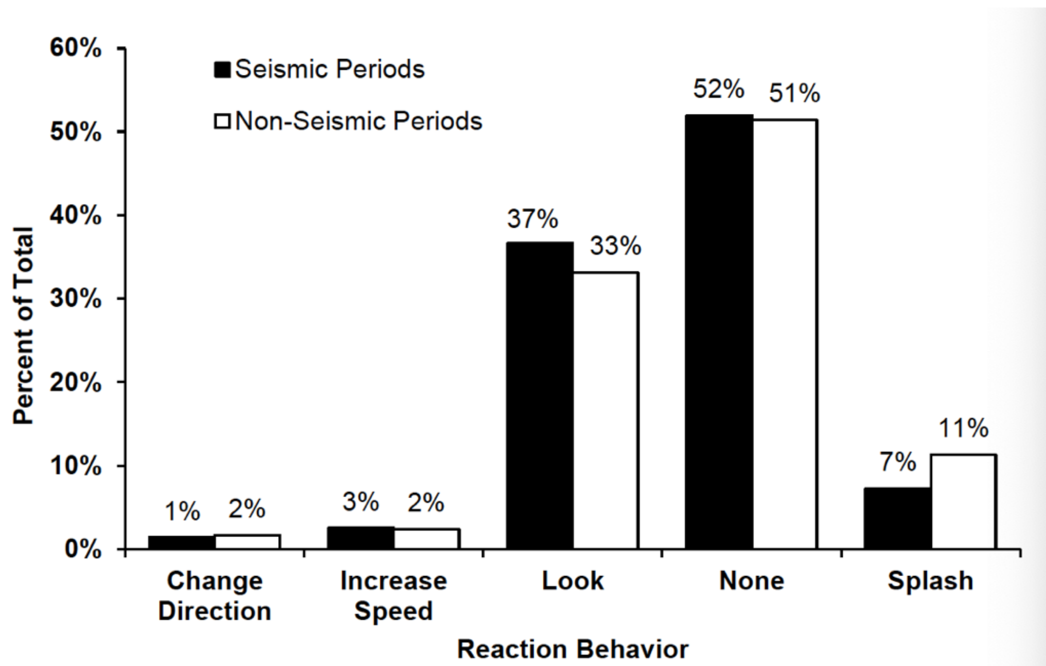

Figure 7-29. Seal Reaction Behaviors for the Chukchi and Beaufort Seas Observed during Seismic and Non-Seismic Periods

Note: Data are reported as percentages of the total sightings recorded for each vessel type, 2006-2013.
Source: Ireland, Bisson et al. (2016)

The 2003 IHA for ConocoPhillips' on-ice seismic activities in the Beaufort Sea (NMFS 2003) concluded that behavioral (disturbance) effects on ringed and bearded seals would be negligible because:

> *The sounds from energy produced by vibrators used during on-ice seismic programs typically are at frequencies well below those used by ringed seals to communicate (1000 Hz). Thus, ringed seal hearing is not likely to be very good at those frequencies and seismic sounds are not likely to have strong masking effects on ringed seal calls. This effect is further moderated by the quiet intervals between seismic energy transmissions. There has been no major displacement of seals away from on-ice seismic operations (Frost and Lowry, 1988).*

The 2003 IHA (NMFS 2003) also referenced a 1998 NEPA evaluation for on-ice seismic activities in the Beaufort Sea, NMFS concluded that any short-term, localized behavioral changes of a small number of seals would be negligible, as they would be biologically insignificant.

In a 2006 IHA for open-water seismic activities by GXT in the Beaufort Sea (NMFS 2006), NMFS concluded that an average of approximately 3,056 ringed seals may be exposed to underwater sounds that could reach the Level B harassment threshold of 160 dB re 1μPa. This estimate was based on estimated ringed seal density for the area and assumed that many seals would have their heads out of the water, thereby further reducing exposure to elevated noises. Based on the population size of ringed seals at that time (245,048 for the Beaufort/Chukchi sea population), the proportion of seals exposed was considered small (*i.e.*, less than 4% of the population).

In 2013, NMFS completed an incremental step consultation with BOEM and BSEE on the effects of the authorization of oil and gas leasing and exploration activities in the U.S. Beaufort and Chukchi seas over a 14-year period (2013 to 2027) concluding:

> *Although the seismic exploration activities BOEM/BSEE plan to authorize in the Chukchi and Beaufort Sea Planning Areas from March 2013 through March 2027 are likely to cause some individual bearded seals to experience changes in their behavioral states that might have adverse consequences (Frid and Dill 2002), these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual bearded seals in ways or to a degree that would reduce their fitness… (NMFS 2013).*

Similar consultations were completed for oil and gas activities in the Chukchi Sea in 2015 providing the same conclusions that oil and gas activities are not likely to adversely affect bearded seals. The 2006–2008 Chukchi Sea seismic surveys recorded seal movements relative to seismic and support vessels, indicating that at locations where received sound levels were greater than 160 dB re 1μPa (NMFS' Level B threshold for harassment), most seals (60%) exhibited "no reaction" to vessels during all 3 years of observations while "look" was the second highest documented reaction (Funk, Ireland et al. 2010). Similar results were documented during monitoring efforts in the Beaufort Sea during this same period 2006–2008. While most seals (60%) exposed to sound levels greater than 160 dB re 1μPa had no reaction, a significant difference was recorded between source vessels and monitoring vessels among seals that did react:

> *Seals exposed to sound levels ≥160 dB rms were recorded swimming away from active seismic vessels compared monitoring vessels ($G = 6.42$, $df = 1$, $p = 0.011$) (Funk, Ireland et al. 2010).*

Kelly, Quakenbush et al. (1986) evaluated several types of anthropogenic noise on ringed seal behavior in terms of whether seals abandoned subnivean lairs or breathing holes. Multiple variables likely play a factor in seal behavioral response when exposed to human-made noises including but not limited to the level of ambient sound at the time of exposure. Based on research conducted with trained dogs, ringed seals departed

29.2% of lairs or breathing holes (n=48) within 150 m of seismic lines more often than sites further away (10.8% of seal structures; n=37); a significant difference based on a goodness-of-fit test (G=5.530, df = 1, $0.01<p<0.025$). Abandonment rates did not differ significantly with distance from control lines (G = 0.071, df = 1).

From Kelly, Quakenbush et al. (1986):

> *Seals departed in 8 of 17 (47%) episodes of people walking at distances of 0.2 to 1.0 km from the Iairs. Skiers at the same ranges resulted in 4 departures in 26 (15%) episodes.*

Snowmachines at distances 0.5 to 2.8 km resulted in seals departing lairs while vibroseis and associated equipment at a distance of 644 m caused a seal to exit a lair. In all cases, seals that departed lairs, eventually returned and hauled out (Kelly, Quakenbush et al. 1986). These observations seem to indicate that behavioral disturbance due to sound exposure is likely short-term and minor.

In summary, ringed seals and bearded seals are the most commonly encountered species of any marine mammals during past exploration activities, and their reactions to seismic surveys have been recorded by PSOs onboard source vessels and monitoring vessels (NMFS 2016). Observation data indicate that seals tend to avoid on-coming vessels and active seismic arrays but their behavioral responses are often neutral; they do not tend to swim away or appear to react strongly even as ships pass fairly close with active arrays (NMFS 2016). They also do not appear to react strongly to icebreaking or on-ice vibroseis surveys, keeping their distance or moving away at some point to an alternate breathing hole or haulout (NMFS 2016).

7.5.3.2. Behavioral Responses during Exploratory Drilling

Harwood, Smith et al. (2007) evaluated the potential impacts of offshore exploratory drilling on ringed seals in the near shore Canadian Beaufort Sea February to June 2003–2 006. The first 3 years of the study (2003–2005) were conducted prior to industry activity in the area, while a 4th year of study (2006) was conducted during the latter part of a single exploratory drilling season. Seal breathing holes and lairs were not notably different in distance from industrial activities during the non-industry (2003 and 2004) and industry (2006) years. The movements, behavior, and home range size of 10 seals tagged in 2006 also did not vary statistically between the 19 days when industry was active (March 20 to April 8) and the following 19 days when industry operations were completed. The density of basking seals was not meaningfully different among the different study years and was comparable to densities found in this same area during surveys conducted in 1974–1979. Harwood concluded that no detectable effect on ringed seals could be discerned in the study area from drilling activities (Harwood, Smith et al. 2007).

During Shell's Chukchi Sea exploration drilling program in 2015, Ireland, Bisson et al. (2016) reported that during vessel-based monitoring:

> *The most frequently observed seal reaction to project vessels was to 'look' at the vessel, followed by 'dive' and 'swim'…The majority of seal movements relative to vessels was 'neutral' or 'unknown'.*

7.5.3.3. Behavioral Responses during Construction and Operation of Oil and Gas Facilities

In a 2001 monitoring report on ringed seals observed during Northstar island construction, Williams, Moulton et al. (2001) reported:

> *Seals in the moat were exposed to received sound levels up to 154 dB re 1 µPa (rms) when they dove close to the bottom. Despite this, no strong avoidance reactions were observed. Levels received by seals at or near the surface of the water were presumably weaker because of pressure release effects (Urick 1983; Greene and Richardson 1988). However,*

> *there was no indication that seals sighted in the moat were reluctant to dive, or that they were doing so for shorter periods than usual, as compared with observations of ringed seals from vessels either underway or stationary [researcher observations]. The juvenile seal observed on 21 June spent more than two minutes swimming (and submerging) in the moat edge nearest to the conductor driving site. Other seals observed in the moat dove and resurfaced at similar intervals during periods with and without pipe driving.*

Williams, Nations et al. (2006) reported that within a few meters of Northstar Island, ringed seal breathing holes and lairs were established in the landfast ice before and during development and construction activities. The 2006 Northstar study documented that of 181 ringed seal lairs, 118 (65%) were still actively used by late May. Many of these structures were maintained by seals for up to 163 days or nearly the entire winter pupping and nursing period, without abandonment, despite the presence of low-frequency industrial noise and vibration due to construction and use of ice roads. Research conducted in the mid- to late 1980s indicated that seals may become habituated to production or operational sounds once construction activities are complete. During construction of a man-made island 1985–1987, Frost and Lowry (1988, as cited in Moulton, Richardson et al. (2003), suggested that local seal populations were less dense within 2 nautical miles (nm) of man-made islands and offshore wells. Additional research in subsequent years (2000 and 2001) indicated seal densities at the same locations were higher than during the construction period, suggesting habituation of ringed seals to operational noises from oil and gas facilities.

A multivariate analysis (Poisson regression) of data from aerial surveys during spring around Northstar between 2000 and 2002 showed no evidence of a reduction in ringed seal densities around the facility (Richardson 2008). Noises or vibrations created during construction, drilling, or production did not appear to affect local ringed seal distribution and abundance relative to baseline years (1997–1999). Some of the highest ringed seal densities in 2000 and 2001 occurred within 1 km of Northstar activities (Richardson 2008). Similarly, research during winter (December) to assess use and densities of ringed seal structures in 1999–2000 did not demonstrate any notable effect due to Northstar construction. Fourteen of 25 (56%) structures (*i.e.*, breathing holes or lairs) were on sea ice less than 1 km of Northstar and all were actively used.

Based on an analysis published in Blackwell, Lawson et al. (2004), although drilling and production sounds from Northstar could have been audible to ringed seals out to about 1.5 km in water and 5 km in air, Moulton, Richardson et al. (2005) reported no indication that drilling activities affected ringed seal numbers or distribution. Richardson and Williams (2004) reported that underwater noise from drilling reached background values at 2 to 4 km concluding that the low-frequency industrial sounds emanating from the Northstar facility during the open-water season resulted in brief, minor localized effects on ringed seals with no known consequences to ice seal populations. Although robust information on ringed seal abundance, densities and population trends are currently unavailable.

7.5.3.4. Behavioral Responses Due to Aircraft and Helicopters

Available information on the reactions of ice seals to aircraft describes reactions of hauled out pinnipeds and not of pinnipeds in the water. Typical observed reactions of hauled out pinnipeds to aircraft include looking up at the aircraft, moving on the ice or land, entering a breathing hole or crack in the ice, or entering the water. Born *et al.* (1999, as cited in (Shell 2011) determined 49% of ringed seals left the ice and entered the water as a reaction to a helicopter flying at 150 m altitude. Seals entered the water when the helicopter was 1,250 m away if the seal was in front of the helicopter and 500 m away if the seal was to the side of the helicopter. The authors noted that more seals reacted to helicopters than to fixed-wing aircraft. The study concluded that the risk of scaring ringed seals by small-type helicopters could be substantially reduced if they do not approach closer than 1,500 m.

Blackwell, Lawson et al. (2004) observed 12 ringed seals during low-altitude overflights of a Bell 212 helicopter at BPXA's Northstar Island in June and July 2000 (nine observations took place concurrent with pipe-driving activities) (Blackwell, Lawson et al. 2004). One seal showed no reaction to the aircraft while the remaining 11 (92%) reacted, either by looking at the helicopter (n=10) or by departing from their basking site (n=1). Blackwell, Lawson et al. (2004) concluded that none of the reactions to helicopters were strong or long lasting and that seals near Northstar in June and July 2000 probably had habituated to industrial sounds and visible activities that had occurred often during the preceding winter and spring.

Helicopters at or below an altitude of 305 m caused radio-tagged ringed seals to depart lairs by diving into the water 50% more than helicopters with higher altitudes. Spotted seals hauled out on land in summer are unusually sensitive to aircraft overflights compared to other species. They have been observed to rush into the water when an aircraft flies by at altitudes up to 300 to 750 m, and occasionally react to aircraft flying as high as 1,370 m at lateral distances as far as 2 km or more (Rugh, Shelden et al. 1997).

7.5.3.5. Summary of Ice Seal Behavioral Resonses to Oil and Gas Activities

In at least 20 ESA Section 7 consultation processes that have considered impacts to ice seals, NMFS has specified terms and conditions to further minimize the effect of any potential incidental take of seals identified in an associated BiOp or LOC. Conditions have included implementation of shutdowns during certain construction activities and monitoring of construction areas to detect the presence of seals before beginning construction activities. For example, NMFS (2018) concluded:

> *The implementation of mitigation measures…is expected to further reduce the significance of ringed and bearded seals reaction to transiting vessels. Therefore, the impact of vessel acoustic and visual harassment is very minor, and thus adverse effects to ringed and bearded seals will be immeasurably small.*

7.5.4. Effects Due to Changes in Habitat (All Ice Seals)

Ringed, bearded, spotted, and ribbon seals depend on sea ice for at least part of their life history. As stated in previous sections, most data on seal habitat as related to oil and gas activities were focused on ringed seals. However, as summarized in this section, a primary concern for ice seal habitat (all species) is changing sea ice conditions.

Therefore, while this section presents available data primarily for ringed seals, the evidence may also apply across all ice seal species. Habitat-related variables including location relative to the fast ice edge, water depth, and ice deformation have been shown to result in substantial and consistent effects on the distribution and abundance of seals (Frost, Lowry et al. 2002). Environmental factors such as date, water depth, degree of ice deformation, presence of meltwater, and percent cloud cover had the most significant effects on seal sighting rates compared to any anthropogenic impact of industrial activities on ringed seals (Moulton, Richardson et al. 2003, Moulton, Richardson et al. 2005).

From Moulton *et al.* (2002, as cited in Moulton, Richardson et al. (2005):

> *In 2001, observed seal density varied significantly with distance from Northstar ($\chi2$ = 53.22, df = 10, P < 0.001), and tended to be higher close to the operations. In fact, significantly more ringed seals occurred close to Northstar than in otherwise comparable conditions farther away (F = 10.03, P = 0.002). 'Natural' factors such as ice deformation accounted for most variation in seal densities.*

Minor changes in ringed seal habitat due to Northstar activities were documented in Richardson (2008) reporting that during the peak of construction in early 2000, the physically altered ice may have covered about 10 km^2, whereas during the first winter of drilling it was much smaller at about 3 km^2, just a small fraction of the sea ice habitat available in the Beaufort Sea for ringed seals. Such small-scale effects to habitat due to oil and gas activities were negligible compared to the natural factors which accounted for statistically significant variability in ringed seal abundance, distribution, and structure use. As described in the 2020 final rule for oil and gas sea ice roads, trails, and pads, ringed seal habitat is not expected to be impacted by construction, operation or maintenance activities given they are temporary in nature and involve only a small portion of ringed seal habitat available in the nearshore area (NMFS 2020).

The effects of potential oil exposure are summarized in Kelly, Quakenbush et al. (1986) stating:

> *Effects of contact with, and ingestion of, crude oil included temporary soiling of the pelage, eye irritation, kidney lesions, and possible liver damage (Geraci and Smith 1975; Smith and Geraci 1975). Six ringed seals immersed for 24 hours in crude oil shortly after capture survived, but three held in captivity for a longer period died within 71 minutes of immersion, apparently as the combined result of stress and exposure to the oil (Smith and Geraci 1975).*

Sea ice is used by bearded, spotted, and ribbon seals for life functions such as breeding and molting (NMFS 2016). Changes in climate are likely a major factor for long-term habitat availability and quality for ice seals (Kelly, Bengtson et al. 2010, Muto, Helker et al. 2021). The NMFS (2018) BiOp for Liberty Development in the Beaufort Sea states:

> *The main concern about the conservation status of ringed and bearded seals stems from the likelihood that their sea ice habitat has been modified by the warming climate and, more so, that the scientific consensus projects accelerated warming in the foreseeable future. A second concern, related by the common driver of carbon dioxide emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem.*

Upon review of scientific literature and MMPA monitoring reports (see Appendix C), no long-term effects to ringed seal habitat have been attributed to oil and gas activities in the U.S. Arctic.

7.6. Pacific Walruses (*Odobenus rosmarus divergens*)

7.6.1. Current Status and Relevant Baseline Information

Pacific walruses occur throughout the continental shelves of the Bering and Chukchi seas, and occasionally in the East Siberian and Beaufort seas (USFWS 2014). Pacific walruses are distributed widely across the Chukchi Sea but are uncommon in the deeper OCS waters of the Beaufort Sea. Figure 7-30 shows the seasonal distribution, breeding areas, and coastal haulouts of Pacific walruses in the Bering and Chukchi seas.

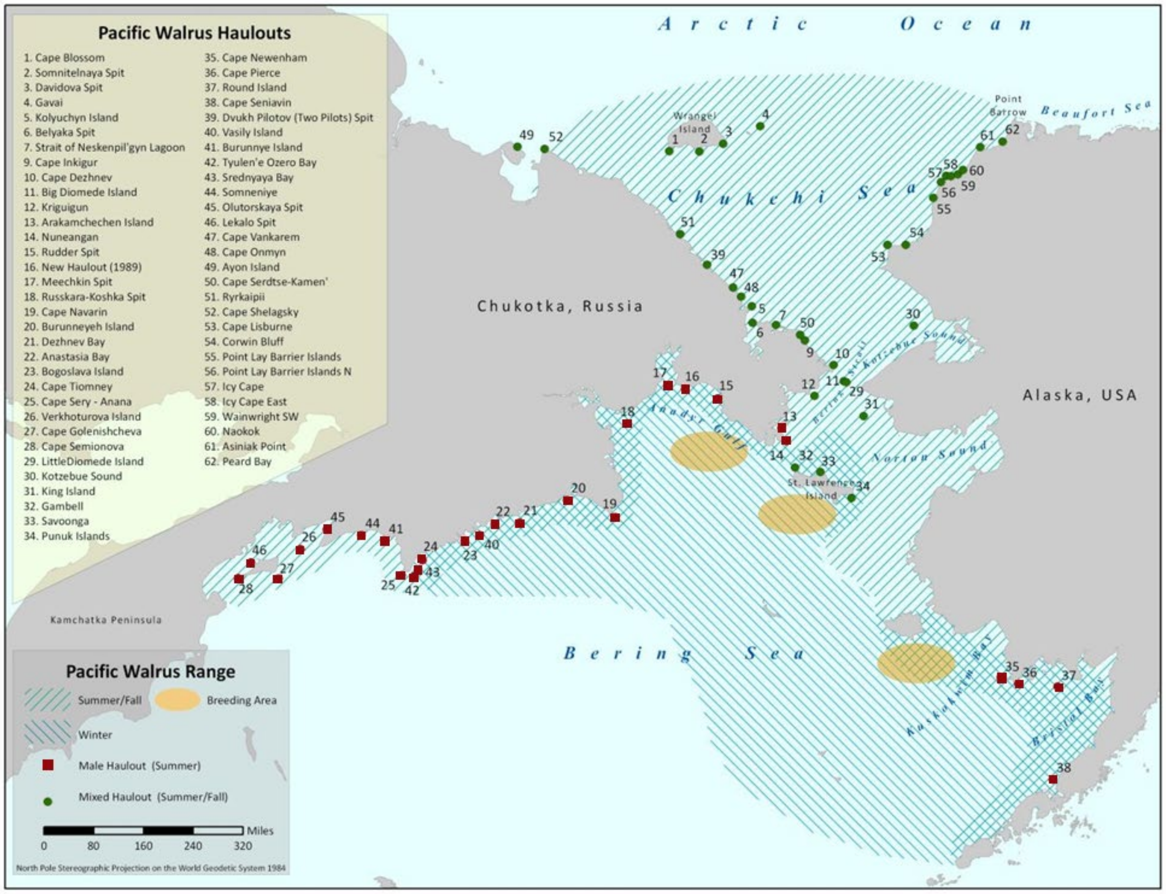

Figure 7-30. Range of Pacific Walruses

Source: USFWS (2014)

Between 1975 and 1990, aerial surveys were carried out by the U.S. and Russia at 5-year intervals, producing mean population estimates ranging from 201,039 to 234,020 animals (USFWS 2014). Efforts to survey the walrus population were suspended until 2006 due to unresolved problems with survey methods that produced population estimates with unacceptably large CIs (Gilbert 1999; Gilbert *et al.* 1992, as cited in (USFWS 2014). Aerial surveys conducted in 2006 estimated 129,000 individuals (95% CI: 55,000–507,000) within the survey area (Speckman *et al.* 2011, as cited in (USFWS 2014). However, this estimate is considered to be biased low because due to poor weather, not all areas important to walruses were surveyed (USFWS 2014). Therefore, the size of the Pacific walrus population has never been known with certainty (MacCracken, Beatty et al. 2017, USFWS 2021). The maximum net productivity rate for this stock has been estimated by USFWS at 8% per year. The PBR for walruses in U.S. waters is 2,580 animals (USFWS 2014).

Over the past decade, the number of walruses hauling out on land along the Alaska and Chukotka coastlines of the Chukchi Sea has increased from hundreds to >100,000 (Kavry *et al.* 2008; Garlich-Miller *et al.* 2011a, Jay *et al.* 2011, as cited in (BLM 2020). This change in distribution within the Chukchi Sea is coincident with the accelerating loss of summer sea ice over the continental shelf (NSIDC 2012, as cited in (BLM 2020).

The USFWS found in 2011 that Pacific walruses warranted protection under the ESA due to climate change and resultant melting of the sea ice it needs to survive. However, in 2017, the USFWS determined that the listing of Pacific walruses as endangered or threatened under the ESA was not warranted (USFWS 2017c; 82 FR 46618). In June of 2021, the U.S. 9th Circuit Court of Appeals ordered the USFWS to reconsider its decision not to list Pacific walruses under the ESA. The species is not designated as depleted under the MMPA (USFWS 2014).

A list of emerging conservation issues for this stock was reported by USFWS (2014) and included: 1) Chukchi sea coast haulout use pattern; 2) ocean acidification impacts on prey; 3) subsistence harvest levels; 4) oil and gas activities (with special concern for the impact of a very large oil spill and impacts on foraging efficiency in the Hanna Shoals region of the Chukchi Sea); 5) international commercial shipping; and 6) disease.

7.6.2. Mortality and Serious Injury

No Pacific walruses have been seriously injured or killed by oil and gas activities in the U.S. Arctic. From 2009 through 2020, industry reported no direct interactions with walruses at all (USFWS 2021).

7.6.3. Behavioral Response Due to Disturbance

Oil and gas activities have occurred sporadically throughout the range of Pacific walruses (MacCracken, Beatty et al. 2017). Exposure has been greatest in the Chukchi Sea during the summer/fall, as there is little overlap between Pacific walruses and oil and gas activities in the Beaufort Sea, where most exploration and production occurs.

7.6.3.1. Behavioral Responses during Seismic Surveys and Exploration

Walruses are frequently observed from oil exploration ships in the Chukchi Sea, but they are rarely observed in the Beaufort Sea. For example, in the Beaufort Sea open-water season from 2006 through 2008, PSOs recorded only six sightings of walruses with a total of 10 individual walruses (Savarese *et al.* 2010, as cited in Funk, Ireland et al. (2010). Five of these sightings occurred in 2007. In total, industry monitoring data have reported only 38 walruses observed between 1995 and 2015 in the Beaufort Sea (USFWS 2021).

Seismic surveys often include PSOs on monitoring ships that are deployed at various distances from the seismic source ships, sometimes more than 75 km away. Sightings from monitoring ships when they are far from the source vessel, or when the seismic arrays are not active (non-seismic conditions, <120 dB re 1μPa), provide a measure of walrus reactions to typical vessel traffic rather than the seismic source. When monitoring ships are traveling under non-seismic conditions, the average closest point of approach to walruses was 265 m (Haley, Ireland et al. 2010). Seismic source vessels traveling under non-seismic conditions appear to disturb walruses at greater distances, perhaps in part because of their larger physical presence, with the average closest point of approach to a walrus being 822 m (Haley, Ireland et al. 2010).

Fifty walruses were observed during 467 hours of marine mammal monitoring associated with ConocoPhillips' 2008 Shallow Hazards Survey in the Chukchi Sea (Brueggeman 2009). Walruses were only observed from mid-September to mid-October with the highest encounter rates during the latter half of September. Only one walrus was observed between 6 and 30 m of the seismic vessel, which was within the 160 dB re 1μPa behavioral disturbance radii (Brueggeman 2009). The behavior of the one walrus observed within the behavioral disturbance zone was designated as "looking", while those observed during no-seismic activity were primarily "swimming".

During monitoring for Shell's 2012 exploration drilling program, Bisson, Reider et al. (2013) estimated that 403 walruses were exposed to continuous sound levels over 120 dB re 1uPa. In 1989 and 1990, aerial surveys and vessel-based observations of Pacific walruses on the surface were conducted to examine response to drilling operations at three Chukchi Sea prospects; several thousand Pacific walruses were documented in the vicinity of the drilling operations (MacCracken, Beatty et al. 2017). The monitoring reports concluded that:

> *(1) Pacific walrus distributions were closely linked with pack ice; (2) pack ice was only near active drilling operations for short time periods; and (3) ice passing near active operations contained few animals. The effects of the drilling operations on Pacific walruses were limited in time, area, and proportion of the population (78 FR 35364).*

In 2015, Shell drilled two wells in the Chukchi Sea in the Burger Prospect. PSOs on support vessels or drill rigs associated with those activities recorded 500 groups comprised of a total of 1,397 Pacific walruses. In 2006–2012, 52 percent of walrus sightings were of small groups in the water, with most behavioral responses of walruses to vessels associated with seismic surveys in the Chukchi Sea offshore continental shelf. Based on the transitory nature of the survey vessels, and the behavioral reactions of the animals to the passage of the vessels, interactions likely resulted in temporary changes in animal behavior with no lasting impacts to the subspecies (Ireland *et al.* 2009 and USFWS 2013a, as cited in (MacCracken, Beatty et al. 2017).

Ireland, Bisson et al. (2016) summarized movement behavior during the 2012 and 2015 drilling seasons in the Chukchi Sea. The most common observation by walruses was "no response" to vessel activities regardless of sound levels recorded. While reactions did include splash, change in direction, or increase in swimming speed, there did not appear to be a considerable difference based on the received sound levels either >120 dB re 1 μPa rms SPL or <120 dB re 1 μPa rms SPL, as shown in Figure 7-31. The weight of evidence from aerial and vessel-based monitoring of Pacific walruses during the 2012 and 2015 exploration programs by Shell in the Chukchi Sea suggest only very localized effects, if any, on the distribution of walruses. Most observed behavioral reactions were characterized as minor because there was no meaningful difference between periods of industrial activity and no activity (Ireland, Bisson et al. 2016).

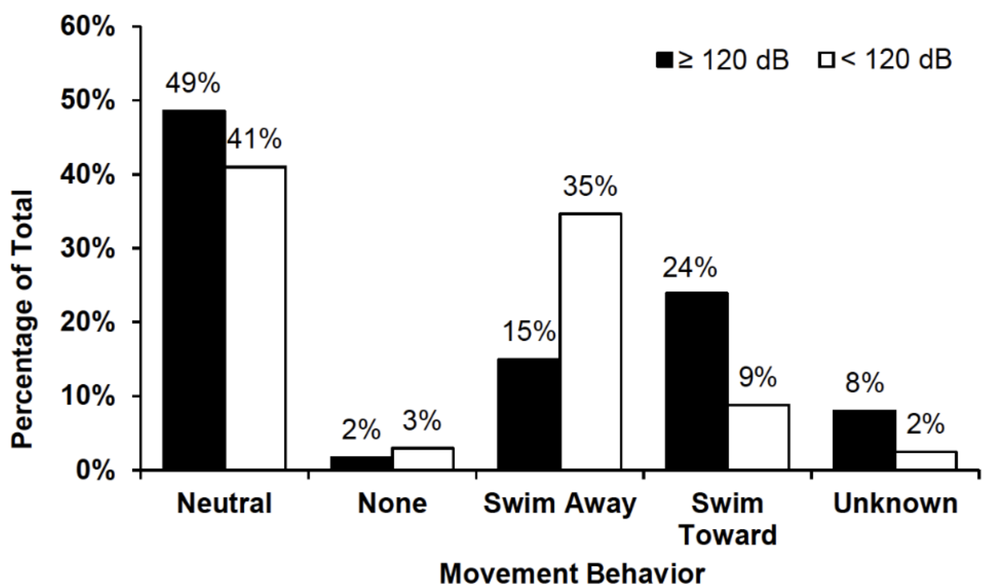

Figure 7-31. Percent of Total Walrus In-Water Sightings Relative to the Vessel Inside or Outside Areas of Received Sounds Levels > 120 dB re 1 μPa rms SPL in 2012 and 2015

Source: Ireland, Bisson et al. (2016)

In summary, monitoring of the effects of seismic surveys and exploratory drilling activities in the Chukchi Sea has documented minimal effects on Pacific walruses; animals have exhibited no response or temporary behavioral changes (MacCracken, Beatty et al. 2017). The authors conclude that oil and gas exploration likely had minor impacts on individual Pacific walruses, and does not appear to have had a negative impact on the Pacific walrus population (MacCracken, Beatty et al. 2017). That said, Pacific walrus abundance and population trends are currently unknown.

7.6.3.2. Behavioral Responses Due to Vessels and Aircraft

Disturbances caused by vessel and air traffic may cause Pacific walrus groups to flee ice or land haulouts, increasing the risk of stampedes. However, Pacific walruses in the water or on ice appear to be tolerant of ship traffic associated with oil and gas activities, based on short-term observations from vessels (MacCracken, Beatty et al. 2017). Brueggeman *et al.* (1991, as cited in MacCracken, Beatty et al. (2017) reported that 75% of Pacific walruses within 1 km of vessels in the Chukchi Sea exhibited no reaction. Fay *et al.* (1984a, as cited in MacCracken, Beatty et al. (2017), also reported observations that Pacific walruses in water generally show little concern about potential disturbance from approaching vessels but will dive or swim away if a vessel is nearing them.

Icebreaking vessels, whether used for in-ice seismic surveys or for ice management near exploratory drilling ships, introduce an additional type of disturbance to walruses compared to non-icebreaking vessels. These activities would take place in late fall to early winter, a time period when walruses are often closely associated with the pack ice edge or are hauled out on coastal shores. Past monitoring efforts indicated that most groups of hauled out walruses showed little reaction to icebreaking activities beyond 805 m, although some walrus groups may be disturbed up to several kilometers away (Brueggeman *et al.* 1990, as cited in (BOEM 2018). Given the dispersed distribution of walruses on the ice, it is unlikely that many walruses have been affected by oil and gas vessels and aircraft in the Chukchi Sea.

Richardson, Greene Jr. et al. (1995) reviewed responses of walruses to aircraft and indicated that individual responses to aircraft can range from orientation (*i.e.*, looking at the aircraft) to leaving a haulout. In general, small herds on haulout sites (terrestrial and pack ice) seem more easily disturbed than large groups, and adult females with calves are more likely to enter the water during an aircraft disturbance. Stronger reactions occur when the aircraft is flying low, passes overhead, or causes abrupt changes in sound.

As reported by USFWS (2014) and based on recent observations, a high number (*i.e.*, thousands) of Pacific walruses haulout on land in the northeastern Chukchi Sea. Concerns have been raised that this aggregation of walruses could be easily disturbed by anthropogenic activity, such as aerial or vessel traffic. Such disturbance can result in stampedes of large numbers of walruses from the land into the water. During this process, smaller animals are vulnerable to crushing. Therefore, the USFWS, along with state and local authorities, have increased efforts to avoid or minimize human activities in these areas during the time of year when walruses are present.

7.6.4. Effects Due to Changes in Habitat

Walruses feed primarily on benthic invertebrates including bivalves, snails, worms, and crustaceans (MacCracken, Beatty et al. 2017). Certain oil and gas industry activities, such as construction of offshore facilitates, dredging, and screeding or if oil was illegally discharged into the environment, have impacted benthic habitats (USFWS 2021). Drilling of exploration wells generally includes release of cuttings onto the seafloor. Benthic prey items, such as bivalves and other invertebrates, would be buried during this process. Therefore, disturbance from oil and gas industry activity and effects from oil exposure may alter the availability and distribution of benthic invertebrate species (USFWS 2021). The low density of walruses in the Beaufort Sea where offshore oil development has occurred, and the ability of benthic habitats to recover from disturbance due to oil industry dredging or screeding activities, or discharge of drilling fluids during exploration activities, indicate that limited effects on walruses are likely due to direct impacts on their prey species (USFWS 2021). Oil spills large enough to affect walrus prey populations have not occurred to date and the chance that a spill from existing oil and gas facilities in the Beaufort Sea would affect walrus habitat in the Chukchi Sea is low.

7.7. Other Pinnipeds

Steller sea lions and harbor seals are distributed in portions of Cook Inlet where oil and gas activities occur. Steller sea lions may also be encountered near haulouts on the lower portion of the Marine Transit Route. California sea lions have been observed in Cook Inlet, but they are considered rare there. None of these species are found in the Chukchi or Beaufort seas.

7.7.1. Current Status and Relevant Baseline Information

7.7.1.1. Steller Sea Lion (*Eumetopias jubatus*)

Steller sea lions from the Western U.S. stock are found in the Bering Sea, and along the Aleutian Islands to Lower Cook Inlet (Muto, Helker et al. 2020) (Figure 7-32). The Western stock of Steller sea lions decreased from 220,000 to 265,000 animals in the late 1970s to less than 50,000 in 2000 (Loughlin *et al.* 1984, Loughlin and York 2000, Burkanov and Loughlin 2005, as cited in (Muto, Helker et al. 2020). Since 2003, the abundance of the Western stock has increased, but there has been considerable regional variation (Sease and Gudmundson 2002; Burkanov and Loughlin 2005; Fritz *et al.* 2013, 2016; all cited in (Muto, Helker et al. 2020). Recent comprehensive aerial photographic and land-based surveys of Western Steller sea lions in Alaska were conducted in 2018 (Aleutian Islands west of Shumagin Islands) and 2019 (Southeast Alaska and Gulf of Alaska east of Shumagin Islands) (Sweeney *et al.* 2018; 2019, as cited in (Muto, Helker et al. 2020). The Western Steller sea lion pup production in Alaska in 2019 was estimated to be 12,581 using these data. The PBR for the U.S. portion of the Western stock is 318 sea lions.

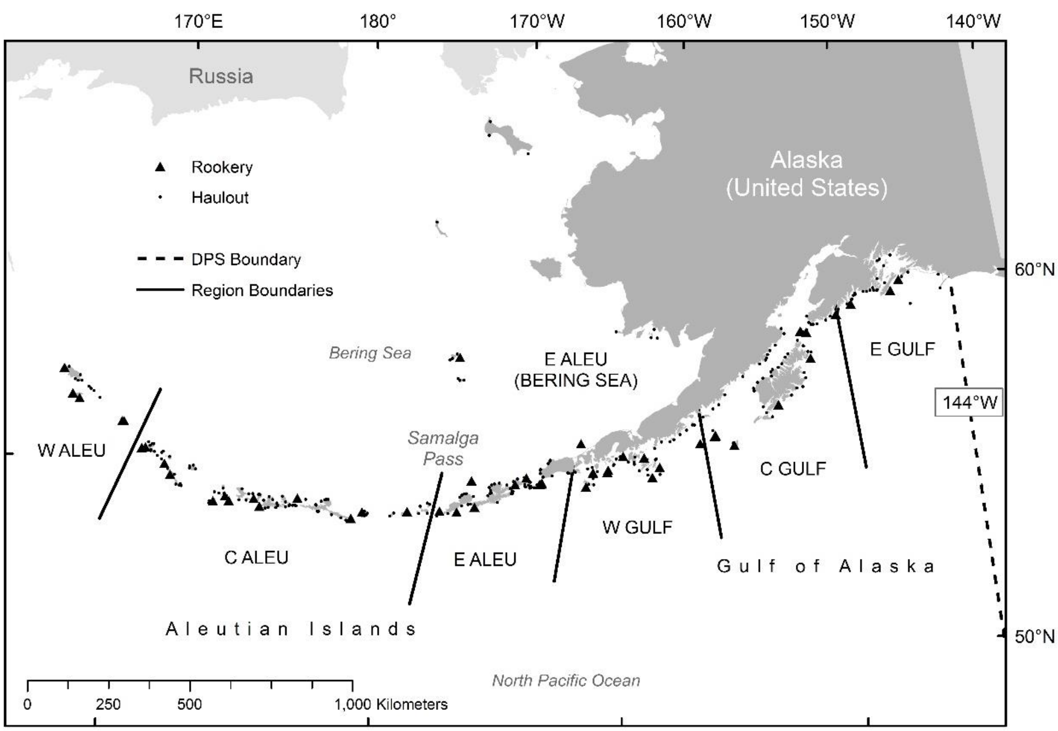

Figure 7-32. Steller Sea Lion Distribution in the Bering Sea and Gulf of Alaska

Source: Muto, Helker et al. (2020)

No Steller sea lion observations were recorded during Apache's 2012 3D seismic program (SAExploration 2012). During the 2018 CIPL project, one group of two Steller sea lions was observed (Sitkiewicz, Hetrick et al. 2018), and during the LCI seismic survey, five Steller sea lions were observed from project vessels and seven during aerial monitoring; all sightings were of solitary animals, one of which was a subadult female (Fairweather Science 2020). In recent monitoring for port construction, Steller sea lions were observed near the Port of Alaska in May and June of 2020; four groups of four individuals were observed in May, and two groups of two individuals were observed in June (61 North Environmental 2020, 61 North Environmental 2020).

Despite the vessel traffic in and around rookery and haulout locations near Dutch Harbor, there have been no reported incidents of ship strike of Steller sea lions in Alaska. In addition, the Steller sea lion population in and around Dutch Harbor has been increasing at about 3% per year, indicating that vessel traffic has not prohibited population growth (Fritz 2012).

The Steller sea lion was listed as threatened under the ESA in 1990 (55 FR 49204). In 1997, NMFS reclassified the Steller sea lion into two DPS (62 FR 24345) and designated the Western Steller sea lion DPS (the segment west of a line near Cape Suckling, Alaska) as endangered (62 FR 24345). Critical habitat is discussed in Section 7.7.3.

7.7.1.2. California Sea Lion (*Zalophus californianus*)

Cook Inlet is considered out of the range of California Sea lions (Carretta, Forney et al. 2020). The species is not discussed in the EIS for Lease Sale 244 in the Cook Inlet planning area (BOEM 2016). The Final Rule for Taking Marine Mammals Incidental to Oil and Gas Activities in Cook Inlet, Alaska (NMFS 2019) states that sightings are very rare in Cook Inlet and that they are not typically observed north of Southeast Alaska waters. However, one sighting of 2 California sea lions was recorded during Apache's 3D seismic study (SAExploration 2012). No California sea lions were observed during monitoring for the LCI seismic survey in 2019 (Fairweather Science 2020) or the CIPL project in 2018 (Sitkiewicz, Hetrick et al. 2018).

7.7.1.3. Harbor Seals (*Phoca vitulina richardii*)

There are 12 stocks of harbor seals identified in Alaskan waters. The Cook Inlet/Shelikof Strait (CI/SS) stock ranges from the southwest tip of Unimak Island east along the southern coast of the Alaska Peninsula to Elizabeth Island off the southwest tip of the Kenai Peninsula, including Cook Inlet, Knik Arm, and Turnagain Arm (Figure 7-33).

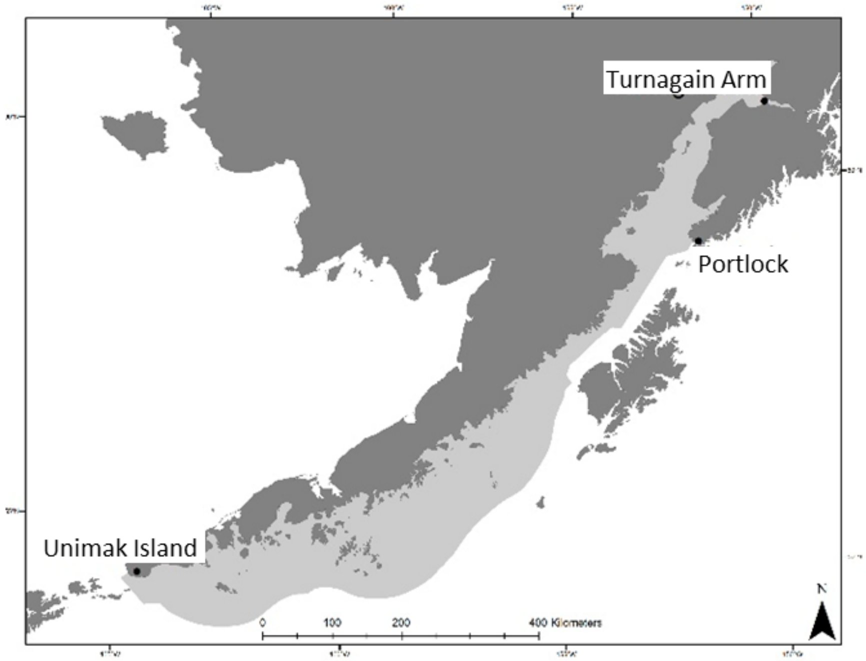

Figure 7-33. Range of Harbor Seals in Cook Inlet/Shelikof Strait Stock

Source: Muto, Helker et al. (2020)

Based on results of a 2018 survey, the abundance of the CI/SS stock is 28,411 animals, with an 8-year trend estimate of -111 animals (Muto, Helker et al. 2020). PBR for the stock is 807 animals.

Results of the 2012 monitoring during Apache's 3D seismic program in Cook Inlet reported that harbor seals were the most frequently observed species with 2,657 individuals observed during 177 separate sightings (SAExploration 2012). During marine mammal monitoring for the CIPL project in Upper Cook Inlet over the period May to September 2018, harbor seals were the most frequently observed species with 313 sightings (approximately 316 individuals). In recent monitoring for port construction, harbor seals were observed near the Port of Alaska from May to September of 2020; the highest number of individuals was observed in June (145) (61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020, 61 North Environmental 2020). They were not observed during October and November (61 North Environmental 2020, 61 North Environmental 2020). During the LCI seismic survey, 10 harbor seals were observed from vessels associated with the project (Fairweather Science 2020). Figure 7-15 in Section 7.2.1.5 shows the location of these observations.

7.7.2. Mortality and Serious Injury

There have been no recorded incidences of mortality or serious injury to harbor seals or Steller sea lions directly attributable to oil and gas industry activities in Cook Inlet. One unidentified marine mammal carcass was observed and reported during monitoring for the CIPL project; the marine mammal's death was not due to CIPL project activities (Sitkiewicz, Hetrick et al. 2018). During the LCI seismic survey, a harbor seal carcass in an advanced stage of decomposition was observed from a support vessel; the mortality was not attributable to the seismic survey due to the decomposed state of the carcass (Fairweather Science 2020).

In addition, despite all of the vessel traffic (oil and gas related and commercial fishing) in and around rookery and haulout locations near Dutch Harbor, there have been no reported incidents of ship strike of Steller sea lions in Alaska (NMFS 2015). The Steller sea lion population in and around Dutch Harbor has been increasing at about 3% per year, indicating that vessel traffic has not prohibited population growth (Fritz 2012, as cited in (NMFS 2015).

7.7.3. Behavioral Response Due to Disturbance

Table 7-4 summarizes the behavior of all pinniped sightings from vessels during the LCI seismic survey. In addition, the monitoring report notes the following reactions for harbor seals (Fairweather Science 2020):

> *Thirty-three percent of live harbor seal sightings occurred during periods of no seismic activity, while 67% of live sightings occurred during periods of seismic activity, including full array. PSOs on board the mitigation vessel observed one reaction ("look") from a harbor seal while the mitigation vessel was anchored; it is likely that the animal was reacting to vessel presence. The average sighting distance for harbor seals during periods of non-seismic activity was ~1050 m, and ~1,200 m during seismic operations.*

And for Steller sea lions (Fairweather Science 2020):

> *Sixty percent of Steller sea lion sightings occurred during periods of no seismic activity, while 40% of sightings were observed during seismic activity including full array. Two of the Steller sea lions showed detectable reactions, but these occurred during periods of no work; both animals exhibited a "look" reaction that appeared to be in response to vessel presence. The average sighting distance for Steller sea lions during periods of non-seismic activity was ~311 m, and ~1,928 m during seismic operations.*

Table 7-4. Pinniped Behaviors Documented from Vessel-Based Surveys during 2019 Lower Cook Inlet Seismic Activities

Pinniped Initial Behavior	Percent of Sightings	Number of Sightings
Travel	50.0	8
Swim	18.8	3
Look	18.8	3
Rest	12.5	2
TOTAL	100	16

Source: Fairweather Science (2020)

Over the duration of the CIPL project, a total of 17 harbor seals were observed within the 2.2-km shutdown zone surrounding ongoing vessel activities, resulting in Level B exposures (Sitkiewicz, Hetrick et al. 2018). No California or Steller sea lions were affected by project activities. During the LCI seismic survey, Level B exposures to 3 harbor seals and 4.9 Steller sea lions were estimated, and one shutdown was enacted due to presence of a Steller sea lion in the shutdown zone (Fairweather Science 2020). Effects due to changes in habitat for other pinnipeds would be similar to those discussed in Section 7.3.1.5, namely contamination from oil spills and leaks and effects on prey species. Timing restrictions on exploration drilling in beluga whale critical habitat (NMFS 2017) may also have reduced impacts on harbor seals and Steller sea lions.

7.7.4. Effects Due to Changes in Habitat

Critical Habitat for Steller sea lions was designated in 1993 (58 FR 45269). As seen in Figure 7-34, designated critical habitat for Steller sea lions is located at the mouth and lower edge of Cook Inlet. Oil and gas operations, including seismic surveys, have taken place outside of these areas and have not impacted Steller sea lion critical habitat. Fish are the primary prey species for marine mammals in Cook Inlet. Only a small fraction of the potentially available fish habitat in Cook Inlet has been impacted by oil and gas activities. There is no direct evidence that oil and gas activities in Cook Inlet have affected Steller sea lion or harbor seal prey species.

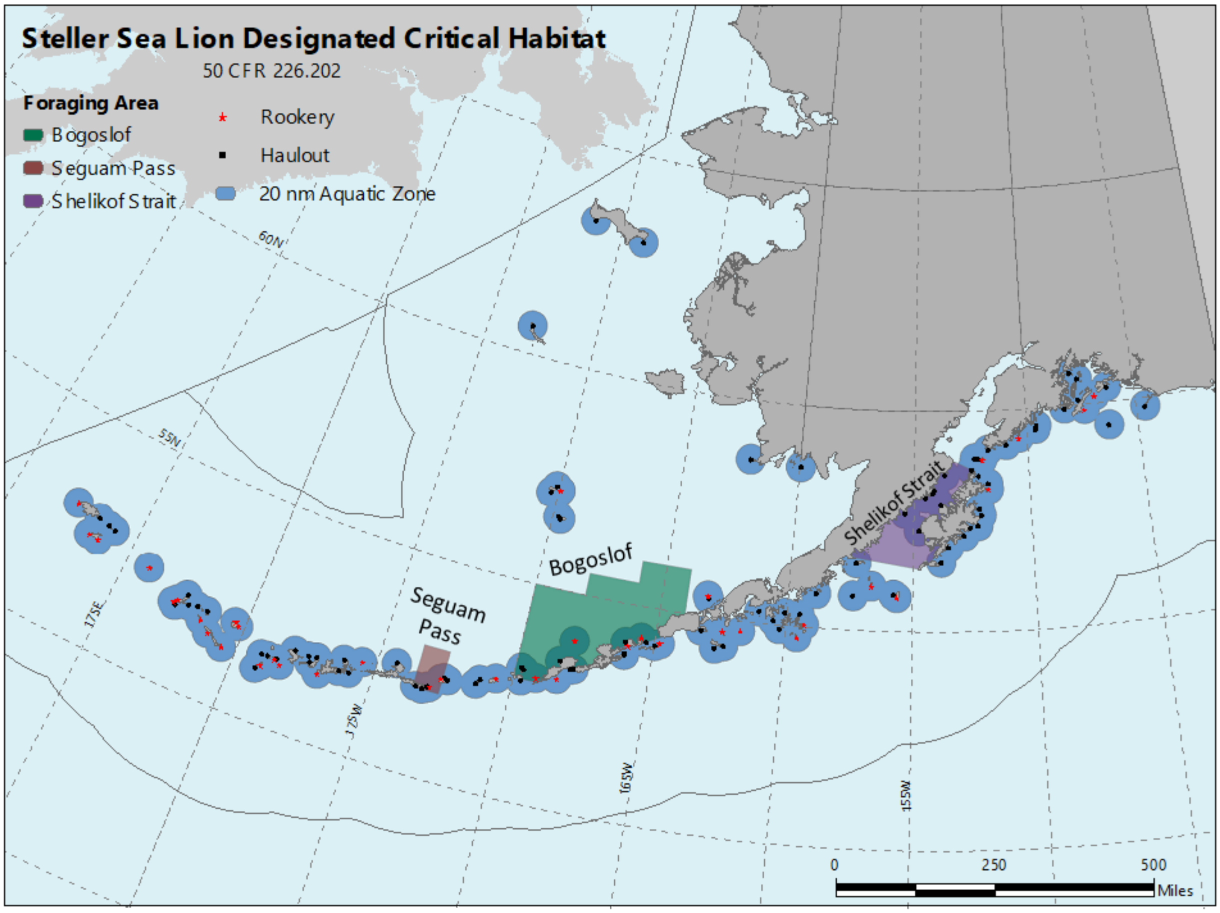

Figure 7-34. Steller Sea Lion Designated Critical Habitat

Source: https://media.fisheries.noaa.gov/dam-migration/steller-sea-lion-critical-habitat-alaska.pdf; (Accessed August 11, 2021)

7.8. Polar Bears (*Ursus maritimus*)

7.8.1. Current Status and Relevant Baseline Information

Two stocks of polar bears occur within the U.S. Arctic: the Chukchi/Bering seas stock (CBS) and Southern Beaufort Sea (SBS) stock (USFWS 2016). The stocks overlap in the eastern Chukchi Sea/western Beaufort region (Amstrup *et al.* 2004, Amstrup *et al.* 2005, as cited in (USFWS 2016). The SBS population is the predominant denning population in Alaska due to the proximity of the Beaufort Sea ice edge to terrestrial habitat during fall when pregnant females come ashore. Both stocks range beyond the U.S.; the CBS population ranges into Russia, and the SBS population ranges into Canada (Figure 7-35).

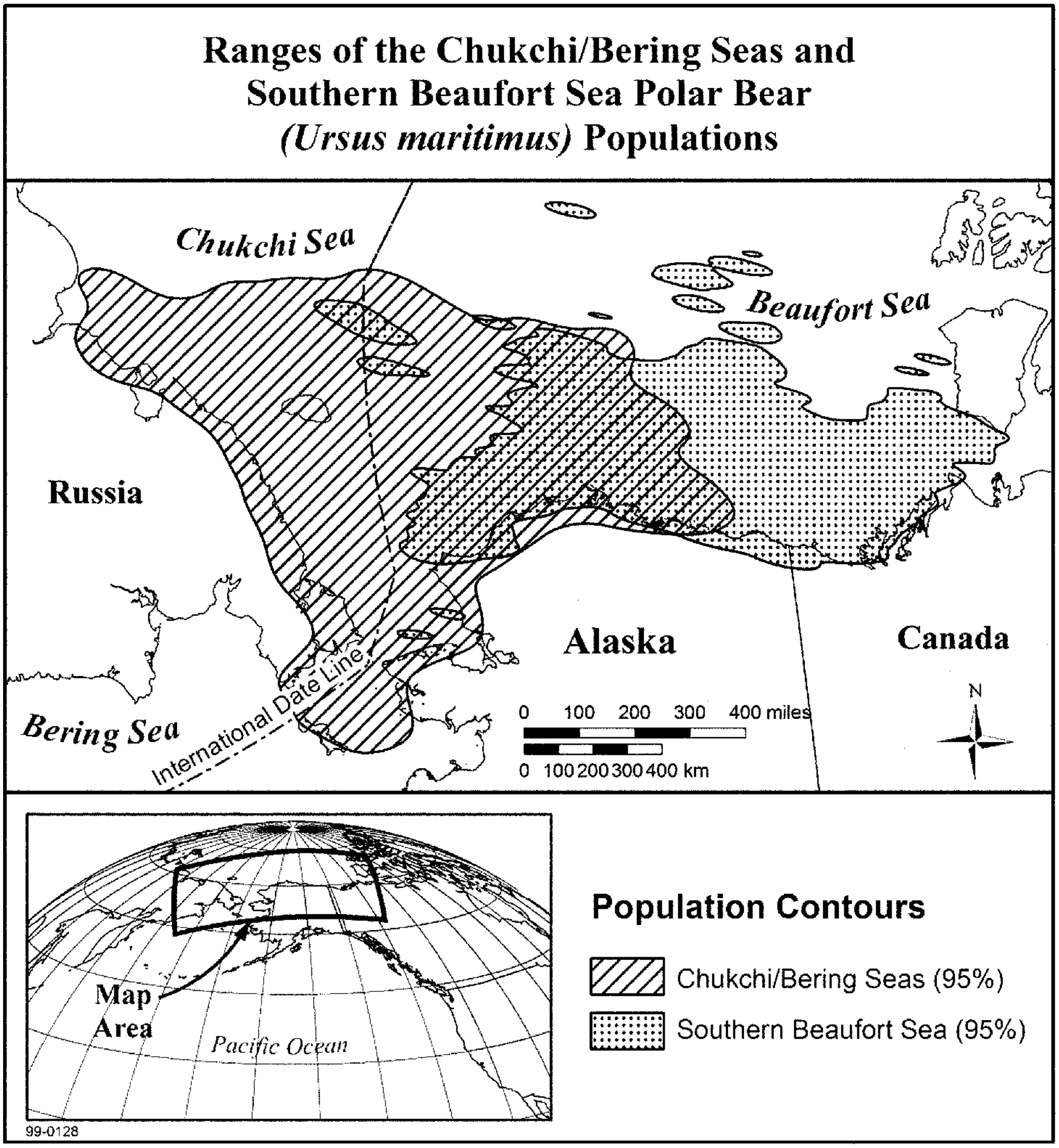

Figure 7-35. Range of the Polar Bear in the Chukchi/Bering Seas and Southern Beaufort Sea

Source: USFWS (2010)

The total worldwide polar bear population is estimated to be 26,000 individuals (95% CI: 22,000 - 31,000), occurring in 19 relatively discrete subpopulations in Canada, Greenland, Norway, Russia, and the U.S. (Wiig, Amstrup et al. 2015). The most recent population estimate for the CBS stock is 2,937 bears (95% CI: 1,552 - 5,944 bears) (Regehr, Hostetter et al. 2018). The most recent population estimate for the SBS stock is 907 bears (95% CI: 606 - 1,212) (Bromaghin *et al.* 2015, as cited in (BLM 2020). A comparison of bears captured in the Chukchi and Beaufort seas in spring 2008–2011 reported that polar bears from the CBS stock had larger body size, better body condition, and higher recruitment, compared with the SBS stock (Rode *et al.* 2014 as cited in (BLM 2020). The most recent SARs (USFWS 2010) state the PBR for the CBS population as 30 bears per year, but there is low confidence in this estimate because of the dated population information used in the calculation. The PBR for the SBS stock is 22 bears per year.

Peak numbers of polar bears observed on land generally occur in late September and early October (USFWS 1995; Schliebe *et al.* 2001, 2008; Kalxdorff *et al.* 2002, all cited in (BLM 2020). Bear numbers onshore have increased in autumn in certain locations, with the greatest concentrations occurring at Barter Island, Cross Island, and Point Barrow, where bears feed on bone piles of bowhead whales taken during the autumn subsistence hunt (Miller *et al.* 2006; Schliebe *et al.* 2008; Atwood *et al.* 2016; Lillie 2018, all cited in (BLM 2020). The number of polar bears onshore is related to sea ice dynamics, although the distribution of bears onshore was most strongly influenced by the availability of food such as these bone piles from subsistence whaling (Wilson, Regehr et al. 2017). Sightings of polar bears at industrial sites in the Beaufort Sea have increased in recent years, consistent with increasing use of coastal habitats as summer sea-ice cover has diminished (Schliebe *et al.* 2008; USFWS 2008b; 76 FR 47010; 81 FR 52276, all cited in BLM (2020).

Ireland, Bisson et al. (2016) prepared a comprehensive review of marine mammal monitoring and mitigation efforts during exploration activities in the Chukchi and Beaufort seas over the period 2006–2015. Small numbers of polar bears were recorded by aerial observers and vessel-based observers in 2006, 2008, and 2012, and by only vessel-based observers in 2013 and 2015. Sightings by aerial and vessel-based observers were distributed across the Chukchi Sea study area where monitoring effort occurred (Figure 7-36).

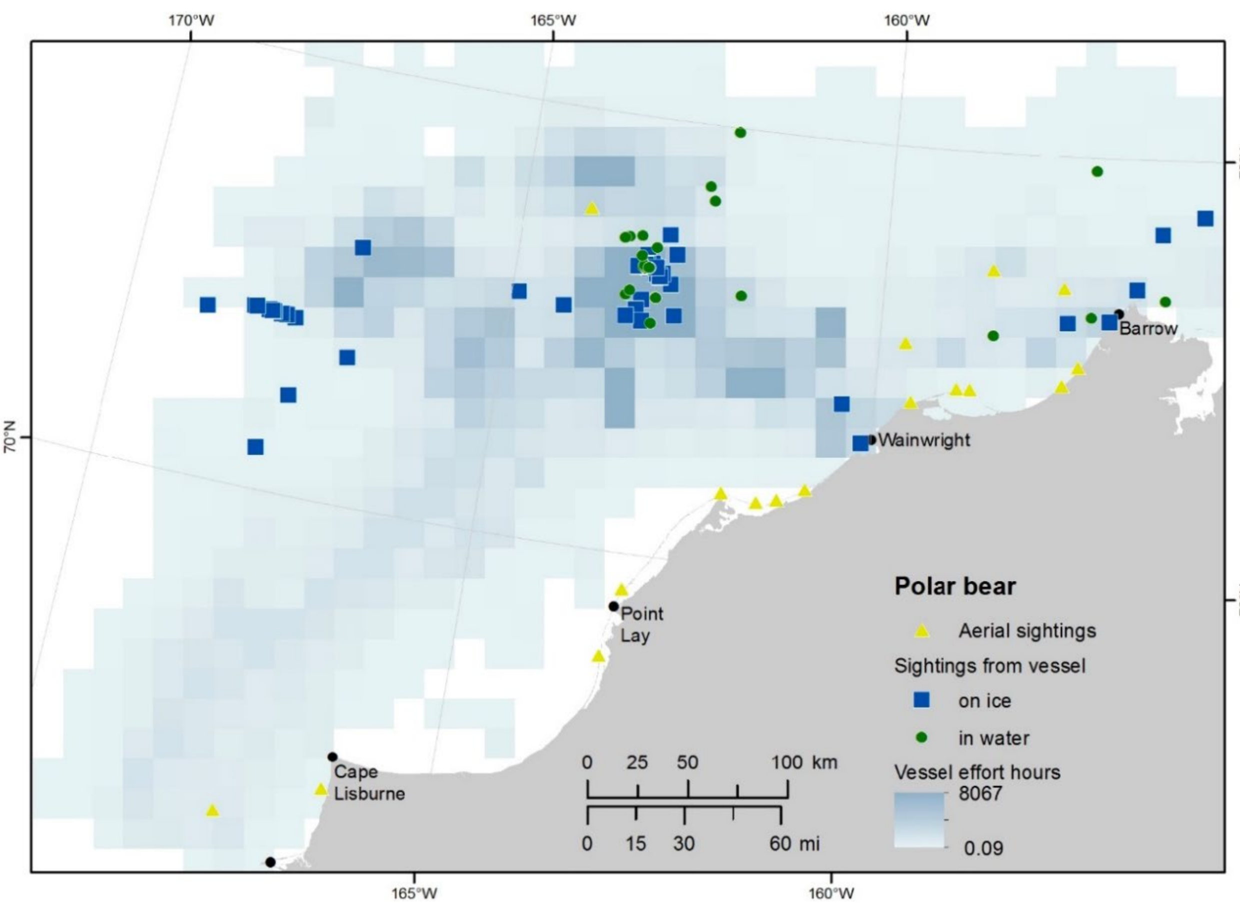

Figure 7-36. Polar Bear Sightings in the Chukchi Sea during Exploration Programs 2006–2015

Source: Ireland, Bisson et al. (2016)

All years in which polar bear sightings occurred in the Chukchi Sea were characterized by high ice persistence, with the exception of 2015, a low ice year with the lowest reported sighting rate of all years. Approximately 97% of polar bear sightings in the Chukchi Sea in 2012 were from observers on vessels working in and near ice (Ireland, Bisson et al. 2016). Five polar bears were sighted near the Burger Prospect in 2015; two in August and three in September, all quite distant from the nearest sea ice.

Ireland, Bisson et al. (2016) also summarized efforts in the Beaufort Sea. Polar bears were observed in the Beaufort Sea during most years of aerial surveys and all years of vessel-based monitoring. Polar bears in the Beaufort Sea were more widely distributed in summer months and more nearshore in the fall (Figure 7-37).

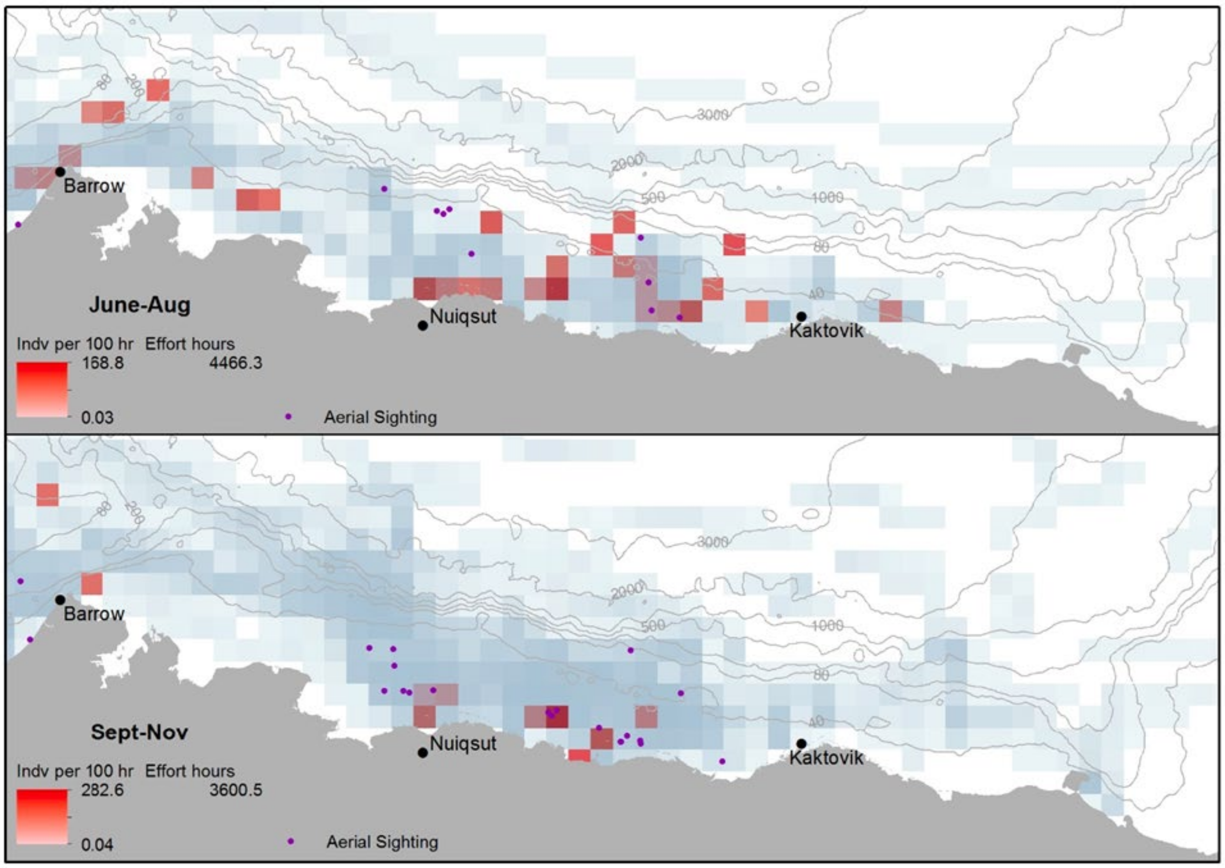

Figure 7-37. Polar Bear Sightings in the Beaufort Sea during Exploration Programs, 2006-2015

Source: Ireland, Bisson et al. (2016)

On May 15, 2008, the USFWS listed the polar bear as threatened (73 FR 28212) throughout its range under the ESA. The listing was based primarily on concerns about shrinking ice cover in Arctic seas due to climate change. Polar bears depend on pack ice for much of their denning habitat and for hunting seals. Thinning and receding ice cover threatens to greatly reduce suitable habitat for polar bears and could have serious population-level effects. Concurrent with the listing rule, USFWS issued an interim special rule (73 FR 28306; May 15, 2008), which was finalized on January 15, 2009 (USFWS 2008). Under the final special rule, if an activity is authorized or exempted under the MMPA or Convention on International Trade in Endangered Species of Wild Fauna and Flora (known as CITES), the USFWS would not require additional authorization under the ESA regulations. The special rule also states that any incidental take of polar bears that results from activities that occur outside of the current range of the species is not a prohibited act under the ESA. Critical habitat designation for polar bears is discussed in Section 7.8.3.4.

7.8.2. Mortality and Serious Injury

Despite increased interactions in the existing oilfields in recent years (see Section 7.8.3 below), lethal take associated with oil and gas activities is rare (BLM 2020). Only five polar bears have been killed at oil and gas industrial sites in Alaska since the late 1960s: one in winter 1969, another in 1990 at the Stinson exploration site in western Camden Bay, north of the planning area (Perham 2005; USFWS 2006b), one bear in 2011 (killed accidentally during a hazing event), and two in 2012 (Miller, Crokus et al. 2018). No polar bears were lethally taken by industry from 2013–2017 (Miller, Crokus et al. 2018). No polar bear-related injuries to humans have occurred as a result of oil and gas industry activities.

7.8.3. Behavioral Response Due to Disturbance

Disturbance impacts on polar bears from industrial activities, such as oil and gas development, may include: disturbance from increasing human-bear interactions, resulting in direct displacement of polar bears; preclusion of polar bear use of preferred habitat (most notably, denning habitat); or displacement of primary prey. Also, increases in circumpolar Arctic oil and gas development, coupled with increases in shipping due to the lengthening open-water season, increase the potential for an oil spill to impact polar bears and their habitat (USFWS 2016). However, as stated in the 2016 Polar Bear Conservation Management Plan:

> *The current partnerships in the United States between industry and natural resource management agencies have led to successful mitigation efforts that have limited disturbance to denning bears and reduced the number of bears killed in defense of life, and are likely to continue to do so in the near future. While monitoring of these potential avenues of stress to polar bears is warranted, these factors do not require threats-based criteria at this time (USFWS 2016).*

In the plan, USFWS determined that direct impacts on polar bears from oil and gas exploration, development, and production activities had been minimal and did not threaten the species overall. This conclusion was based primarily on:

> *1) The relatively limited and localized nature of the development activities; 2) existing mitigation measures that were in place; and 3) the availability of suitable alternative habitat for polar bears. The Service also noted that data on direct quantifiable impacts to polar bear habitat from oil and gas activities was lacking (USFWS 2016).*

Various studies have evaluated the effects of human disturbance on polar bears and support the conclusion that effects from oil and gas activities on polar bears are acceptable from a stewardship perspective.

7.8.3.1. Behavioral Responses During Seismic Surveys

Given that onshore seismic surveys in Arctic regions occur in winter so that potential effects on tundra are minimized, they overlap temporally with the period when female polar bears are in maternal dens giving birth and raising their young (Rode *et al.* 2018, as cited in (Wilson and Durner 2020). Wilson and Durner (2020) simulated the potential effects of five hypothetical seismic survey designs on denning polar bears, ranging from no spatial or temporal restrictions on survey efforts, to explicit timing of surveys in different regions of the 1002 Area. The authors suggest that large reductions in the probability of disturbance can occur through careful planning on the timing and distribution of proposed activities even when surveys are planned in areas with a high density of polar bear dens.

Polar bears are not commonly observed during open-water seismic surveys in the Chukchi Sea (Patterson, Blackwell et al. 2007, Brueggeman 2009, Hartin, Bisson et al. 2011). For example, Hartin, Bisson et al.

(2011) reported that no polar bears were observed during clearance and geotechnical surveys in the Chukchi Sea over the period August to October 2011, and Brueggeman (2009) reported sighting only one polar bear during monitoring for ConocoPhillips' open-water shallow hazard survey from September 7 to October 31, 2008 in the Chukchi Sea. The single polar bear was observed during the first half of September more than 200 m from the vessel and closer to shore. Patterson, Blackwell et al. (2007) observed no polar bears from seismic vessels operating the Chukchi Sea over the period July to September 2006. Ireland, Bisson et al. (2016) did not report any reactions of polar bear to oil and gas activities in the Beaufort Sea.

In the Beaufort Sea during a total of 1,268 hours of marine mammal monitoring for an open-water seismic survey along 4,912 km of ship trackline near Spy Island, only 13 sightings of 16 individual polar bears were made from source vessels (Hauser, Moulton et al. 2008). Of the 13 polar bear sightings, 61% occurred during non-seismic periods, while 30% and 8% of sightings occurred during seismic and post-seismic periods, respectively. During both seismic and non-seismic operations, most polar bears showed "no reaction" (69% of 13 sightings); and "looking" was recorded during the remaining polar bear sightings. All sightings were of polar bears on the barrier islands, other than one sighting of an animal swimming in the water. The single polar bear observed in the water occurred during a seismic period and the bear was observed swimming away from the vessel (Hauser, Moulton et al. 2008). No power-downs were implemented, as the polar bear was seen within or about to enter the ≥190-dB re 1µPa safety radius. Hauser, Moulton et al. (2008) concluded:

> *There were never any strong behavioral reactions by polar bears to the presence of seismic source vessels. Additionally, no polar bears were observed within the ≥190 dB safety radius, but one polar bear was estimated to have potentially received sound levels ≥160 dB before the above mentioned shut-down was implemented. Indirect estimates of the number of individual polar bears exposed to sound levels ≥190 dB were also estimated. It was estimated that were a total of four individuals that were potentially exposed to received sound levels of ≥190 dB during the Eni/PGS seismic survey. This assumes the polar bears were swimming underwater and showed no avoidance of the sound source.*

Although the seismic work near Spy Island did not require any power downs due to polar bear sightings, HDR Alaska Inc. (2013) reported that during a Simpson Lagoon OBC survey from July to September 2012, two shutdowns occurred due to polar bear sightings. Patterson, Blackwell et al. (2007) reported observations of four polar bears and no power downs or shutdowns during site clearance and geohazard surveys in the Beaufort Sea in the summer of 2006. During the north Prudhoe Bay 3D OBS seismic survey from July to August of 2014, Lomac-MacNair, Smultea et al. (2015) documented 11 sightings for a total of 18 bears (including three cubs) observed by PSOs from the project vessels and others at distances ranging from 100 to approximately 3,000 m. No shutdowns were required, but on one occasion bears were close enough in the water that the vessel speed was slowed to 2 kts, and the PSO requested that the vessel switch lines to allow for greater distance from the polar bear and the source vessel.

During seismic studies in the Chukchi Sea in 2015, five polar bears were observed by vessel-based PSOs (Ireland, Bisson et al. 2016). All five of these sightings were in areas where received sound levels were ≥120 dB re 1 µPa rms SPL. PSOs recorded a reaction of "look" for all five polar bears. Four polar bear movements relative to the vessel were recorded as "neutral" and one was recorded as "swimming away" from the vessel (Ireland, Bisson et al. 2016).

7.8.3.2. Behavioral Responses Near Existing Oilfields

Amstrup (1993, as cited in (BLM 2020) reported that 10 of 12 denning polar bears tolerated exposure to a variety of disturbance stimuli near dens with no apparent change in productivity (survival of cubs). Two females denned successfully (produced young) on the south shore of a barrier island within 2.7 km of an active oil processing facility and others denned successfully after a variety of human disturbances near their dens. Similarly, during winter 2000–2001, two females denned successfully within 402.3 m and 804.6 m of remediation activities being conducted on Flaxman Island (MacGillivray *et al.* 2003, as cited in (BLM 2020). In contrast, Amstrup (1993, as cited in (BLM 2020) found that several females responded to disturbance early in the denning period by moving to other sites, suggesting that females may be more likely to abandon dens in response to disturbance early in the denning period, rather than later. Initiating intensive human activities during the period when female polar bears seek den sites (October–November) would give them the opportunity to choose sites in less-disturbed locations (Amstrup 1993, as cited in (BLM 2020), at least in areas where oilfield activity occurs consistently throughout the year.

Some female polar bears have denned successfully in the existing oilfields where industry activities occurred as near as 50–100 m from occupied dens, whereas other females abandoned dens where activities occurred at distances of 100–500 m. In the final rule for the current Alaska Beaufort Sea ITRs (USFWS 2016), the USFWS stated that in 2006, 2009, 2010, and 2011, polar bears established dens prior to the onset of industry activity within 500 m or less of the den site, but remained in the den through the normal denning cycle and later left with cubs, apparently undisturbed despite the proximity of industrial activity. Planning projects, where examining the placement and timing of activities, can further reduce potential disturbance to denned bears (Wilson and Durner 2020).

Over the period 2010–2014, the oil and gas industry reported a total of 1,234 observations of 1,911 polar bears (Durner, Laidre et al. 2016) and during the most recent 7-year period for which data are complete (2010 to 2016), the oil and gas industry reported a total of 1,582 observations of 2,373 polar bears (Miller, Crokus et al. 2018). As reported in Durner, Laidre et al. (2016):

> *Of the 1,911 bears observed, no incidental (i.e., disturbance) takes of bears were reported for 81% of the bears (1,549). Of the remaining 362 bears observed, incidental takes were reported for 78 bears. The oil and gas industry reported intentional takes by deterrence activities for 260 bears. Effects were unknown for 23 bears and one lethal take of a bear occurred as a result of industrial activity.*

Other studies have shown that the incidence of human/bear encounters and harassment by deterrence (hazing) remains relatively low (BLM 2020). Of the 2,373 bears observed, no incidental (disturbance) takes of bears were reported for 83.9% of the bears (1,978 bears). From 2010 through 2016, industry reported that 395 of 2,373 polar bears (16.6%) observed near industrial sites in the Alaska North Slope oilfields were disturbed either unintentionally (incidental take) or by intentional deterrence (Miller, Crokus et al. 2018):

> *The percentage of reported take by intentional deterrence decreased over time from a high of 39 percent of the bears observed in 2005 to 14 percent during 2010–2014 (81 FR 52276). The USFWS attributes the decrease in deterrence events to increased polar bear safety and awareness training of industry personnel, as well as ongoing deterrence education, training, and monitoring programs (76 FR 47010; 81 FR 52276).*

Although reports are rare, polar bears have exhibited den abandonment due to noise disturbance from human activity (Belikov 1976, Lentfer and Hensel 1980 and Amstrup 1993, as cited in Owen, Pagano et al. (2020) and (Larson, Smith et al. 2020). It might be expected that polar bears in dens are more vulnerable to noise exposure earlier in the denning season, and that the acoustic buffering capacity of the dens increases over time as snow becomes deeper and older. The author's findings indicate polar bear dens during winter effectively attenuate sound likely reducing the potential for acoustic disturbance within the den relative to outside noise levels (Owen, Pagano et al. 2020). Additionally, most of the industrial sources tested exhibited the greatest noise levels at low frequencies, which were outside the range of polar bear hearing. Because low-frequency sounds propagate over longer distances compared to high-frequency sounds, the decline in hearing sensitivity of polar bears at frequencies below 125 Hz predisposes them to poorer detection of sounds from long distances. In combination, the attenuation of sound propagation into the den and reduced sensitivity to sound energy below 125 Hz reduces the potential for audibility of the industrial sources tested (Owen, Pagano et al. 2020).

7.8.3.3. Behavioral Responses to Vessels and Aircraft

Larson, Smith et al. (2020) found that aircraft noise had the highest potential to initiate den abandonment. However, while all human activities elicited varying degrees of response, the overall response intensity was less than anticipated, even under high-use scenarios. Data from Larson, Smith et al. (2020) indicate that the current guideline of a 1.6-km buffer zone effectively minimizes disturbance to denning polar bears. The authors found that polar bear dens were not abandoned, even when subjected to intense stressors, such as people digging into them or snowmachines parked atop of them, and during the multiyear den monitoring study, they did not observe any premature den abandonments that may have led to reproductive failure.

Unintentional disturbance can occur to denning polar bears. Owen, Pagano et al. (2020) found that within a closed den, polar bears had a high probability of detecting aircraft (≥75%) at distances ≤1.6 km, and ground-based noise sources also had high probabilities of detection at distances ≤0.8 km. On average, closed dens reduced noise levels by 15 dB relative to open dens. Owen, Pagano et al. (2020) reported that although polar bear snow dens effectively attenuate acoustic SPLs, noise from some industrial support vehicles was likely to be detected farther from dens than previously documented.

(USFWS 2021) reported that bears on the surface may experience disturbance due to aircraft noise or visual stimuli from aircraft overhead. Observations of polar bears during fall coastal surveys flown at altitudes lower than approximately 450 m indicated variable short-term reactions ranging from no reaction to running away (USFWS 2021).

7.8.3.4. Effects Due to Changes in Habitat

The USFWS designated critical habitat for polar bears in Alaska in 2011 (75 FR 76086). Three units of critical habitat were designated, corresponding to the following primary constituent elements of critical habitat described in the final rule:

- Sea-ice habitat, used for feeding, breeding, denning, and movements, in U.S. territorial waters.
- Terrestrial denning habitat, on land along the northern coast of Alaska, with characteristics suitable for capturing and retaining snow drifts of sufficient depth to sustain maternal dens through winter, occurring within 32 km of the coast between the U.S.–Canada border on the east and the Shaviovik and Kavik rivers on the west (including the planning area), and within 8 km of the coast from the Shaviovik and Kavik rivers west to Point Barrow.
- Barrier island habitat, used for denning, refuge from human disturbance, and movements along the coast for access to denning and feeding habitats, comprising barrier islands and associated mainland spits, along with the water, ice, and terrestrial habitat within 1.6 km of those features, designated as a no-disturbance zone.

In 2010, the USFWS designated a total of 484,734 km^2 of Alaskan and adjacent territorial and U.S. waters as critical habitat for the polar bear through a formal rulemaking process (USFWS 2010). The designation was set aside in 2013 as a result of legal challenges by several groups. In 2016, the set aside was reversed by the courts and the original designation was reinstated. The critical habitat designation for polar bears includes sea ice habitat (Figure 7-38) and terrestrial denning habitat (Figures 7-39 and 7-40).

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, BLM 2020, BLM 2020). While there is no record of a large oil spill in polar bear habitat in the U.S. Arctic, such an event could cause adverse effects on both bears and their habitat. For additional discussion on the adverse effects of oil spills, please see Section 4.6.

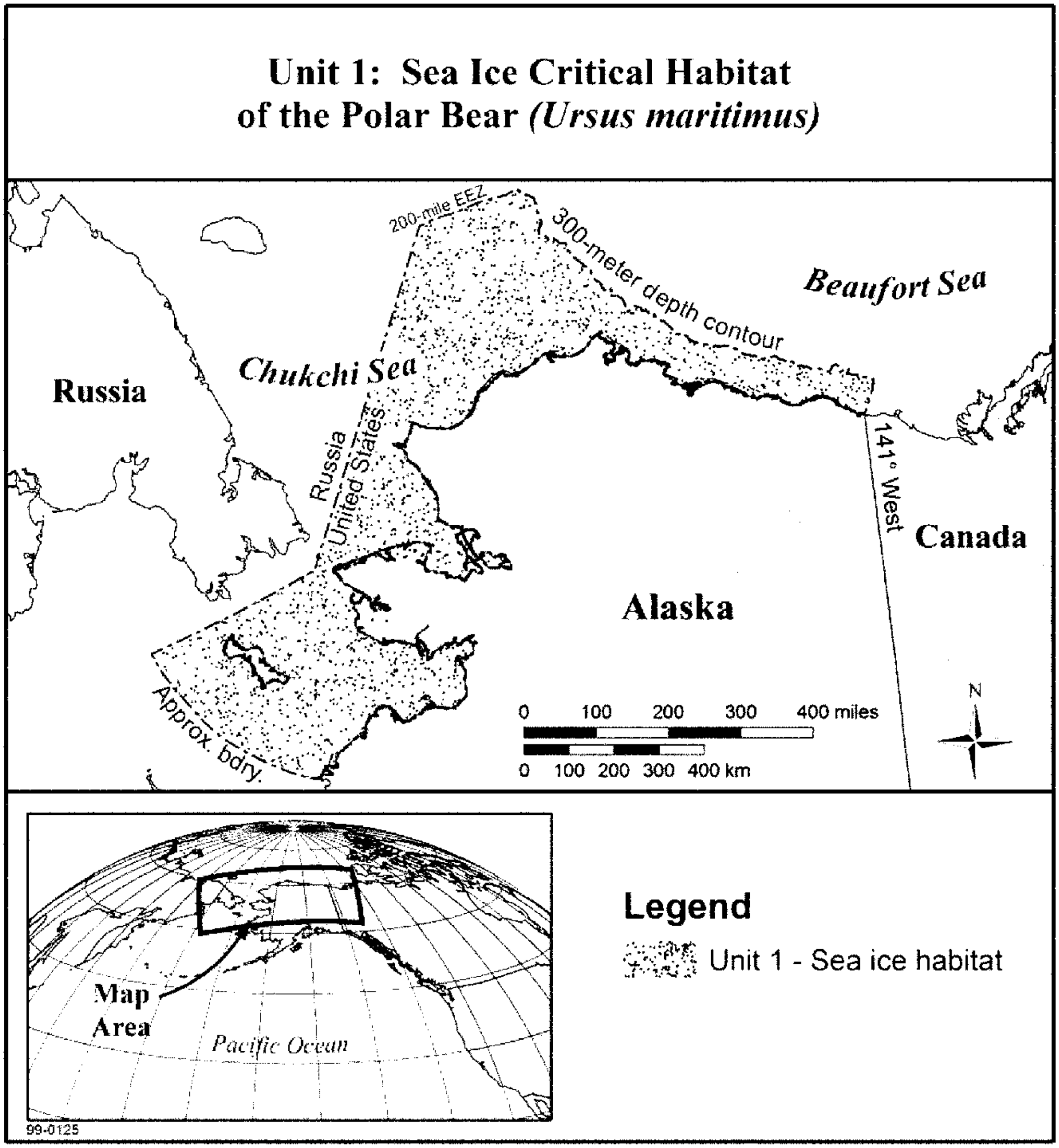

Figure 7-38. Polar Bear Critical Habitat in Sea Ice

Source: USFWS (2010)

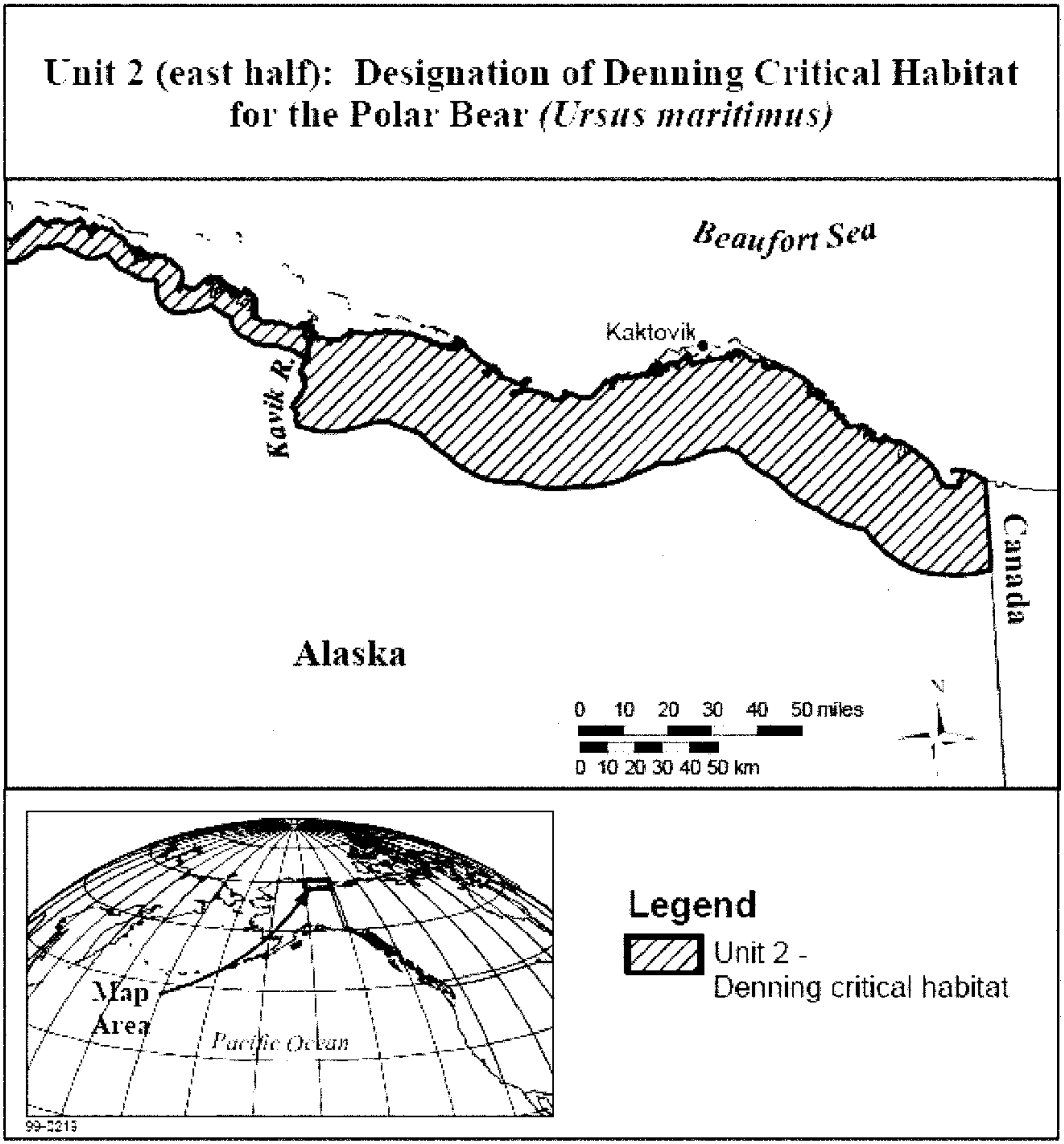

Figure 7-39. Eastern Half of Polar Bear Terrestrial Critical Habitat

Source: USFWS (2010)

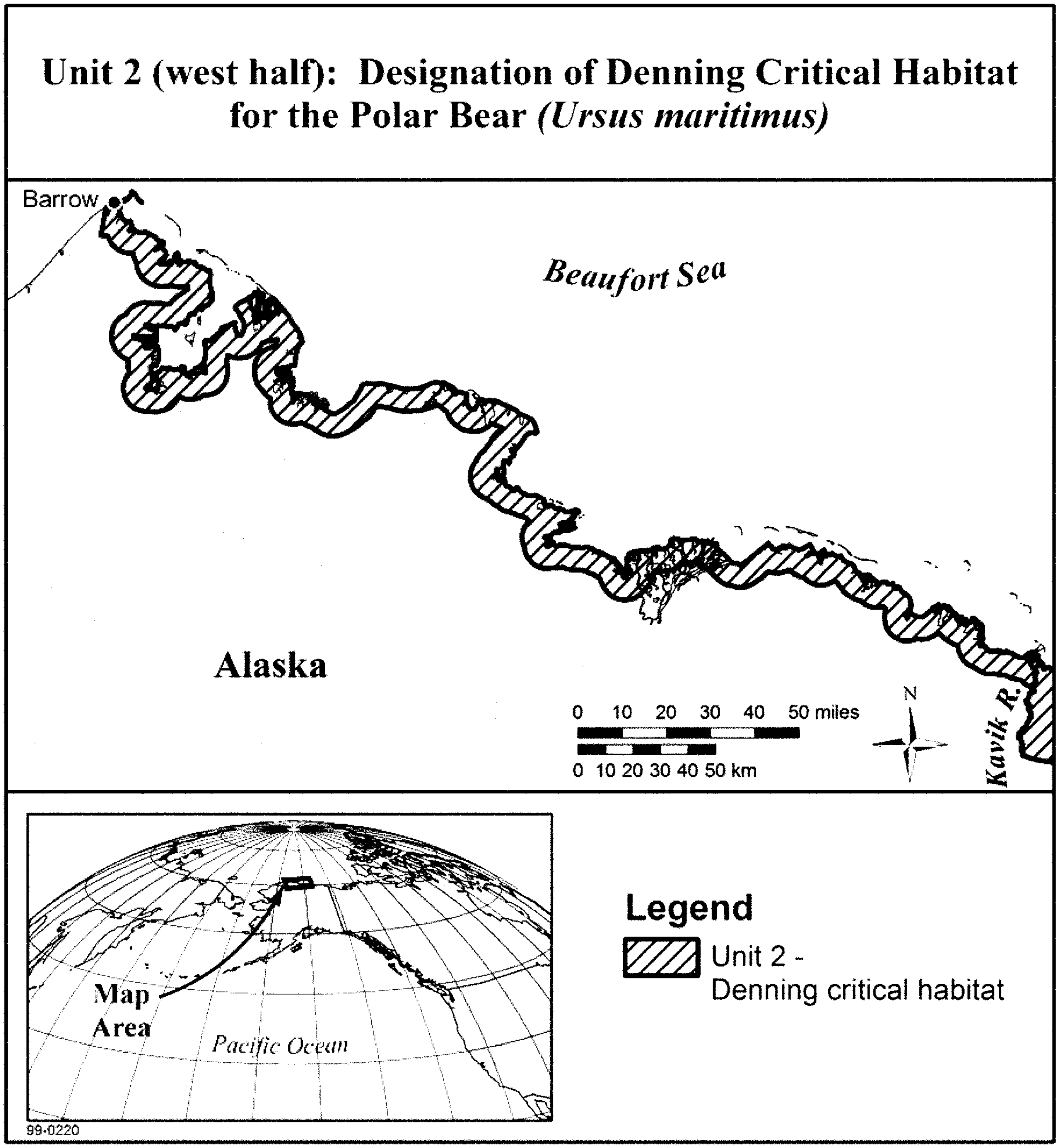

Figure 7-40. Western Half of Polar Bear Terrestrial Critical Habitat

Source: USFWS (2010)

Temporary polar bear habitat loss or alteration would be reduced by the mitigation measures described in BLM (2020) and USFWS (2021). These MMPA rules and associated LOAs require surveys to locate polar bear dens before activities begin. In addition, certain activities are excluded within 1.6 km around dens, thereby reducing the probability of altering winter denning habitat when bears are present. In areas where gravel is placed for pads or roads, potential maternal denning habitat would likely be avoided by some bears because of the presence of the existing facilities and associated human activity (BLM 2020). Other stipulations (BLM 2020) require minimizing the development footprint to limit the potential areas of important coastal habitat that could be altered or lost.

USFWS (2010) lists the following conservation concerns for both stocks of polar bear in the U.S.: 1) oil and gas exploration, 2) climate change, and 3) subsistence harvest (especially for the SBS stock, which is currently declining in abundance).

7.9. Sea Otters (*Enhydra lutris*)

7.9.1. Current Status and Relevant Baseline Information

Three DPSs of Alaskan northern sea otters are recognized: southwest, southcentral, and southeast (USFWS 2017). As shown in Figure 7-41, the southwest Alaska DPS extends into the west side of Cook Inlet and the southcentral DPS can be found along the eastern side of Lower Cook Inlet. A shown in Figure 3-9, past and present oil and gas activities and facilities are situated in Upper Cook Inlet north of Kalgin Island, or along the eastern shoreline north of Anchor Point. Sea otters are managed by the USFWS.

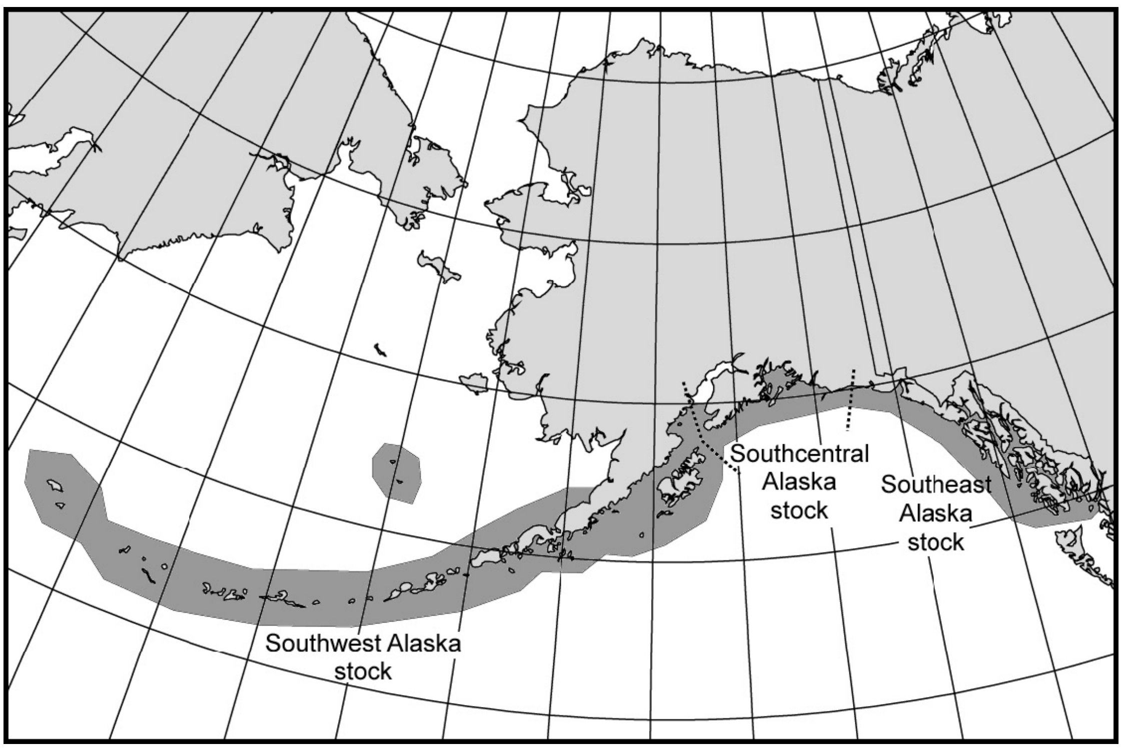

Figure 7-41. Approximate Boundaries of Sea Otter Stocks in Alaska

Source: USFWS (2014)

For the southwest Alaska DPS, an aerial survey of Kamishak Bay and western Cook Inlet conducted in June 2002 resulted in an estimate of 6,918 sea otters (USFWS 2014). For the southcentral Alaska DPS, in 2008 an aerial survey was conducted within Kachemak Bay resulting in an estimate of 3,596 sea otters (USFWS unpublished data, as cited in (USFWS 2014). A 2010 aerial survey in Kenai Fjords National Park resulted in an estimate of 1,322 sea otters (Coletti *et al.* 2011, as cited in (USFWS 2014). Eastern Lower Cook Inlet was surveyed as part of a larger area in 2002, yielding an estimate of 962 sea otters (Bodkin *et al.* 2003b, as cited in (USFWS 2014) for the areas not covered in 2008 and 2010. PBR for the southwestern Alaska DPS is 450 sea otters per year (USFWS 2014), and PBR for the southcentral Alaska DPS is 1,466 (USFWS 2014). Based on 2017 aerial surveys reported by (Garlich-Miller, Esslinger et al. 2017), an estimated abundance estimate for the southwest Alaska stock was 10,737 (SE = 2,323) and the estimated abundance for part of the southcentral Alaska stock that occurs in the eastern part of Cook Inlet was 9,152

(SE = 1,020). The highest densities of sea otters in Lower Cook Inlet were observed along the north shore of Kachemak Bay and in Port Graham (Garlich-Miller, Esslinger et al. 2017).

From the USFWS (2013a, as cited in (USFWS 2017):

> *The southwest Alaska DPS of the northern sea otter was designated as a threatened species in 2005 (70 FR 46366; August 9, 2005). At the time of the 2005 final listing rule, it was estimated that the southwest DPS had experienced a rapid decline in abundance of more than 50 percent since the late 1980s and consisted of approximately 42,000 sea otters (USFWS 2017). The cause of the overall decline is not known with certainty, but the weight of evidence points to increased predation, probably by the killer whale (Orcinus orca), as the most likely cause.*

Sea otter critical habitat is discussed in Section 7.9.4.

7.9.2. Mortality and Serious Injury

There have been no recorded deaths or severe injury of sea otters directly attributed to oil and gas operations in Cook Inlet or in the vicinity Dutch Harbor. A dead sea otter was encountered during a period of no work during the 2019 LCI seismic survey (Fairweather Science 2020), and the cause of death was not known.

Collisions between listed otters and vessels associated with oil and gas activity that could cause mortality or serious injury are considered unlikely because of the limited oil and gas related vessel traffic that occurs in the range of the listed DPS on the western side of Cook Inlet (USFWS 2017). In addition, otters are primarily found in the nearshore areas of the Cook Inlet where vessels from oil and gas activity are less likely to transit.

Vulnerability of sea otters to oiling was demonstrated by the 1989 *Exxon Valdez* oil spill in Prince William Sound (USFWS 2014). Estimates of mortality for the Prince William Sound area vary from 750 otters (Garshelis 1997, as cited in (USFWS 2014) to 2,650 otters (Garrott *et al.* 1993, as cited in (USFWS 2014). Statewide, 3,905 sea otters were estimated to have died in Alaska as a result of the spill (DeGange *et al.* 1994, as cited in (USFWS 2014). While the catastrophic release of oil has the potential to take large numbers of sea otters, there is no evidence that other effects (such as disturbance) associated with routine oil and gas development and transport have had a direct impact on the southcentral or southwestern Alaska sea otter stocks (USFWS 2014). Sea otters are particularly vulnerable to oil spills because of their dense fur and high metabolic rate which if oiled can decrease buoyancy and cause hypothermia (Lipscomb, Harris et al. 1993).

7.9.3. Behavioral Response Due to Disturbance

Based on the range of sea otters in Cook Inlet, existing oil and gas facilities in the inlet (Figure 3-9) have not overlapped substantially with areas used by northern sea otters (USFWS 2017). However, also as shown in Figure 3-9, Hilcorp, Alaska LLC owns 14 leases in the southern and eastern portion of Cook Inlet. Seismic activities in the vicinity of these leases have overlapped with areas sea otter use. During Hilcorp's LCI seismic survey in 2019, a total of 666 live sightings (*i.e.*, groups) of approximately 5,868 individual sea otters were observed from aircraft; vessel based PSOs recorded sightings of 42 sea otters (Fairweather Science 2020). One of the vessel-based sightings was of a deceased sea otter. Figure 7-15 depicts the location of observations during aerial surveys for that project.

Noise associated with the oil and gas seismic surveys in Cook Inlet are generally within the effective hearing range of sea otters: 125 Hz to 32 kHz as per Ghoul and Reichmuth (2012); 75 Hz to 75 kHz as per Southall, Bowles et al. (2007); and 100 Hz to 40 kHz as per Finneran and Jenkins (2012). Sea otters exposed to anthropogenic noise respond behaviorally by exhibiting escape responses, or physiologically through increased heart rate, or stress hormonal responses (Atkinson *et al.* 2009, Wikelski and Cooke, 2006; both cited in (BOEM 2016). However, they have been observed to be resistant to some acoustic stimuli including airguns (Davis, Williams et al. 1988, Ghoul and Reichmuth 2012) and quickly become habituated to anthropogenic noises (Ghoul and Reichmuth 2012).

Behaviors exhibited by sea otters during a seismic survey in Lower Cook Inlet included: mill, travel, swim, look, rest, feed, surface active, and dive (Fairweather Science 2020). Before ramping up the airguns during the seismic work, a PSO or trained crewmember cleared a 50-m sea otter exclusion zone using vessel lights. Forty-six percent of live sea otter sightings were recorded during periods of no seismic activity, while 54% were observed during periods of seismic activity, including full array. The average sighting distance for live sea otters during periods of no seismic activity was approximately 455 m, and approximately 837 m during seismic activities including full array. PSOs on board the source vessel observed one sea otter that was grooming at 700 m while seismic operations (full array) were occurring. The animal showed no detectable signs of distress, and eventually dove. This dive was recorded as a reaction and was likely a response to vessel presence, given the grooming behavior observed while seismic activity was occurring (Fairweather Science 2020). The post project monitoring report stated zero Level A exposures and only 11 Level B exposures for sea otters; these were well below the allowable Level A and B exposures of 2 and 847 sea otters, respectively.

Helicopters are used to support oil and gas activities in Cook Inlet. Minor and short-term behavioral responses of mustelids (i.e., sea otters) to helicopters have been documented in several locations including Alaska (BOEM 2016). Visual presence of aircraft alone is not likely to cause disturbance of sea otters; however, aircraft noise and visual stimuli may result in disruptions in sea otter behavior including diving under water to swimming erratically during overflights (USFWS 2018). Aerial surveys more intensive search patterns (*i.e.*, flights which circled overhead at low altitudes) as summarized by (USFWS 2018), reported a rate of Level B harassment below 0.1% (18 confirmed takes of approximately 19,500 animals observed).

Offshore supply vessels (OSVs) may encounter listed southwest DPS sea otters when transiting in and out of Dutch Harbor in the Aleutian Islands as they transit to and from the Chukchi or Beaufort seas (USFWS 2015). The Sea Otter Recovery Plan determined disturbance of sea otters by boat traffic as a threat of low importance to the species' recovery (Service 2013a, as cited in (USFWS 2017)).

7.9.4. Effects Due to Changes in Habitat

The USFWS designated 15,000 km^2 of critical habitat for the southwest DPS of sea otters in 2009 (74 FR 51988). This critical habitat is broken into 5 units: Western Aleutian; Eastern Aleutian; South Alaska Peninsula; Bristol Bay; and Kodiak; Kamishak; and Alaska Peninsula (Figure 7-42).

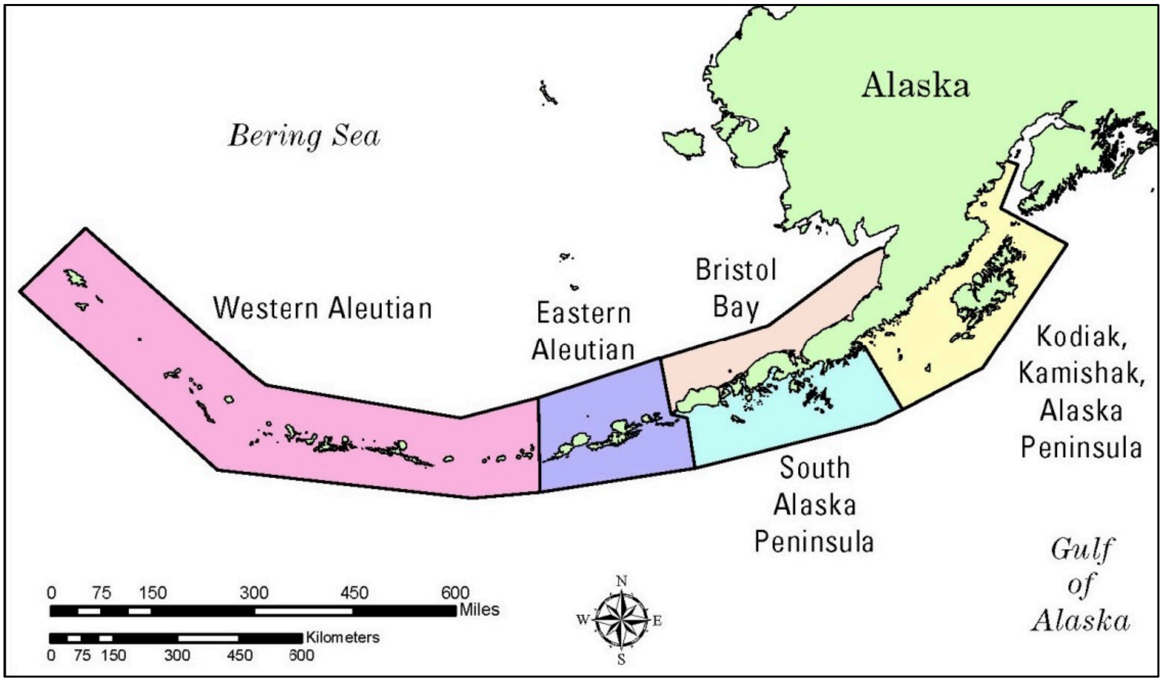

Figure 7-42. Sea Otter Critical Habitat

Source: USFWS (2017)

Eastern Aleutian critical habitat (Unit 2) occurs in nearshore waters around Unalaska Island. It is likely that some OSVs transiting though Dutch Harbor have entered this unit. However, vessel traffic has not likely impacted or caused destruction of critical habitat the intersect has been limited to the port of Dutch Harbor where habitat is already degraded due to the presence of infrastructure (USFWS 2015).

The Kodiak, Kamishak, and Alaska Peninsula critical habitat (Unit 5) does not overlap substantially with past and present oil and gas activities in Cook Inlet. While seismic airguns have the potential to alter the availability of sea otter invertebrate food sources, Vella *et al.* (2001, as cited in (USFWS 2017) concluded that there are generally few behavioral or physiological effects on invertebrates unless the organisms are very close (within several feet) to a powerful noise source. Consequently, noises from seismic airguns are not likely to decrease the availability of invertebrate crustaceans, bivalves, or mollusks or modify otter critical habitat.

A 2012 report by USGS (Bodkin, Ballachey et al. 2012) compared foraging areas to documented oil distribution to evaluate whether sea otters may be exposed to lingering oil from the *Exxon Valdez* oil spill through foraging. By assessing dive behavior of sea otters, the authors estimated an oil exposure rate ranging from 2 to 4 times per year for males and 2 to 24 times per year for females. Exposure rates increased in spring when intertidal foraging doubled for females and females were with pups. The majority (82%) of foraging pits were within 0.5 m of the zero tidal elevation and 15% were above 0.5 m, where 65% of lingering oil remained as of the time of the study (2008) (Bodkin, Ballachey et al. 2012).

Harwell and Gentile (2014) described evidence of sub-surface oil residue in portions of Prince William Sound (specifically Knight Island) as the remaining long-term risk to sea otters and their habitat leftover from the 1989 *Exxon Valdez* oil spill located outside of Cook Inlet. A quantitative model developed by (Harwell and Gentile 2014) helped evaluate the potential for sea otter exposure to sub-surface oil residue, and predicted that the estimated frequencies of encountering oil did not constitute a plausible continued risk for the animals occurring around Knight Island, an area that had been heavily oiled during the spill. The model specifically quantified potential risk due to exposure if a sea otter encountered sub-surface oil residue while digging a pit for prey.

Harwell and Gentile (2014) stated:

> *…the model simulated chronic doses to 500,000 sea otters by randomly assigning a specific value for each stochastic parameter in each simulation hour, sampled from empirically based lognormal data distributions. Many sensitivity analyses scenarios were conducted to explore alternative model parameters and model structures. Altogether, >1 billion sea otter hours were simulated to capture the variability in environmental, SSOR, and sea otter characteristics. In this way, the simulated population captured the full range of plausible exposures to PAHs that could occur to sea otters at NKI [Knight Island]. These analyses demonstrated that physically contacting SSOR was the dominant exposure pathway of PAHs to sea otters in oiled areas.*

7.10. Cumulative Effects of Oil and Gas Activities on Marine Mammals in Arctic and Cook Inlet

As described in Section 4.7, a cumulative effect is defined by NEPA regulations as:

> *The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR § 1508.7).*

Since 2000, there have been at least 33 NEPA evaluations[2] for oil and gas activities in the U.S. Arctic and Cook Inlet, not including NEPA analyses completed for more than 100 IHAs and LOAs issued by NMFS and USFWS between 2000 and 2020 (see Figures 5-1 and 5-2). Similarly, formal ESA consultations also typically require preparation of a cumulative effects assessment. In compliance with CEQ guidelines (CEQ 1997), many EAs[3] and every EIS must address cumulative effects to some degree. These documents, as well as the Alaska Marine Mammal Stock Assessments,[4] provide decision-makers with information regarding other activities in the region that, in combination with oil and gas activities, could result in a cumulative effect.

Several key challenges exist for identifying and documenting cumulative effects on marine mammals, least of which includes the ability to monitor marine mammal populations or their exposure to multiple stressors. In 2003, the National Research Council (NRC) published a report titled *Cumulative Environmental Effects of Oil and Gas Activities on Alaska's North Slope* (NRC 2003). The 2003 NRC report aimed to assess the lack of information and understanding (at that time) regarding cumulative effects of oil and gas activities on Alaska's North Slope (including both onshore and offshore activities). The "Findings" section of the report is organized by topic including the following, which are applicable to offshore oil and gas development:

[2] This number includes the EA published in 1999 for Northstar Development.

[3] In some cases, some oil and gas activities may be too limited in extent or duration to result in noticeable direct or indirect effects on marine mammals in terms of important life functions and requirements. Therefore, it would not be required under NEPA to evaluate cumulative effects if direct and indirect effects are considered negligible.

[4] https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessment-reports-region; (Accessed October 14, 2021)

- Industry growth;
- Interactions of oil and gas with climate change;
- Oil spills;
- Expansion into new areas;
- Socioeconomic changes in local communities;
- Interference with subsistence; and
- Aesthetic, cultural, and spiritual consequences (NRC 2003).

These topics are common themes in most cumulative effects assessments presented in the NEPA documents published between 2000 and 2020, as described above. NRC (2003) acknowledges the major efforts made by government and industry to conduct research, monitoring, and assessments of oil and gas activities in Alaska to determine whether direct, indirect, or cumulative effects occur. To fill knowledge gaps and promote adaptive management, NRC (2003) concludes with a series of recommendations applicable to marine mammals and subsistence hunting, as follows:

- Comprehensive planning (to include traditional knowledge and specifically, information gathered by subsistence hunters);
- Ecosystem research;
- Offshore oil spill mitigation (although no large offshore oil spills or very large oil spills have occurred from Alaska OCS activities even a low potential is a major concern (also see BOEM (2015); and
- Human communities including perceived threats to a traditional way of life.

Other than being part of NEPA or ESA-related assessments (*i.e.*, BiOps), a cumulative effects study has not been undertaken in Cook Inlet during the period 2000–2020. However, cumulative effects is a very common topic in public comments on development activities in Cook Inlet. As an example, Marine Mammal Commission (MMC) letters to NMFS regarding Apache's seismic surveys and exploration activities expressed concern that NMFS issued IHAs for the incidental taking of Cook Inlet beluga whales without adequate consideration of cumulative effects of current and planned activities on the population (NMFS 2012, NMFS 2013). Those activities include not only oil and gas exploration but also port construction, shipping, coastal development, military, fisheries, and mineral extraction.

The MMC stated that authorizing incidental harassment over multiple years without a better understanding of the potential contribution of oil and gas exploration and other activities to the population's more than 10-year-long decline could exacerbate the situation and reduce the stock's prospects of eventual recovery. The MMC recommended that NMFS, rather than continuing to consider only the incremental effects of new activities in incidental take authorizations, develop clear policies and adopt clear criteria for ensuring full consideration of cumulative effects in Cook Inlet. The MMC comments echo what many public comments frequently state about cumulative effects on marine mammals, whether it be Cook Inlet or the U.S. Arctic. Many commenters often request that activities are deferred until such time that an agency (USFWS or NMFS), with reasonable confidence, can support a conclusion that activities would affect no more than a small number of marine mammals and have no more than a negligible impact on marine mammal populations.

While challenges exist in terms of documenting cumulative effects on marine mammals, threats that may result in adverse cumulative effects may include: 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 (Huntington 2009) (see Section 4.7).

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8. Effects of Oil and Gas Activities on Subsistence Activities and Subsistence Users

Oil and gas activities can have both direct and indirect effects on subsistence activities and subsistence users. As stated in Braund and Kruse (2009):

> *Most Alaska coastal communities in the likely areas of OCS development have a sociocultural and economic uniqueness. These communities are predominantly Alaska Native communities with distinctive social relationships. They also have relatively underdeveloped market economies. Subsistence harvesting and sharing are integral components of these communities.*
>
> *Petroleum development has historically affected communities throughout the state even when they are far from the action, because of kinship and social networks.*

Table 1-1 lists marine mammal species important to subsistence users for each region (*i.e.*, the U.S. Arctic and Cook Inlet). In addition to marine mammals, fish are an important subsistence resource for many Alaskan communities in the Arctic and Cook Inlet. This report focuses on the potential effects of oil and gas activities on marine mammals; therefore, while fish provide food security and subsistence harvest of fish is culturally significant, the effects of oil and gas activities on subsistence use of various fish species are not included in this report.

8.1. Marine Mammal Subsistence Activities in the U.S. Arctic

Subsistence activity in the U.S. Arctic is a central organizing element of the Iñupiaq society (BOEM 2018). Subsistence activities are highly regarded by the Iñupiat for the cultural values and sense of identity they bring. Subsistence is also an important economic pursuit, not because the harvested food can be sold but because subsistence allows Alaska Natives to purchase less food. Through the pursuit, collection, and sharing of natural resources, subsistence integrates nutritional and spiritual relationships with the land. Hunters, families, and communities are connected for simple sharing. For example, the most important ceremony, Nalukataq, celebrates the bowhead whale harvest (Bacon, Hepa et al. 2011). Other values include an emphasis on the community, its needs, and its support of other individuals. Thus, through food-sharing and cooperative hunting and harvesting efforts, subsistence connects community members and relatives throughout the community (Unger 2014). This sharing, trading, and bartering of subsistence foods also structures relationships among communities, while at the same time the giving of such foods helps maintain ties with family members elsewhere in Alaska (Courtnage and Braund 1984).

Reliance on subsistence harvests of marine mammals in coastal villages is well documented (Braund and Kruse 2009, Galginaitis 2009, Kofinas, BurnSilver et al. 2016). For example, Brower, Olemaun et al. (2000) reported that in one year (*i.e.*, 1994), 61% of the edible harvest of subsistence species in the community of Kaktovik was due to hunting of marine mammals. Suydam, George et al. (2011) reported on the utilization of bowhead whales for subsistence by community and by year. While the composition of harvested marine mammal species varies greatly by coastal community in the Bering and Chukchi Seas, there are numerous annual reports and compilations that codify the importance of marine mammals to the diet of community members in this area and the importance of marine mammals to the community in terms of food security (Galginaitis and Funk 2004). (Kruse, Kleinfeld et al. 1982) acknowledged that as of the late 1970s, while local Alaska North Slope economies benefited through tax revenues, employment and public services, subsistence activities not only continued to produce preferred foods but were a social binding force not to be replaced.

While fish provide food security and the subsistence harvest of fish is culturally significant, the effects of oil and gas activities on subsistence use of various fish species are not included in this report which focuses solely on marine mammals. Section 8.1 of this report focuses on the extent and significance of subsistence hunting to U.S. Arctic communities. Section 8.2 of this report focuses on the effects oil and gas activities has had on the communities, and how these effects have changed over time in response to mitigation requirements agreed upon in the CAA.

8.1.1. Bowhead Whale Hunting

Iñupiat spiritual and emotional life centers on bowhead whale hunting (Courtnage and Braund 1984). The importance of the whale hunt is more than emotional and spiritual. The organization of the crews does much to delineate important social and kin ties within communities and to define community leadership patterns as well. Structured sharing of landed whales helps determine social relations both within and between communities (Courtnage and Braund 1984). The bowhead whale harvest is shared as people from across the U.S. Arctic gather to participate in celebrations such as Kivgiq (Figure 8-1). The close relationship between the people, their social organization, and the cultural value of subsistence hunting may be unparalleled when compared with other areas in the U.S. (Bacon, Hepa et al. 2011). It is recognized that any disruption to hunting of bowhead whales and loss of opportunities to harvest and share whales and other marine resources likely would have severe, and thus, major adverse impacts to sociocultural systems (BOEM 2018).

Figure 8-1. Celebrating Kivgiq in Utqiaġvik

Source: https://iwc.int/alaska; Bill Hess; (Accessed July 3, 2021)

Archaeological evidence indicates ancestral whaling began about 1,700 years ago on St. Lawrence Island, Diomede Islands, the eastern coast of the Bering Sea, and the Alaska North Slope (Larsen and Rainey 1948; Mason 2009, as cited in (Stephen R. Braund & Associates 2018). Whaling occurred when village populations were high enough to support whaling crews. Hunting intensified in the 16th Century when the presence of nearshore ice increased and facilitated access to whaling grounds (Alaska Consultants, Inc. and Stephen R. Braund & Associates 1984, as cited in (Stephen R. Braund & Associates 2018). By the 19th century, large whaling villages (Gambell on St. Lawrence Island, Wales, Point Hope, and Utqiaġvik) had become established, and whaling traditions were central to their culture (Alaska Consultants, Inc. and Stephen R. Braund & Associates 1984; Braund and Moorehead 1995, as cited in (Stephen R. Braund & Associates 2018).

Today, 12 Alaska Native communities hunt bowhead whales: Utqiaġvik, Nuiqsut, Point Hope, Point Lay, Kaktovik, Gambell, Kivalina, Little Diomede, Savoonga, Shaktoolik[5], Wainwright, and Wales (Suydam and George 2018). The AEWC, which is comprised of 11 of the 12 communities[6] manages the Alaskan bowhead whale harvest through an agreement with NOAA. The allowable harvest level is determined using a quota system that complies with the schedule for whaling operations of the IWC. The bowhead whale quota is based on the nutritional and cultural needs of Alaskan Native communities and on estimates of the population size and status of the Bering-Chukchi-Beaufort seas stock of bowhead whales (Donovan 1982, Braund 1992). As described in Section 6.5, to minimize impacts to bowhead whale hunting, the NSB typically requests offshore oil and gas operators to enter into a CAA with the AEWC (ADNR 2019). However, despite the assurances provided in a CAA, potential threats to whaling activities have been a major cause for anxiety about offshore oil gas development for people in Nuiqsut, Kaktovik, and Utqiaġvik (BOEM 2018). These concerns were highlighted by the Village of Nuiqsut in their comments on the potential impacts of the Liberty Development Project which stated "Potential effects to subsistence whaling practices and harvest patterns and potential effects to the community of Nuiqsut…are largely independent of potential negligible biological impacts to the bowhead population and its migration route" (BOEM 2018).

The majority of bowhead whales are taken by NSB villages. For example, over the period 1974 to 2016, of the total bowhead whales harvested (1,373) Utqiaġvik took 700 bowheads, Kaktovik 108, Nuiqsut 86, Point Hope 141, and Wainwright 132 (Suydam and George 2018). Point Lay became a member of the AEWC in 2008 and landed its first whale in more than 70 years in 2009. Shaktoolik and Little Diomede harvested one bowhead each in 1980 and 1999, respectively (Suydam and George 2018). Shaktoolik is not currently a member of AEWC.

Table 8-1 summarizes subsistence harvests of bowhead whales from all 12 villages over the period 2000–2019. The subsistence hunt for bowheads typically occurs during spring and autumn as whales migrate between the Bering and Beaufort seas. Yearly bowhead harvests are affected by environmental conditions (*e.g.*, wind speed and direction, fog, and temperature), stability of shorefast ice, and sea ice concentration, type, and movement. The success of each hunt, and therefore, the yearly totals are affected by these environmental factors, and show considerable annual and regional variation (Galginaitis 2014, Suydam, George et al. 2019).

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[5] Shaktoolik has not regularly participated in the hunt and is not listed as a member of AEWC.

[6] http://www.aewc-alaska.org; (Accessed July 3, 2021)

Table 8-1. Summary of Alaska Native Subsistence Harvest of Bowhead Whales 2000–2019

Year	Landed	Struck and Lost	Struck and Lost Mortality[a]	Total (landed + struck and lost mortality)
2000	35	N/A	N/A	N/A
2001	49	N/A	N/A	N/A
2002	37	N/A	N/A	N/A
2003	35	N/A	N/A	N/A
2004	36	7	3[a]	43
2005	55	13	2	68
2007	41	22	4	63
2008	38	12	4	50
2009	31	7	0	38
2010	45	26	6	71
2011	38	13	3	51
2012	55	14	5	69
2013	46	11	2	57
2014	38	15	12	50
2015	39	10	6	45
2016	47	12	12	59
2017	50	7	5	55
2018	47	21	17	64
2019	30	6	5	36

[a] Whaling captain's estimate on bowheads' chance of survival (assumed dead).
Source: Suydam and George (2004), Suydam and George (2005), Suydam, George et al. (2006), Suydam, George et al. (2007), Suydam, George et al. (2008), Suydam, George et al. (2009), Suydam, George et al. (2010), Suydam, George et al. (2011), Suydam, George et al. (2012), Suydam, George et al. (2013), Suydam, George et al. (2014), (Suydam, George et al. 2016, Suydam, George et al. 2017), Suydam, George et al. (2018), Suydam and George (2018), Suydam, George et al. (2019), Suydam, George et al. (2020)

The migration of bowhead whales lends to a seasonal variation in hunting by each of the villages based on their location. For example, spring hunts are typically done by westerly communities (Wales, Little Diomede, Kivalina, Point Hope, and Point Lay), the villages of Gambell, Savoonga, Wainwright, and Utqiaġvik hunt in both spring and fall, while Nuiqsut and Kaktovik only participate in fall hunts. Shaktoolik, located in Norton Sound, has not regularly participated in the hunt. In recent years, the St. Lawrence Island communities of Gambell and Savoonga have been continuing their harvests into January and February due to changes in sea ice (NMFS 2018). The level of harvest for each village is established each season through consultation with the AEWC and can be adjusted during the season if a village does not need its allocation. Figure 8-2 presents the number of whales landed by community for the period 1974–2017.

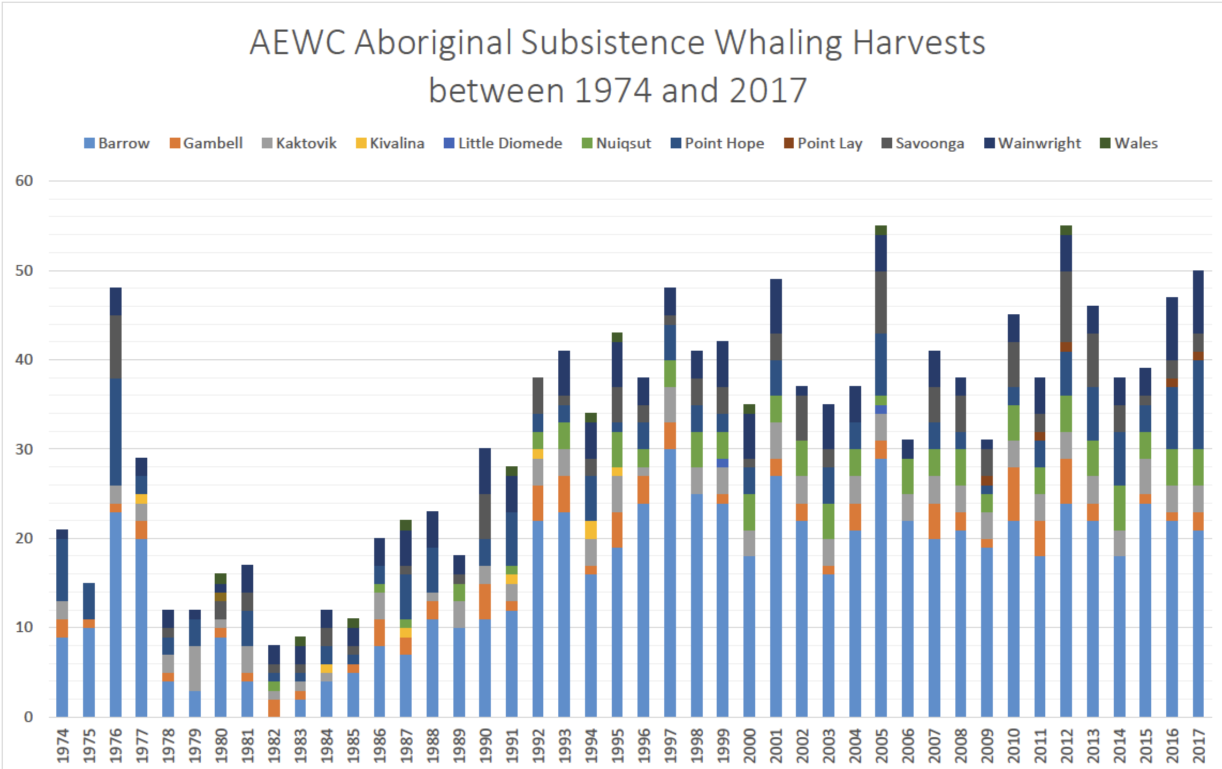

Figure 8-2. AEWC Aboriginal Subsistence Whaling Harvests 1974–2017

Description: *This figure shows the number of whales taken by 11 whaling communities. Total number of whales taken varies by year with the most (more than 50) taken in 2005 and 2012, and the fewest in 1982 (less than 10). In general, Utqiagvik (Barrow) takes the most whales each year. The total number of whales taken in the most recent year recorded was 50, with 20 taken by Utqiagvik.*

Source: NMFS (2018)

Figure 8-3 shows the Cross Island bowhead whaling boat Global Positioning System (GPS) tracklines for the years 2001–2020. Generally, Nuiqsut whalers do not prefer to look for whales greater than 32 km from Cross Island (BOEM 2018). Figure 8-4 shows the days of the year for whales landed at Cross Island by year for the period 1982–2020. Nuiqsut whalers reported that the whaling seasons are generally shorter than previous years (Galginaitis 2021). With regard to how Nuiqsut whalers ‘scout’ for whales, Galginaitis (2021) states:

> *…good fall whaling weather is determined more by wind speed and sea conditions than anything else. Whalers prefer days with no wind, but winds of 5–10 mph (8–16 km/h), or even higher, can be acceptable. Sea conditions generally correspond with wind speed, but scouting can occur with higher winds, depending on the circumstances. Ice cover generally moderates the effect of wind by dampening wave height, especially when the ice edge is not too far from shore but also to some extent when there are floating ice floes. Since 2001, the ice edge has always been quite distant from shore, and significant ice floes have been mostly absent, but have been present in several years. 2018 was one such year, in that floating ice was a significant factor in determining how far boats could travel from Cross Island and in what directions. Ice also makes whales more difficult to follow, since whales can swim under (and among) ice floes whereas the whalers must navigate around them.*

Fog was also a factor on several days in 2018, and Nuiqsut whalers only landed three whales.

Regarding concerns about oil and gas activities, and based on their observations, Nuiqsut whalers believe noise and other disturbances over the 25-year life of the Liberty operation would cause some whales to shift seaward, which could increase the distance whalers need to travel to find and strike whales. Based on their observations, Nuiqsut whalers expected that some whales would be disturbed, harried, exhibit more wary or skittish behavior, and thus become more difficult to approach for a strike (Galginaitis 2014).

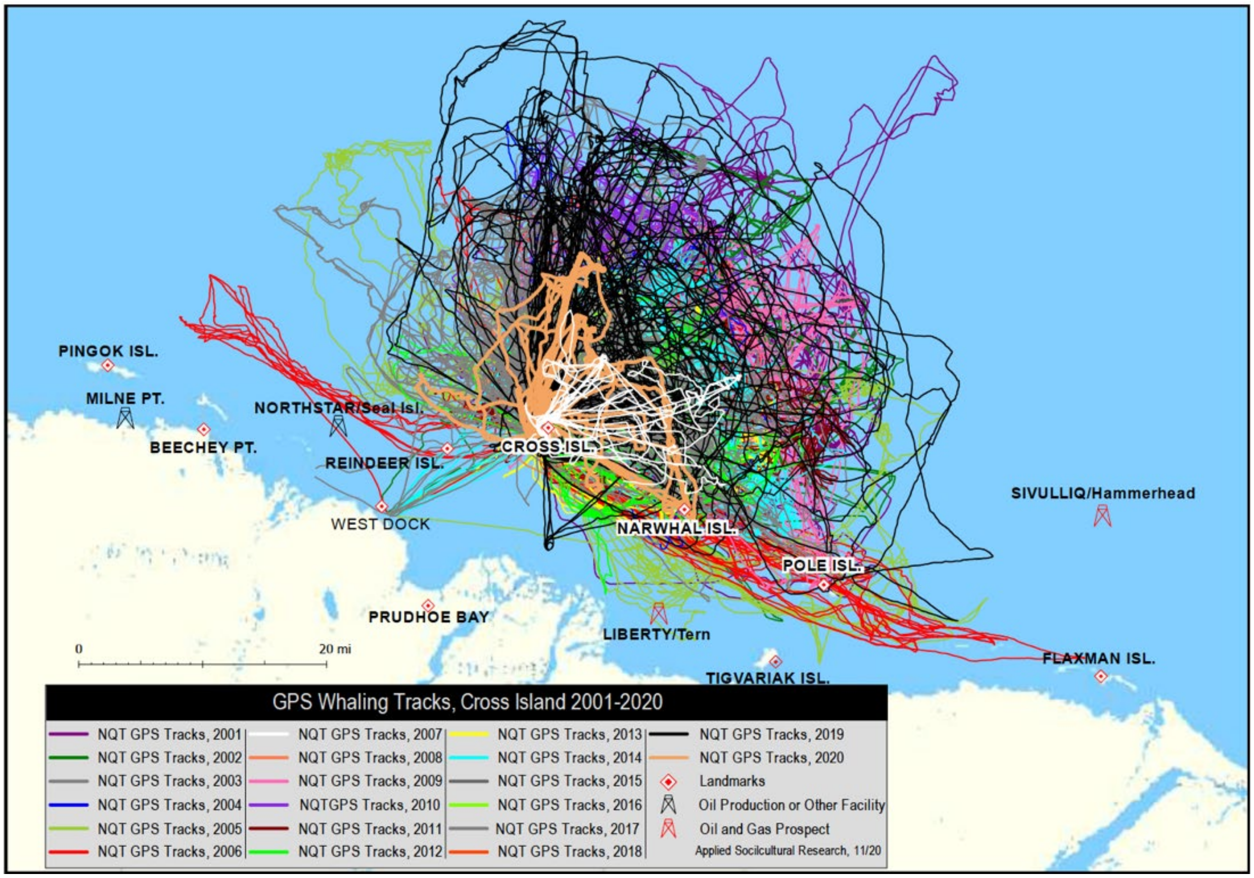

Figure 8-3. All Cross Island Subsistence Whaling GPS Tracks from 2001–2020

Description: *This figure shows whaling tracks centered on Cross Island and extending east to Flaxman Island and west of Beechy Point. In recent years, 2016-2020, the whaling has been concentrated just off of Cross Island. Tracks out to Flaxman Island and off of Beechy Point only occurred in 2006. In 2010 and 2019 whaling extended further offshore than in other years.*

Source: Galginaitis (2021)

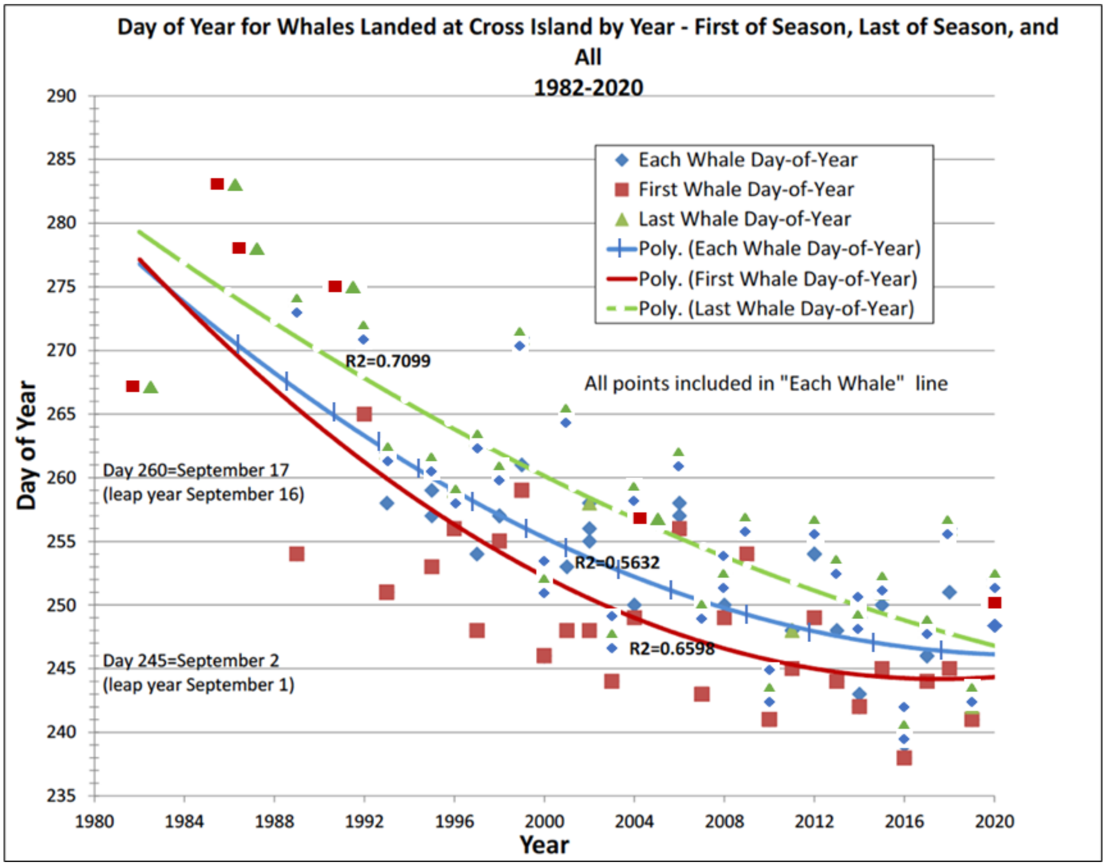

Figure 8-4. Day of Year for First, Last and All Landed Whales at Cross Island, Alaska, 1982-2020

Source: Galginaitis (2021)

8.1.2. Beluga Whale Harvests

Over the period 2014 to 2018, a total of 502 beluga whales from the Beaufort Sea stock were landed by U.S. Arctic subsistence hunters: 133 by Alaska Natives and 369 by Canadian Inuvialuit (Muto, Helker et al. 2020). A total of 275 belugas assumed to be from the Eastern Chukchi Sea stock were landed by Alaska Natives over the same time period. Beluga whales harvested by Alaska Natives at Utqiaġvik in spring are generally thought to be from the Beaufort Sea stock, while those harvested in summer are likely from the Eastern Chukchi Sea stock. These are minimum estimates of the total number of beluga whales taken, because not all struck and injured or killed whales are landed; struck and lost whales are not consistently reported (Muto, Helker et al. 2020).

In 2020, NMFS signed an agreement with the Alaska Beluga Whale Committee (ABWC) to co-manage western Alaska beluga whale populations in the Bering Sea (including Bristol Bay), Chukchi Sea, and Beaufort Sea (Muto, Helker et al. 2021). The co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of beluga whales (to the maximum extent allowed by law) as a tool for conserving beluga whale populations in Alaska.[7]

Beluga is a core subsistence species for Kaktovik; in 2011, beluga was widely shared in the community; 76% of households reported using beluga whales for subsistence purposes; and households used on average

[7] https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska; (Accessed July 3, 2021)

121 pounds of beluga in 2011 (Kofinas *et al.*, 2016). Over the period 2007 to 2012, the village of Kaktovik reported estimated beluga harvests in 3 of the 5 years: 6 whales in 2007, 2 in 2009, and 8 in 2010 (Harcharek, Kayotuk et al. 2018). Muto, Helker et al. (2021) reports that between 2014 and 2018, Alaska Native subsistence hunters took 27 beluga whales from the Beaufort Sea stock and Canadian Inuvialuit hunters took 75 from the stock. Alaska Natives harvested 55 animals from the Eastern Chukchi Sea beluga whale stock over the same period (Muto, Helker et al. 2021). However, these Eastern Chukchi Sea stock harvest numbers include takes from Kotzebue Sound (10 whales in 2014, 1 in 2015, 9 in 2016, 2 in 2017, and 15 in 2018), which are likely from a population that is genetically distinct from the Eastern Chukchi Sea beluga whale stock. Beluga whales harvested at Utqiaġvik in spring are assumed to be from the Beaufort Sea stock, while those harvested in summer are assumed to be from the Eastern Chukchi Sea stock (Muto, Helker et al. 2021).

8.1.3. Other Whale Hunting

Minke whale subsistence hunting by Alaska Natives is rare but has occurred. Officially, Alaska Natives are not authorized to take minke whales for subsistence purposes, as a harvest limit for this species in this region has not been approved by the IWC, of which the U.S. is a member nation. Only seven minke whales were reported to have been taken for subsistence use by Alaska Natives between 1930 and 1987 (C. Allison, International Whaling Commission, UK, pers. comm., as cited in Muto, Helker et al. (2020). The most recent reported catch in Alaska was of two whales in 1989 (Anonymous 1991, as cited in Muto, Helker et al. (2020), but reporting is likely incomplete. Based on this information, the average annual subsistence take was zero minke whales in 2012–2016.

There are no reports of subsistence harvest of killer whales in Alaska or Canada (Muto, Helker et al. 2020). Also, subsistence hunters in Alaska and Russia have not been reported to take fin whales from the Northeast Pacific stock or North Pacific right whales from the ENP stock (Muto, Helker et al. 2020).

Regarding aboriginal subsistence hunting of gray whales, Carretta, Delean et al. (2020) reported the following: in 2018, the IWC approved a 7-year quota (2019–2025) of 980 gray whales landed, with an annual cap of 140, for Russian and U.S. (Makah Indian Tribe) aboriginals based on the joint request and needs statements submitted by the U.S. and the Russian Federation. The U.S. and the Russian Federation have agreed that the quota will be shared with an average annual harvest of 135 whales by the Russian Chukotka people and 5 whales by the Makah Indian Tribe. Total takes by the Russian hunt during the past 5 years were: 143 in 2012, 127 in 2013, 124 in 2014, 125 in 2015, and 120 in 2016 (IWC). There were no whales taken by the Makah Indian Tribe during that period because their request for a waiver under the MMPA is still under review by NMFS. Based on this information, the annual subsistence take averaged 128 whales during the 5-year period from 2012 to 2016. The IWC reports a total of 3,787 gray whales harvested from annual aboriginal subsistence hunts for the 32-year period 1985 to 2016, which includes struck and lost whales. The estimated population size of ENP gray whales has increased during this same period.

8.1.4. Ice Seal Hunting

Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest ice seals (Ice Seal Committee 2016, as cited in Muto, Helker et al. (2020). The Ice Seal Committee co-manages the ice seal harvest with NMFS and has collected data on harvests since 2008. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information back to 1960 (Quakenbush, Citta et al. 2009).

In the Alaska North Slope region, six communities harvest ice seals: Point Hope, Point Lay, Wainwright, Utqiaġvik, Nuiqsut, and Kaktovik (Ice Seal Committee 2017). Bearded seals are the preferred species for food and umiak coverings. Ringed seals are also common for food and blubber that is usually rendered into seal oil (Ice Seal Committee 2017). Spotted and ribbon seals are also harvested (Muto, Helker et al. 2020), but not as frequently. Ice Seal Committee (2017) summarized subsistence seal takes in these communities from 1960 to 2014 (see Tables 8-2 and 8-3).

Burns and Eley (1978) reported:

> *We have seen in previous surveys that densities [of ringed seals] decrease in the vicinity of coastal villages and these decreased densities apparently are due to disturbance by snow machines and general village activities rather than by hunting. The same general trends are seen around villages whether or not much hunting is accomplished by the residents of the village.*

Table 8-2. Historical Ice Seal Takes in Kaktovik, Utqiaġvik, and Wainwright

	Kaktovik					Utqiaġvik					Wainwright				
Year	Bearded	Ringed	Spotted	Ribbon	Total	Bearded	Ringed	Spotted	Ribbon	Total	Bearded	Ringed	Spotted	Ribbon	Total
1962	ND	ND	ND	ND	**ND**	-	-	-	-	**450**	-	-	-	-	**328**
1965	ND	ND	ND	ND	**ND**	40	54	20	0	**114**	100	205	40	0	**345**
1966	ND	ND	ND	ND	**ND**	-	-	-	-	**63**	-	-	-	-	**69**
1967	ND	ND	ND	ND	**ND**	-	-	-	-	**31**	-	-	-	-	**277**
1968	ND	ND	ND	ND	**ND**	-	-	-	-	**102**	-	-	-	-	**40**
1969	-	-	-	-	**90**	-	-	-	-	**2100**	-	-	-	-	**450**
1970	-	-	-	-	**120**	-	-	-	-	**2000**	-	-	-	-	**480**
1971	-	-	-	-	**70**	-	-	-	-	**1800**	-	-	-	-	**250**
1972	-	-	-	-	**70**	-	-	-	-	**1600**	-	-	-	-	**250**
1985	21	151	0	0	**172**	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
1986	17	44	1	0	**62**	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
1987	ND	ND	ND	ND	**ND**	236	466	2	0	**704**	ND	ND	ND	ND	**ND**
1988	ND	ND	ND	ND	**ND**	179	388	4	0	**571**	97	63	5	0	**165**
1989	ND	ND	ND	ND	**ND**	109	328	4	0	**441**	74	86	12	0	**172**
1992	17	39	7	0	**63**	463	300	65	0	**828**	159	153	10	0	**322**
1994	21	16	3	0	**40**	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
1995	ND	ND	ND	ND	**ND**	431	345	0	0	**776**	ND	ND	ND	ND	**ND**
1996	ND	ND	ND	ND	**ND**	192	180	0	0	**372**	ND	ND	ND	ND	**ND**
2000	ND	ND	ND	ND	**ND**	729	586	32	0	**1347**	ND	ND	ND	ND	**ND**
2001	ND	ND	ND	ND	**ND**	327	387	7	0	**721**	ND	ND	ND	ND	**ND**
2003	8	17	0	0	**25**	776	413	12	0	**1201**	79	27	3	0	**109**
2014	ND	ND	ND	ND	**ND**	1070	428	98	0	**1596**	ND	ND	ND	ND	**ND**

ND - No data
Note: If a year is not shown, there is no data for any village during that year.
Source: Ice Seal Committee (2017)

Table 8-3. Historical Ice Seal Takes in Point Lay, Point Hope, and Nuiqsut

	Point Lay					Point Hope					Nuiqsut				
Year	**Bearded**	**Ringed**	**Spotted**	**Ribbon**	**Total**	**Bearded**	**Ringed**	**Spotted**	**Ribbon**	**Total**	**Bearded**	**Ringed**	**Spotted**	**Ribbon**	**Total**
1960	ND	ND	ND	ND	ND	28	210	1	0	**239**	ND	ND	ND	ND	**ND**
1961	ND	ND	ND	ND	ND	177	1708	2	4	**1891**	ND	ND	ND	ND	**ND**
1962	-	-	-	-	300	-	-	-	-	**2000**	ND	ND	ND	ND	**ND**
1965	ND	ND	ND	ND	ND	250	1615	150	0	**2016**	ND	ND	ND	ND	**ND**
1966	ND	ND	ND	ND	ND	-	-	-	-	**2571**	ND	ND	ND	ND	**ND**
1967	ND	ND	ND	ND	ND	-	-	-	-	**980**	ND	ND	ND	ND	**ND**
1968	ND	ND	ND	ND	ND	-	-	-	-	**264**	ND	ND	ND	ND	**ND**
1969	ND	ND	ND	ND	ND	-	-	-	-	**2300**	ND	ND	ND	ND	**ND**
1970	ND	ND	ND	ND	ND	-	-	-	-	**1900**	ND	ND	ND	ND	**ND**
1971	ND	ND	ND	ND	ND	-	-	-	-	**2000**	ND	ND	ND	ND	**ND**
1972	ND	ND	ND	ND	ND	-	-	-	-	**1800**	ND	ND	ND	ND	**ND**
1985	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	15	40	2	0	**57**
1987	13	49	53	0	115	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
1992	ND	ND	ND	ND	ND	160	365	50	0	**575**	16	24	6	0	**46**
1994	32	17	23	0	72	21	1100	0	0	**1121**	0	24	0	0	**24**
1995	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	17	155	0	0	**172**
1996	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
2000	ND	ND	ND	ND	ND	57	28	0	0	**85**	0	25	0	0	**25**
2003	32	17	2	0	51	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
2012	55	51	8	0	114	ND	ND	ND	ND	**ND**	ND	ND	ND	ND	**ND**
2014	ND	ND	ND	ND	ND	ND	ND	ND	ND	**ND**	26	58	7	0	**91**

ND - No data
Note: If a year is not shown, there are no data for any village during that year.
Source: Ice Seal Committee (2017)

8.1.5. Walrus Hunting

Villages along the Chukchi Sea coast have access to walruses each summer. Occasionally, Beaufort Sea villages may also encounter walruses. Walrus meat, skin, and blubber provide important food resources and tusks provide materials for constructing handicrafts. Over the past 60 years, estimated annual harvest levels of Pacific walruses have ranged from 3,184 to 16,127 animals (Figure 8-5) (USFWS 2014). Harvest levels since 2006 are 5% to 68% lower than this long-term average. It is not known whether recent reductions in harvest levels reflect changes in walrus abundance or hunting opportunities, but hunters consistently state that more frequent and severe storms are affecting hunting effort (EWC 2003, Oozeva *et al.* 2004, as cited in (USFWS 2014). Other factors affecting harvest levels included: 1) the cessation of Russian commercial walrus harvests after 1990; and 2) changes in political, economic, and social conditions of subsistence hunters in Alaska and Chukotka.

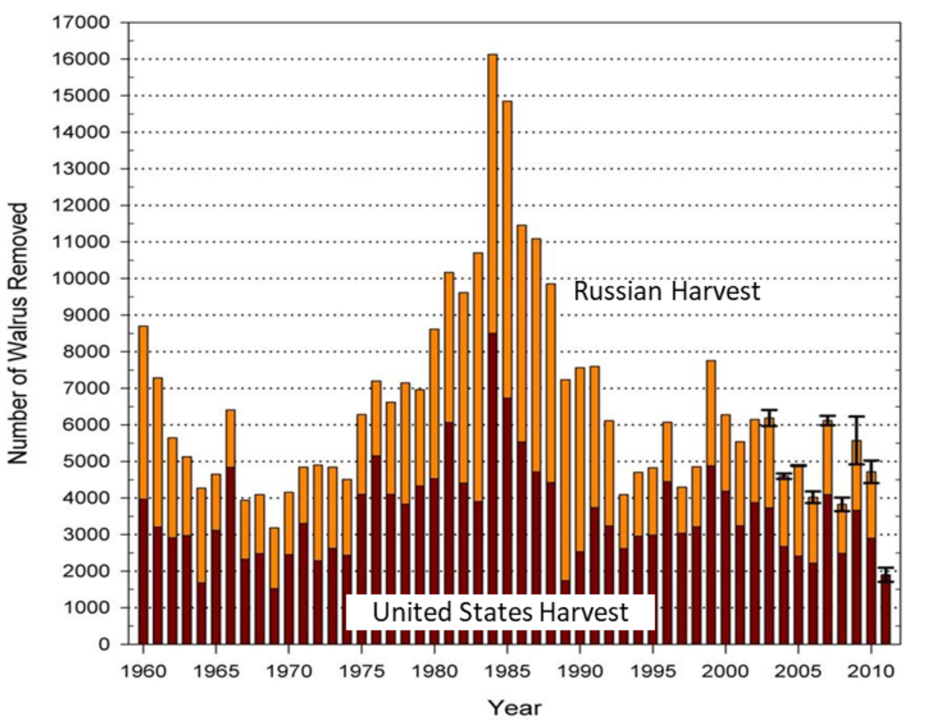

Figure 8-5. Total Annual Subsistence Harvest of Pacific Walruses 1960-2011

Source: USFWS (2014)

8.1.6. Polar Bear Hunting

Alaska Natives can legally harvest polar bears under the MMPA and ESA. The harvest of CBS stock is managed by the U.S.–Russia Polar Bear Commission; the current harvest limit is 85 bears per year (increased from 58 in July 2018), of which no more than one-third will be females (82 FR 17446). For the 5-year period from 2013 to 2018, an average of 15 bears per year were removed from the U.S. portion of the CBS stock and an additional 32 bears were removed in Russia (PBSG 2019, as cited in BLM (2020).

SBS polar bear harvests are managed through the Inuvialuit–Iñupiat Agreement, a voluntary Native-to-Native agreement between the U.S. and Canada (Nageak *et al.* 1991, as cited in BLM (2020). For the 10-year period from 2006 through 2015, an average of 28 bears per year were removed from the U.S. portion of the CBS stock, averaging 57% males, 29% females, and 14% unknown sex (USFWS 2021). For this same period (2006–2015), an average of 19 bears were removed from the U.S. portion of the SBS stock. The average sex composition of removals during this period was 27% female, 50% male, and 23% unknown

(USFWS 2021). An additional 14 bears per year were harvested in Canada (USFWS 2017). Polar bears are observed in the Kaktovik vicinity, especially in the fall, but not many are harvested (Harcharek, Kayotuk et al. 2018).

The current management protocol for lethal takes of polar bear from sources such as subsistence harvest by Alaska Natives does not allow for any additional lethal take under the MMPA from other sources, such as those that could occur during seismic surveys or other oil and gas activity (Wilson and Durner 2020).

While subsistence activities reported from Cross Island for the period 2001–2007 focus on whaling, on occasion, a polar bear may be taken if it poses a threat to hunters when butchering a whale on the island after a successful whale hunt (Galginaitis 2009).

8.2. Observations by Subsistence Users Regarding Industry and Marine Mammals in the U.S. Arctic

Observations regarding marine mammal behavior by subsistence users in the U.S. Arctic have been documented through various methods over the past 20+ years including through interviews, public comments during industry- or agency-sponsored meetings, research, or surveys. For example, research by M. Galginaitis provides detailed information on subsistence hunting of bowhead whales from Cross Island (Galginaitis and Funk 2004, Galginaitis 2009, Galginaitis 2014, Galginaitis 2019). Galginaitis began working with whalers from Nuiqsut in 1982, but it was not until June 2001 that Galginaitis was invited to be present during the fall subsistence hunt from Cross Island. Since 2001, Galginaitis has published several reports summarizing data from the hunt and whalers' observations of bowhead whale behavior, which have been included in various subsections that follow.

The following subsections provide an overview of some of the observations about marine mammals and oil and gas activities (or other disturbances) as expressed by subsistence users living in Alaska North Slope villages. For the purposes of this report, focusing on potential effects of oil and gas activities on marine mammal distribution and behavior, subsections are organized by key topics including: general human or industry activity; communication and coordination with industry; noise; oil spills; access to marine mammals; climate change; and cumulative effects. While these subheadings are not a comprehensive list, it is intended to collate subsistence user observations following the general topics discussed in this report.

8.2.1. General Observations about Industry or Marine Mammals

Richardson and Malme (1993) reported that most local residents shared that it was difficult to distinguish bowhead feeding behavior from other behavior from a moving boat at sea (Richardson and Thomson 2002). Bowheads seen from a boat are likely avoiding the boat even if they were previously feeding before the boat approached.

In a January 17, 1998 interview with T. Agiak regarding whales observed off Bernard Spit, he stated:

> *…when they get that close to the shore, there, they, ah, they spook pretty easy. Once you get close to them they take off. You can follow them in that shallow water where they swim along and...knock bubbles…that's shallow water, yeah, shallow water. Spook easier (Richardson and Thomson 2002).*

Galginaitis (2021) describes that over the 20-year study, two or three explicit observations by whalers were noted about whale feeding behavior. Whales were reported feeding on the surface of the water with their mouths open within about 16 km of Cross Island. Such observations by the whalers were considered rare meaning that such observations were not common or that feeding behavior is difficult to determine. Galginaitis (2021) acknowledges that Nuiqsut whalers do not tend to speculate about whale behavior when they are unsure, in which case they usually do not say anything. Over the study period 2001–2020, if obvious feeding behavior had been observed, it likely would have been reported. Whalers from Nuiqsut do believe that when whales stay close the Cross Island, they are likely feeding rather than migrating through. Notably, when whalers are whaling, their attention is focused on that task and marine mammal observations may not be documented often due to inclement weather or other conditions that make recording the information challenging.

Galginaitis and Funk (2004) summarized observations from the 2001 hunting season by Nuiqsut whalers stating that the whales were more skittish or "spookier" than years prior. Whales were described as staying around ice floes rather than open water, "playing hide and seek" amidst the floating ice, even when plenty of open water was available. In past years, whales were observed by hunters swimming in straight paths underwater, whereas in 2001 bowhead whale swimming behavior was unpredictable and whales would surface in locations that lacked any sort of clear pattern (rather than surfacing in a predictable pattern of locations). Possible causes for this behavior, as described by hunters, included:

- Oil and gas activities (especially survey work offshore for a natural gas pipeline);
- Barge traffic associated with the Kaktovik Sewer and Water Project;
- Killer whales offshore and east of Cross Island (not observed but hypothesized based on Elders' previous experiences);
- Ice conditions in Canadian waters; or
- Other air or water traffic east of Cross Island.

Galginaitis (2009) reported:

> *In 2001, the whalers reported that most whales they saw were farther from Cross Island than 'normal', were traveling at a greater speed than usual, and seemed 'skittish' or behavioral[ly] disturbed even before they encountered the whalers' boats. The measures of the 2001 season bear this out, as the whalers' trips for 2001 were the longest both in terms of distance and time duration of all the season documented. The average strike distance for 2001 was 19.5 miles from Cross Island.*

A 2007 paper by Noongwook, The Native Village of Savoonga et al. (2007) documented traditional knowledge from Yupik whalers of St. Lawrence Island stating that changes in environmental conditions appeared to influence the distribution of bowhead whales relative to the Island. Hunters reported greater numbers of bowheads near St. Lawrence Island in the winter and earlier spring migration.

Regarding subsistence user observations about oil and gas resources, a resident of Utqiaġvik made the following statement during a February 2019 public meeting for the EIS on the Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program (BLM 2019):

> *Energy—this—we are all talking about energy up here. That energy—because we live in the most extreme climate in the United States, maybe on the face of the planet, other than Antarctica, we should have extreme energy security up here. Energy security. And that means natural gas for our communities.*

In 2000, an investigation focused on documenting evidence of harvest disruption from oil and gas activities on the "mixed subsistence-cash economies" of Kaktovik and Nuiqsut based on respondent data collected in 1985, 1986, 1992, 1993, and 1998. As summarized in MMS (2000), Pedersen *et al.* (2000) stated:

> *Harvest effects from increasing industrialization on subsistence harvests were documented in the two communities through this study. Comparisons with similar data from SW Alaska communities indicate that variability in resource harvests between years is less strong in*

> *Nuiqsut and Kaktovik. Unsuccessful harvest of a major subsistence resource in Kaktovik in 1985, and harvest area displacement in the Nuiqsut area in 1993 (and 1994), recorded in community harvest data sets, are events firmly connected to anthropogenic effects rather than seasonal or population variations as is the case SW Alaska community data sets.*

In a report by Hovelsrud, McKenna et al. (2008), reduced access to marine mammals is described as having not only nutritional and economic implications but also effects on the transmission of traditional cultural.

8.2.2. Subsistence User Comments about Communication and Coordination with Industry

On March 28 and 29, 2000, MMS held an Information Update Meeting at the Iñupiat Heritage Center in Utqiaġvik, Alaska. Honorable George Ahmaogak, Mayor of the NSB welcomed more than 100 attendees to view 15 presentations by the oil and gas industry and MMS (now BOEM) as part of the Alaska Environmental Studies Program initiated in 1974 (MMS 2000). During a welcoming statement, Mayor Ahmaogak stated:

> *There are some issues that we at the North Slope Borough have been pounding on. Issues such as noise out in the ocean. We complain about seismic noise in the water, in the ocean, flying over the air, especially for Kaktovik whalers and Nuiqsut whalers, and it also impacts Barrow whalers. We complain about noise activity all of the time in the Prudhoe Bay area. This is an impact that we see from our standpoint.*
>
> *As mayor, that is what I see that I want to resolve…I don't want to take an adversarial (speaks Iñupiat) role. I think that is wrong. I think the way we seriously take these issues to heart if we are going to protect our whaling is to roll up our sleeves and be able to try somehow work those factors in to protect our interest instead of (speaks in Iñupiat) that isn't going to get us anywhere. But we need some clear language that is going to protect a lot of these issues. That is where I come from (MMS 2000).*

In a 2008 report by EDAW Inc., more than half the surveyed whaling captains were confident their community can influence offshore and onshore oil and gas development due to a growing responsiveness by the industry to address local concerns. For example, a specific comment stated:

> *Conditions have been placed on offshore development. They [the oil industry] understand pretty well what we are doing out there. There is better communication with industry. They inform us of their activities through public hearings, etc. Villagers have long expressed a preference for onshore development; the companies have become more adaptable and addressed village concerns such as reducing impacts on caribou migration.*
>
> *However, some whaling captains expressed that the oil and gas industry just "goes through the motions of cooperating with us (EDAW Inc., Adams/Russel Consulting et al. 2008).*

8.2.3. Subsistence User Comments about Noise in the U.S. Arctic

Huntington and Quakenbush (2009) and Stephen R. Braund & Associates (2010), Stephen R. Braund & Associates (2010) describe observations by hunters and concern that unmitigated anthropogenic noise offshore may result in changes in bowhead whale movements, and could result in making them less accessible to Alaska Native subsistence hunters. For example, Huntington and Quakenbush (2009) reported concerns raised by hunters from Kaktovik that noise from offshore oil activity in their traditional hunting area will cause animals to move offshore, making them more difficult to hunt. Hunters from Utqiaġvik noted that changes in sea ice and increased noise from snowmachine travel on the fast ice have led to noticeable changes in the spring bowhead whale migration. In addition, the hunters commented that bowhead whales avoided an area offshore of Point Barrow when a test well in the area was being drilled, where the whales returned to the area after the drilling was completed.

EDAW Inc., Adams/Russel Consulting et al. (2008) reported that noise and other disturbances from industry activity is designated as the major factor in the disturbance of bowhead migration patterns during the fall whaling season, whereas changes in the spring bowhead migration pattern are largely attributed to climate change. A high percentage of surveyed whaling captains (69%) from the NSB felt it was not possible to have oil and gas development offshore while also providing safeguards to protect the environment and important cultural activities (EDAW Inc., Adams/Russel Consulting et al. 2008).

Iñupiat whalers believe that some migrating bowheads are diverted by noises at greater distances than have been demonstrated by scientific studies (BP Exploration Alaska 2009). The whalers have also mentioned that bowheads sometimes seem more "skittish" and more difficult to approach when industrial activities are underway in the area (Galginaitis 2006; 2007, as cited in BP Exploration Alaska (2009); and public comments at NMFS, Open Water Meeting, April 2010, Anchorage, Alaska).

In an interview conducted on January 16, 1998, G. Kaleak stated:

> *...out here, and hardly any whales, cause activity was going on. Also seismic activity. And it showed in their study, when we was in Prudhoe, that when, every time they, you know they were using that air hammer to detect the seismic activity below it there was no whales spotted—very little. Then after, after they shut down the numbers were like in the hundreds, that they had spotted. And it, and they told them that, yeah, no whales are going to go around a seismic boat or vessel (Richardson and Thomson 2002).*

The AEWC has commented extensively on the issue of noise impacts to bowhead whales, beluga whales, and other marine mammals:

> *As has been documented time and time again, bowhead whales, beluga whales and other marine mammals react to very low levels of underwater noise. Studies conducted by Richardson and others, as have been discuss[ed] in the 2008 Arctic Regional Biological Opinion, document bowhead whale deflection when received sound levels are at or perhaps lower than 120 dB. More recently, we understand that monitoring activities from Shell's seismic activity in the Beaufort during 2007 and 2008 demonstrate that call detection rates drop significantly during airgun operation. Disruption of communication and migration patterns certainly meets the definition of "harassment" under the MMPA and therefore must be regulated by NMFS. (NMFS 2016)*

Harry Brower, representing the AEWC, in written comments dated April 9, 2010 stated:

> *Our observations, proven correct time and again by scientific research, are that bowhead whales change their behavior when industrial activity is taking place in their usual habitat. Because of these changes in behavior, the whales become less available or completely unavailable to our hunters during the time the activity is occurring, due both to noise disturbance and to pollution in the water. We also are very concerned that some habitats might be abandoned altogether if industrial activity increases or if it is undertaken in a way that creates ongoing disturbance.*

Similar comments were made by the ABWC regarding beluga whales and potential noise from proposed seismic operations in the Chukchi and Beaufort seas. A 2007 ABWC letter to NMFS stated:

> *Even small disturbances are known to impact the hunt and alter behavior of the whales this time of year and in these areas…Belugas have good hearing sensitivity across a*

> *relatively wide frequency band. They are known to be sensitive to noise from human activities. Traditionally, village residents were required to stay away from the shoreline and maintain silence near the shoreline as the time for beluga hunting approached, so as not to deflect the belugas away. Hunters in Kotzebue Sound, to the south of Kasegaluk Lagoon, have observed that belugas avoid areas of high boat traffic, noise from the shore, or frequent overflights by aircraft. (ABWC 2007)*

Huntington (2013) noted that whalers from Kaktovik and Nuiqsut were very concerned regarding the impact industrial activity in Camden Bay would have on their subsistence hunting. It was recognized that while CAAs help mitigate impacts of human activities, not all vessel operators are part of CAAs. Community members recommended that studies be conducted on the long-term impact of industrial activity on the presence and use patterns of marine mammals in Camden Bay. Similar requests for long-term, comprehensive studies on the impact of industrial activities on subsistence hunting and the marine mammal populations on which they are dependent are common from both coastal communities in the Beaufort and Chukchi seas and non-governmental organizations.

Stephen R. Braund & Associates (2013) commented that, based on their interviews with community members in the Nuiqsut region, a majority of mitigation measures were, in concept, considered effective. However, individual mitigation stipulations varied in effectiveness due to differences in how they were implemented by development companies. No measures were considered "ineffective" in their design, but rather in their implementation. In many cases, key informants provided recommendations for how a mitigation measure could be enhanced to improve its effectiveness. Stephen R. Braund & Associates (2013) found that in a number of cases, local residents were unaware of the presence of a mitigation measure. In addition, local residents' frustrations were often directed toward the mitigation process rather than the mitigation measures themselves, indicating that improved communication and consultation with local communities could improve local perceptions related to mitigation. Finally, the study team found that in most cases, there is no official mechanism for monitoring mitigation measures after they have been implemented, or for measuring their effectiveness. This is particularly true for social mitigation measures aimed at reducing impacts on subsistence activities.

Alaska Natives have noted that bowheads may become increasingly "skittish" in the presence of seismic noise and exhibit behaviors such as tail-slapping, which translates to danger for nearby subsistence harvesters (NMFS 2006). Alaska Natives and the IWC have expressed concerns that cumulative effects of increased or concurrent seismic surveys in the Chukchi and Beaufort seas may have population-level effects on subsistence stocks. Such impacts would have long-term effects subsistence harvests.

NMFS (2012) stated:

> *Iñupiat subsistence whalers have stated that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and, thereby, is interfering with the subsistence hunt at Barrow (Ahmaogak 1989). Whalers have reported reaction distances, where whales begin to divert from their migratory path, on the order of 10 mi (T. Albert cited in USDOI, MMS 1995) to 35 mi (F. Kanayurak in USDOI, MMS 1997). Kanayurak stated that the bowheads…are displaced from their normal migratory path by as much as 30 miles.*

Aerts and Richardson (2008) also noted that "skittish" behavior by bowheads was reported by Nuiqsut whalers:

> *Skittish' is defined as whales traveling faster, spending more time on the surface or near the ice edge, or exhibiting a more erratic course during migration. In 2007, whalers noted*

> *that bowheads were more difficult to follow … whalers do not want vessel activity east of Cross Island but tolerate vessels to the west [where Northstar is located].*

Observations by subsistence hunters documented in Stephen R. Braund & Associates (2010) have commented on noise disturbing seals stating:

> *Point Hope is having hard time catching seals. There was a little seismic operation that went on in the Arctic a few years back, and our seals haven't come back yet—Earl Kingik, Point Hope (NMFS 2011).*

In a study of subsistence hunting in Utqiaġvik, Nuiqsut, and Katktovik, Stephen R. Braund & Associates (2010) found that while ringed and bearded seals can be hunted year-round, there tends to be a peak in July for seal hunting by these communities. Additionally, while most of the identified hunting areas in the study were closer to shore, some hunters traveled between 32.2 and 40.3 km offshore to hunt seals, with the mouth of the Colville River and Thetis Island shown as popular seal hunting grounds.

Appendix B of the 2018 Final EIS (BOEM 2018) for the proposed Liberty project in Foggy Island Bay of the Beaufort Sea summarized public comments on marine mammals stating an overarching concern that underwater noise from the project could cause bowhead whales to shift from their migratory path and thereby, affect the Nuiqsut bowhead whale subsistence hunt.

8.2.4. Subsistence User Comments about Oil Spills in the U.S. Arctic

Small oil spills have the potential to impact sociocultural systems by affecting subsistence harvest patterns (BOEM 2018). Subsistence harvesters could purposely reduce their harvests of a particular subsistence food resource or avoid hunting areas altogether due to potential contamination of habitats and wild foods. This in turn affects the cultural practice of harvesting and the social and nutritional practices of sharing and consuming wild foods (BOEM 2018). In the unlikely event of a large spill, impacts could be expected to occur for whaling for Kaktovik and Utqiaġvik crews (BOEM 2018), primarily due to avoidance because of potential contamination of bowhead whales as a food source.

Braund and Kruse (2009) noted that:

1. There was a consensus among Alaska North Slope residents that oil and gas activities individually and through cumulative effects posed a threat to the subsistence lifestyle on the Alaska North Slope;
2. Alaska North Slope residents fear the consequences of an oil spill, primarily due to the industry's inability to clean up an oil spill in ice-infested waters;
3. Hunters have concerns that anthropogenic noise related to oil and gas activities will impact marine mammals and other wildlife species such that successful hunts of animals will be more expensive, take longer, and pose a greater risk;
4. Contamination from drilling mud of fish used for subsistence is a concern;
5. Climate change is linked to oil and gas development and together result in greater adverse cumulative effects; and
6. Community members were aware of mitigation efforts on the part of the oil and gas industry.

The document included specific quotes and suggestions from individual community members, which were informative. Stephen R. Braund & Associates (2010) documented the concern among community members that there is no plan to remove oil from ice-infested waters, and that persistent oil from a spill or unauthorized discharge will severely damage their "ocean garden". The image of damage to their "ocean garden" comes up frequently in statements from community members concerned regarding the potential impacts of oil and gas activities on their culture and lifestyle. Similar concerns were expressed by Edwardson (2012) and Whiting (2012).

The following statements, respectively, were from the village of Point Hope (Cannon 2011), the mayor of the NSB (Itta 2011), and the Vice President of the Koniag Corporation (Powers 2011) regarding comments on Chukchi Lease Sale 193:

> *The Native Village of Point Hope is gravely concerned about the potential effects of oil and gas development on the Arctic Ocean. The analysis seems rushed and incomplete. We are encouraged that BOEMRE has now for the first time admitted that a very large oil spill is possible in the Chukchi Sea from oil drilling. But the analysis contained in the revised SEIS is confusing and does not give a clear picture of what an oil spill would look like or how it would affect our Ocean and coasts. For example, it does not tell us what the oil plume would look like, and it only gives big ranges of the amount of the coast that would be covered if there were an oil spill. We urge BOEMRE to complete an analysis that addresses these shortcomings and provides a clearer picture of the consequences of a large oil spill. We also urge BOEMRE to discuss more deeply the shortcomings of oil spill response in the Arctic Ocean, with its harsh and remote conditions, [and]*

> *The NSB continues to hold the position that leasing and oil and gas industry operations should not be permitted in the Chukchi Sea. As we outlined again in our November 2010 comments, this position is based on our longstanding beliefs that the risk of a significant oil spill cannot be eliminated, that the capability does not exist to effectively respond to such a spill in our remote and challenging environment, and that too little is known out the ecosystem. Additional comments included the following topics: significance thresholds for impacts are problematic; pollution control technologies undertaken elsewhere in the Arctic should be considered; and additional mitigation measures such as zero discharge technology, no Chukchi Sea transit until July 15 or the end of the beluga hunt, measure to avoid bird strikes; shutdowns to avoid the fall hunts, and making monitoring and environmental data public., [and]*

> *…the SEIS provides sufficient information and analysis; Sale 193 is critical to Alaska's future economy; safety and environmental standards are sufficient and efforts will be guided by lease stipulations; mitigation measures such as seasonal operating restrictions will minimize effects; and many jobs would be created.*

Brower (2015) commented that a number of mitigation measures should be considered and included in future CAAs. These measures would include: 1) an oil spill contingency mitigation agreement; 2) protection of subsistence resources; 3) aircraft and vessel limitations; 4) protection of the area referred to as the "boulder patch"; 4) native allotment mitigation; 5) noise mitigation and monitoring; 6) offshore monitoring; 7) improvements in blow-out protection; 8) safety of the proposed primary drilling rig; 9) seasonal drilling restrictions, 10) well capping equipment and relief well rig; 11) Oil Spill Response Plan and well control plans; 12) waste management and disposal; 13) subsea pipeline and leak detection; 14) tank or pipeline source controls and spill prevention methods; 15) air quality impacts; 16) human health impacts; 17) economic benefit plans; and 18) abandonment plans. This list of mitigation actions, if fully implemented, would contribute considerably to the reduction of angst in the coastal communities in the Beaufort and Chukchi Sea region.

8.2.5. Observations from U.S. Arctic Subsistence Users Regarding Climate Change

In a subsistence study for the communities of Wainwright and Point Lay, Stephen R. Braund & Associates (2013) reported that variability in hunting success was attributed by community members to the following variables: ice; wind; aircraft and vessel traffic; and other factors such as resource health or equipment failures. The most persistent concern raised by hunters who participated in the study was absence of sea ice, which could result in an increase in frequency of storms and increased sea-state impacting the ability to conduct a subsistence hunt (BOEM 2018).

As described in Hovelsrud, McKenna et al. (2008), successful marine mammal hunting often strongly influences a community's vulnerability to climate change because successful harvest is closely tied to the sensitivity and resiliency of marine mammals to such changes. Significant changes to the health, distribution, and composition of marine mammals relative to the communities that hunt them are expected due to climate change.

Transcripts from a public meeting in Kaktovik, Alaska held on February 5, 2019 for the Final EIS on the Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program (BLM 2019) included a comment regarding climate change and polar bears stating:

> *The polar bear situation is because of climate change. The ocean is opened up right now out there. It's been open a lot. The bears are coming ashore because of climate change. It's not the problems that they are getting used to us being around them. It's they don't have a habitat. They are coming ashore, and that's directly related to the oil situation. The fact that we have climate change, the oil is open - - the ocean is open, and the bears have to come ashore. So you know - - and some of it could be mitigated by the whaling captains. They took a lot of blubber this year and threw in (sic) the ocean. That could have been food for the bears.*

Since 2016, a multidisciplinary team out of the Lamont-Doherty Earth Observatory has been working with community elders in Kotzebue to study the changes in sea ice and marine life in the Kotzebue Sound.[8] This community-based research project, *Ikaaġvik Sikukun* (Iñupiaq for ice bridges), combines decades of knowledge from the elders with scientific data to understand the impact that climate change has had on the area and the Indigenous way of life. The community's traditional way of life and subsistence living, which depends on hunting bearded seals, is being threatened by rapidly melting sea ice coverage and a reduced hunting season. From the local subsistence perspective, the study found that climate change affected how the receding ice made it physically more challenging for the community members to hunt on the ice and the duration of the hunting season which is becoming much shorter. These combined factors has made hunting seals, which the community needs for subsistence, general well-being, and maintaining an Indigenous way of life, much more difficult.

Huntington, Quakenbush et al. (2016) commented that based on interviews with subsistence hunters in coastal Alaska the following concerns, amongst others, were identified: 1) extensive changes in sea ice and weather affecting the timing of migrations and the distribution and abundance of marine mammals in traditional hunting areas; and 2) technological advancements (*e.g.*, better and more reliable outboard engines) and modified hunting practices have allowed hunters to adjust to environmental changes and increased human activities. Huntington, Quakenbush et al. (2016) concluded that it was uncertain as to whether the hunters could adapt to further changes. More importantly, the hunters are aware that there may be limits to accommodations they can make regarding to access to marine mammals in a period where the Arctic is warming and sea ice is receding.

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[8] https://www.ikaagviksikukun.org/; (Accessed September 9, 2021)

8.2.6. Observations from Subsistence Users Regarding Cumulative Effects in the U.S. Arctic

Public comments summarized in the 2018 Final EIS for the proposed Liberty project noted that the EIS failed to place potential impacts of the project in the context of increased industrialization around Nuiqsut "that comes to the community from all sides". The commenter further stated that the EIS "fails to cope with the multiple and cumulative effects of increasing development around Nuiqsut" (BOEM 2018).

In the May 2020 Eastern Bering Sea Beluga Whale Newsletter[9] published by ABWC, a resident of Unalakleet was cited as stating:

> *Beluga has always been an important food source for indigenous people of northern Alaska. We understand that most if not all our food sources are under attack from global warming or industrial activities. It is the duty of all people to protect all species from becoming extinct so that our children and grandchildren too will come to enjoy and appreciate our way of life (Frank Katchatag, Native Village of Unalakleet).*

Huntington, Quakenbush et al. (2016) also commented that based on interviews with subsistence hunters in coastal Alaska industrial activity (*e.g.*, shipping and oil and gas development) causing marine mammals to avoid areas important to the hunters was of concern. This statement and others expressing similar concerns provide strong support for the development of and commitment to long-term monitoring programs to 1) track the success rate of marine mammal subsistence hunters by year and by species; 2) monitor the abundance level of key marine mammal species, 3) monitor levels of anthropogenic noise in the marine environment, and 4) track changes in key socioeconomic indices related to the culture and lifestyle of coastal communities in the Beaufort and Chukchi seas region (Nasgovitz 2017). Regarding such efforts, Robards, Huntington et al. (2018) provided comments on successful practices in the past, which integrate the opinions of coastal community members. A commitment to long-term funding and long-term study designs to adequately capture the multifactorial nature of impacts on the lives and culture of coastal community members over the next 20 years (USFWS 2018). Moore and Reeves (2018) provide further recommendations regarding the development of metrics needed to evaluate the resilience of bowhead whale populations in the Arctic.

The 2019 public meeting transcript from Kaktovik for the Final EIS on the Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program (BLM 2019) included a comment regarding potential cumulative effects on polar bears and how that, in turn, affects local communities on the Alaska North Slope. The specific comment stated:

> *More people in the Lower 48 have more opportunities to go up inland and look at the animals or enjoy the wildlife than we do…You speak about the bears, about their impact and everything. What about the impact that the tourism has with the bears? We have had six bears taken this year because they are so used to having people around them that won't do anything to them to having boats around them constantly all summer long to where they can't disturb them, they can't shoo them off, they can't do anything. So they are used to coming into town and thinking that nothing is going to happen to them. But it's become a danger to our community, a danger to our children, danger to our families. But people are putting more importance on animals than they are on the people in the community.*

It should be recognized that, given the dependence of U.S. Arctic coastal communities on subsistence hunting for food, food security is a primary concern to all community residents in this region. Community

[9] http://www.north-slope.org/departments/wildlife-management/co-management-organizations/alaska-beluga-whale-committee/abwc-newsletters; (Accessed September 8, 2021)

angst regarding food security is a primary example of cumulative effects. For example, Wainwright hunters focused comments on how environmental features combined with anthropogenic activities can influence access to bowhead whales, bearded seals, and walruses (Stephen R. Braund & Associates 2013).

8.2.7. Alaska North Slope Social Indicators within the Context of U.S. Arctic Oil and Gas Activities

Alaska Native communities have a rich and distinct culture strongly tied to marine mammals. The relatively recent transition from a traditional subsistence culture to a more cash-oriented economy due, in large part to oil and gas activities, is likely contributing to anxiety about cultural identity and social well-being. (Kruse, Kleinfeld et al. 1982) provided an important overview of how oil and gas development on the Alaska North Slope affected Iñupiat communities. Energy development has had positive effects including tax revenues, job creation, and an extensive system of public facilities and services (*i.e.*, schools, medical clinics and utilities); however, several social problems (*i.e.*, alcoholism, traumatic death such as homicide and suicide) that have undermined Iñupiat cultural stability have been documented (Kruse, Kleinfeld et al. 1982).

Evidence of climate change is further contributing to feeling a lack of control over life. Over the last four decades, major changes in infrastructure including air travel, education, utilities, telecommunications, health, retail food and household goods, and recreation have also altered the way Alaska North Slope residents live (Stephen R. Braund & Associates 2009).

Beginning in the 1970s, there have been a series of social indicator studies in Alaska, primarily focused on Alaska's North Slope communities. A 2011 study funded by BOEM entitled "Social Indicators in Coastal Alaska: Arctic Communities" (SICAA) intended to develop and implement a "social indicator system" on Alaska's North Slope. The study, drawing on previous social indicator research dating back to the 1970s, was to provide baseline data on the well-being of Alaska North Slope residents (Stephen R. Braund & Associates 2017). The study lists SICAA social indicators for Alaska North Slope communities, as defined in Table 8-4 in terms of common indicators used for the period 1977–2003.

Table 8-4. Comparable Social Indicators of Living Conditions on Alaska North Slope: 1977–2003

SICAA Domain	Common Social Indicators 1977–2003
Economic Well-Being	Work for pay
	Number of subsistence activities
	Satisfaction with job opportunities
	Satisfaction with kinds of things you can buy in stores
	Satisfaction with cost of living
	Lifestyle preference
	Satisfaction with health services
	Perception of drinking, drugs, fighting, stealing
Cultural Continuity	Satisfaction with sharing and helping
Local Control	Voting behavior
	Satisfaction with influence over oil development
Education	Voting behavior
	Satisfaction with influence over oil development
Physical Environment	Proportion food from subsistence
	Satisfaction with amount of fish and game available locally
	Satisfaction with opportunities to hunt and fish
Overall Well-being	Satisfaction with village life

Source: Stephen R. Braund & Associates (2017)

Stephen R. Braund & Associates (2009) reported that fear of impacts from offshore oil and gas exploration and development on subsistence was becoming more evident through research using social indicators, even in the absence of realized impacts. In other words, perceived or anticipated impacts may be just as notable as realized impacts of oil and gas on subsistence activities. For example, (Braund and Kruse 2009) stated that in the 1980s, the Iñupiat expressed fear that industrial noise would divert bowhead whales from the seasonal migratory route. While there are multiple social indicators that have been defined in literature since the 1970s and 1980s, Stephen R. Braund & Associates (2017) reported a general continuity with the terms and definitions used to assess potential effects of oil and gas activities on Alaska Native communities. The 2017 SICAA report summarizes the results of household surveys designed to establish a baseline against which future impact assessments could be compared using social indicators. The SICAA survey documented subsistence activities in which Alaska North Slope residents had participated during the recent year (2015) and asked whether they had experienced effects of oil and gas activities during those subsistence activities. This section provides a brief synopsis of information available in the literature within the framework of the SICAA indicators listed in Table 8-4, focusing on marine mammal subsistence, where possible.

The SICAA study reported that 26% of whaling captains in the region reported an impact from oil and gas activities. In Kaktovik, 50% of whaling captains interviewed reported an impact, and in Nuiqsut 45% of whaling captain respondents reported an impact. Additionally, between 6 and 33% of whaling crew members in the six survey communities reported some form of impact of oil and gas development on their subsistence (Stephen R. Braund & Associates 2017).

> *The principal types of reported impacts on subsistence whaling in 2015 were disruptions to migration, auditory disruptions, difficulty hunting, and the need to travel farther. The principal categories of industry activity that caused impacts to subsistence whaling in 2015 were marine vessels and barges; various types of aircraft; and drilling. The principal methods to mitigate impacts…were (1) honoring the convention with subsistence hunters not to disrupt traditional subsistence activities, (2) avoiding seismic, drilling, barge, and overflight activities during hunting periods, (3) being more responsive to hunters' needs, and (4) no development activities in subsistence hunting areas/ocean. Whaling impacts were reported from March through October, with almost half (48 percent) of reports of impacts during the fall hunting month of September.*

8.2.7.1. Economic Well-Being

A number of publications address the positive effects of oil and gas development on coastal communities in the Beaufort and Chukchi seas region (Braund and Kruse 2009, Stephen R. Braund & Associates 2017). For example, Fagnani (2015), the CEO of the Aleut Corporation at the time, offered support for the Liberty Project, citing the job opportunities, economic benefits, past responsible construction of artificial islands, and a 30-year safety record of operating offshore in the U.S. Arctic. Stephen R. Braund & Associates (2017) reported that in 2003, approximately one-third of Alaska North Slope communities were "very satisfied" with their household income and jobs. However, approximately 35% of households surveyed during the SICAA study reported being "very dissatisfied" with the cost of living in 2016.

The 2019 transcript from the public meeting held in Kaktovik, Alaska on the Final EIS for the Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program (BLM 2019) documented the following comment from a Kaktovik resident:

> *…the taxation from oil development, look at what it's brought. I speak to the elders all the time and they say don't want (sic) to go back to wood stoves or anything like that. Look at the benefits that we get for our children, the schools, the hot water, the plumbing, everything. All our road system. All of that is due because of oil development.*

Anxiety about how life changed with oil and gas development and, in particular, the associated increase in money (i.e., income or tax revenues) was reported through interviews conducted by Kruse, Kleinfeld et al. (1982) in the late 1970s. Specific comments by Iñupiat residents were that "People's way of living has changed because of too much money" and that "Materially we're better off [but] the culture is being lost faster.*"*

8.2.7.2. Cultural Continuity

Surveys of coastal community members in the Beaufort and Chukchi sea region have identified numerous information needs including: 1) development of a comprehensive research plan; 2) design and implement a survey to better understand perception of community youth and students; and 3) an in-depth investigation of the dependence on subsistence foods in the four communities (EDAW Inc., Adams/Russel Consulting et al. 2008). Many community members feel that more information is needed to ensure that impacts from oil and gas development will not damage their culture and way of life

In 2003, two-thirds or more of Alaska North Slope, Bering Straits, and Northwest Arctic Iñupiat households reported that a lifestyle involving both wage work and harvesting, herding, or processing their own food was preferred. The percentage of Alaska North Slope Iñupiat preferring "both" was higher in 2016 than in 2003 (Stephen R. Braund & Associates 2017). Kruse (1991) also acknowledged that subsistence activities (harvest and distribution) offer benefits well beyond nutrition that are less common with jobs that pay a wage.

8.2.7.3. Local Control

A number of CAAs and POCs highlight the importance of support for improved communications between coastal communities and industry during periods of oil and gas activities. It is recognized that adequate communications are not possible without an adequate infrastructure, which is entirely lacking in many of the smaller (*i.e.*, non-hub) communities along the coast of the Chukchi and Beaufort seas. Commonly in CAAs and POCs, support including communication infrastructure and labor is agreed to between industry and the local communities.

Stephen R. Braund & Associates (2017) reported that 56% Alaska North Slope Iñupiat households were very satisfied with their influence on the management of natural resources, as compared with only 42% in the Northwest Arctic (*i.e.*, Chukchi Sea communities). In addition, 74% of Alaska North Slope Iñupiat households were at least somewhat satisfied with their influence on reducing environmental problems in their area compared with 70% in the Northwest Arctic.

During a February 2019 public meeting for the EIS on the Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program (BLM 2019), a resident of Utqiaġvik stated:

> *We have lots of new technologies today proven. We have been pumping subsea pipeline oil to market for 20 years now. New technologies that could alleviate some of the mitigation issues. They use thaw-stable areas nearshore and some of the rivers, like the Sagavanirktok River.*
>
> *…policies are ingrained in our Title 19, including the coastal resource atlas, which has a lot of good information that you could garner from. And it's good information that we use to help guide and steward large project reviews internal to the North Slope Borough. So very important tools can be used and not—it gives you a— almost a crystal ball view of the resources and how they move into traditional knowledge.*

TK shared with resource managers, such as that used to develop the coastal resource atlas described by this Utqiagvik resident, may provide opportunities for communities to exhibit local control by informing the regulatory process with local knowledge.

8.2.7.4. Education

In the 1970s, there was a marked increase in high school education opportunities on the Alaska North Slope. Approximately 62% of Alaska North Slope households surveyed in 2015 during the SICAA study had a high school diploma, substantially higher than in 2003 (38%). However, in both 2003 and 2016, the percentage of Iñupiat households with a vocational or college degree lagged behind that of the international comparison regions as documented in 2003 (Stephen R. Braund & Associates 2017).

8.2.7.5. Physical Environment

In 2003, approximately 32% of households surveyed in Alaska North Slope communities expressed concern about pollution and contaminated fish and animals. Pollution was reported by survey respondents as due to industrial development (Stephen R. Braund & Associates 2017).

8.2.7.6. Overall Well-Being

Overall well-being can be described as satisfaction with life as a whole. In 2003, 95% of Alaska North Slope households were at least somewhat satisfied with life. In 2016, 60% of Alaska North Slope Iñupiat households surveyed by Stephen R. Braund & Associates (2017) reported being "very satisfied" with life. Compared to the Northwest Arctic communities, these percentages were higher, indicating a slightly better sense of overall well-being on the Alaska North Slope for the study period. Over a 10-year period (1977–1988), Kruse (1991) reported that while wage-paying jobs increased among Alaska North Slope Borough residents, subsistence activities also increased suggesting that a subsistence lifestyle is not just a matter of necessity but support overall wellbeing of Iñupiat.

In February 2019, a public meeting was held in Utqiaġvik regarding the proposed Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program (BLM 2019). Transcripts from the meeting noted a comment regarding the significance of bowhead whaling to the culture, health, and food security of the community:

> *When you look at our whaling, we are reminded by beautiful pictures of whaling and paintings of them here. We look at the responsibility of the whaling captain, which is— covers quite a bit. When you look at the whaling captain's responsibility over time, to look out for their people, to provide for, to encourage, to get people involved, to go after something as huge as a whale, we had to work together. That's a friendly reminder for all of us, working together. I always put it this way: Anybody can catch a seal or a caribou and feed their family for a day or a week or whatever that will bring. But if you are going to be serious about feeding your community for a year and beyond, you have to work together to harvest something that big.*

8.3. Marine Mammal Subsistence Activities in Cook Inlet

Subsistence harvest of marine mammals by Alaska Natives in Cook Inlet is limited relative to their use in the U.S. Arctic. Table 8-5 summarizes subsistence use harvest of marine mammals as recorded in SARs (USFWS 2014, Muto, Helker et al. 2020, Muto, Helker et al. 2021). Harvests are recorded in the table for the most recent period that data are available.

Table 8-5. Summary of Alaska Native Annual Subsistence Harvest Levels for Marine Mammal Species in Cook Inlet[1]

	Beluga Whales	Other Cetaceans	Harbor Seals	Steller Sea Lion	Sea Otter
Number Harvested	0 (2018-2022)[2]	0 (2013-2017)	233 (2004-2008)	20 (2011)[4] 8 (2014)[5]	369[3] (2006-2010)

Sources: USFWS (2014), USFWS (2014), (Muto, Helker et al. 2020), Muto, Helker et al. (2021)
[1] Period for which the data are provided in parentheses
[2] 2014 and 2016 population estimates were below 350 whales (Wade, Boyd et al. 2019), so harvest is not allowed for 2018-2022
[3] 76 animals from the southwest Alaska DPS and 293 animals from the southcentral DPS
[4] Harvested on Kodiak Island
[5] Harvested in southcentral Alaska

8.3.1. Beluga Whale Hunting

Subsistence harvest of Cook Inlet beluga whales was an important to Alaska Natives residing in Tyonek and Alaska Native subsistence hunters in Anchorage. Between 1993 and 1998, annual subsistence take of Cook Inlet belugas ranged from 17 to more than 123 individuals (NMFS 2016). Annual subsistence take by Alaska Natives during 1995 to 1998 averaged 77 whales (Angliss and Lodge 2002, as cited in (NMFS 2016). The harvest was as high as 20% of the population in 1996 (NMFS 2016).

Cook Inlet beluga whale abundance estimates significantly declined between 1994 and 1998; in 1999 Cook Inlet subsistence hunters voluntarily stopped hunting and the federal government took actions to conserve, protect, and prevent further declines in the abundance of these whales (Muto, Helker et al. 2021). Public Laws 106-31 (1999) and 106-553 (2000) established a moratorium on Cook Inlet beluga whale harvests and required that harvests only occur pursuant to a cooperative agreement between NMFS and affected Alaska Native organizations. In December 2000, interim harvest regulations for 2001 through 2004 were created (69 FR 17973, April 6, 2004). Three Cook Inlet beluga whales were harvested under this interim harvest plan over the 2001–2004 period. In August 2004, a long-term harvest plan, which allowed up to eight whales to be harvested between 2005 and 2009, was created (NMFS 2008). Two whales were harvested in 2005 and no whales have been harvested since that year. In 2007, The Native Village of Tyonek agreed not to hunt the whales.

The final rule on long-term harvest of Cook Inlet belugas was signed in 2008 (73 FR 60976). It established the harvest level for a 5-year period based on the average abundance in the previous 5-year period and the growth rate during the previous 10-year period (NMFS 2008). The average abundance of Cook Inlet beluga whales remained below 350 whales during the second review period (2008–2012); therefore, a harvest was not allowed for the subsequent 5-year period (2013–2017) (Muto, Helker et al. 2021). The average abundance for a third review period (2013–2017) using the 2014 and 2016 estimates was still below 350 whales (Wade, Boyd et al. 2019) and a harvest was not allowed for the subsequent 5-year period (2018–2022).

8.3.2. Other Cetacean Hunting

Harbor porpoise in the Gulf of Alaska were hunted by prehistoric societies from Kodiak Island and areas around Cook Inlet and Prince William Sound (Shelden *et al.* 2014). Subsistence hunters have not reported harvest of harbor porpoise since the early 1900s (Shelden *et al.* 2014, as cited in (Muto, Helker et al. 2020). Subsistence hunters in Alaska are not authorized to take from the Central North Pacific stock of humpback whales, and no takes were reported between 2013 and 2017. Likewise, there are no reports of subsistence harvest of killer whales in Alaska (Muto, Helker et al. 2020).

8.3.3. Harbor Seal Hunting

Subsistence hunting for harbor seals is conducted opportunistically and at low levels among Alaska Natives who may be fishing or traveling in Upper Cook Inlet near the mouths of the Susitna River, Beluga River, and the Little Susitna River (NMFS 2013). Some detailed information on the subsistence harvest of harbor seals is available from past studies conducted by the Alaska Department of Fish and Game (ADF&G) (Wolfe 2001). In 2008, 33 harbor seals were taken for harvest in the Upper Kenai - Cook Inlet area. In the same study, reports from hunters stated that harbor seal populations in the area were increasing (28.6%) or remaining stable (71.4%). The specific hunting regions identified were Anchorage, Homer, Kenai, and Tyonek, and hunting generally peaks in March, September, and November (Wolfe *et al.*, 2009). Generally, the timing and location of subsistence harvest of Cook Inlet harbor seals would not overlap spatially with oil and gas activity.

More recently, the Alaska Native subsistence harvest of harbor seals has been estimated by the Alaska Native Harbor Seal Commission (ANHSC) and ADF&G. Muto, Helker et al. (2020) reported that the average annual harvest of harbor seals in Cook Inlet over the period 2004–2008 was 233 animals; 104 were harvested in 2014. Data are not available for harvests in 2011, 2012, or 2017 (Muto, Helker et al. 2020).

8.3.4. Sea Otter Hunting

Data for subsistence harvest of sea otters from the southwest and southcentral Alaska DPS are collected by a mandatory Marking, Tagging and Reporting Program administered by the USFWS since 1988 (USFWS 2014). The mean reported annual subsistence take during 2006–2010 was 76 animals for the southwest Alaska DPS and 293 animals from the southcentral DPS (USFWS 2014). The majority of the southwest Alaska DPS harvest (83%) comes from the Kodiak Archipelago; areas within the stock that show signs of continued population declines have little to no record of subsistence harvest (USFWS 2014). The majority of the harvest from the southcentral Alaska DPS over the past 5 years has occurred in northern and eastern Prince William Sound (USFWS 2014).

8.3.5. Steller Sea Lion

Data were collected on the Alaska Native harvest of Western U.S. Steller sea lions for 7 communities on Kodiak Island in 2011 and 15 communities in Southcentral Alaska in 2014. The ANHSC and ADF&G estimated a total of 20 adult sea lions were harvested on Kodiak Island in 2011 (Wolfe *et al.* 2012, as cited in (Muto, Helker et al. 2020) and about 8 sea lions (CI = 6-15.3) were harvested in southcentral Alaska in 2014, with adults comprising 84% of the harvest (ANHSC 2015, as cited in (Muto, Helker et al. 2020).

8.4. Observations by Subsistence Users Regarding Marine Mammals in Cook Inlet

8.4.1. Marine Mammal Responses to General Human or Industry Activity

In terms of scale, there is less reliance on marine mammals for subsistence by Cook Inlet communities when compared to the villages along the Chukchi and Beaufort seas. For this reason, less information is available in literature and public comments regarding subsistence user observations in Cook Inlet. For the period 2000–2020, two communities routinely submitted public comment letters related to proposed oil and gas activities in the Cook Inlet region, namely the Native Village of Tyonek and the Seldovia Village Tribe. These comments as well as other available studies on subsistence and traditional knowledge in southcentral Alaska and Cook Inlet are summarized here.

Huntington (2000) conducted semi-directive interviews in 1998 and 1999 with hunters in Cook Inlet to gather information regarding the ecology of Cook Inlet beluga whales. Some hunters expressed that an increase in human activity such as onshore development, fishing and recreational boating, and airplane activity in and around the Kenai River may have affected beluga distribution and abundance. However, feeding belugas seemed unbothered by humans in or near the river. Hunters observed that Cook Inlet belugas seemed to know when they are being hunted, reporting avoidance behavior such as diving away or using a "decoy" beluga when another whale is being hunted (Huntington 2000).

Comments were also received on Cook Inlet lease sale 244. A letter from the Seldovia Village Tribe (Opheim 2016) stated:

> *Why would we want to continue to put resources that are all ready (sic) on the decline in more danger by adding more drill rigs and more pollutants finding their way into Cook Inlet via the rather lax APDES permit that will be out for comment this fall.*

Similar comments were also noted in transcripts from the public meeting held in Kenai for Lease Sale 244 in 2016 (BOEM 2016) with a resident of Kasilof stating:

> *Our marine life are disappearing. Concerns for sea otters, sea lions, whales, beluga whales, our salmon, our halibut are shrinking. This is important to every Alaskan. Let's not forget our subsistence way of life. Everybody using that—well, a lot of people are using that inlet for survival, commercial fisheries. There will be lots of environmental concerns. And why do we risk a nonrenewable resource over a renewable resource like salmon?*

> *In a report on the Coastal Community Vulnerability Index and Visualizations of Change in Cook Inlet, Alaska (Holen 2019), a comment regarding marine mammals observed in unusual locations was received from a Village of Tyonek member:*

> *Harbor seals have begun appearing in Chuit Lake. They are concerned about what may be causing this behavior in local seal populations. Beluga whales are also exhibiting strange behavior by entering Robert's Creek to feed. Marine mammals entering freshwater areas to feed is something they have never observed before.*

8.4.2. Subsistence User Concerns about Potential Oil Spills in Cook Inlet

The *Exxon Valdez* oil spill affected Alaska Native communities in Lower Cook Inlet, namely Nanwalek and Port Graham. For village residents in Prince William Sound and communities near Kodiak, the spill caused uncertainty about the future of natural resource populations and the subsistence uses that they supported (Braund and Kruse 2009). As stated by Gary Kompkoff, president of the Tatitlek Village Council (quoted in Fall *et al.* 2001, as cited in Braund and Kruse (2009):

> *Mussels, clams, starfish - things are dying off and floating up on the beaches. The tides come and go out, come in and go out. The scientists do their research one day, and everything looks fine. But what about the tide coming in? There's frustration, uncertainty and fear—a fear of what the future's going to bring. We go from fear to anger to frustration with this thing. It's going to be with us for a long time.*

Communities close to the origin of the spill in Prince William Sound and Lower Cook Inlet, as well as Ouzinkie in the Kodiak Island Borough, reported higher and more persistent levels of spill impacts than more distant communities. By 1993, the vast majority of households who still said that the spill's effects were impacting their subsistence uses cited reduced resource populations as the cause of the decline (Braund and Kruse 2009).

While concerns about contamination in specific resources due to *Exxon Valdez* oil spill waned after the first years post spill, they persisted among many households (especially in Chenega Bay, Tatitlek, Port Graham, and Nanwalek) 5 and even 10 years later (Braund and Kruse 2009). A substantial number of households reported that they had not received adequate information about the safety of subsistence foods. However, many households in the spill area returned to using subsistence foods despite lingering contamination fears. The economic and cultural necessities of using subsistence foods compelled Alaska Natives of the spill area to resume subsistence harvests even at increased costs of time, money, and health concerns (Braund and Kruse 2009).

Fall *et al.* (2001, as cited in Braund and Kruse (2009)) concluded:

> *By these measures, there was stability in the basic organization of the factors of production and distribution during the oil spill crisis in the villages of Prince William Sound and Lower Cook Inlet. This is evidence that, at the local level of extended household networks, there was no collapse triggered by the strains of the spill. While the spill created major local disruptions of food procurement and employment patterns, the spill did not transform the pattern of relationships in the subsistence sector. The traditional extended kinship networks adapted to the short-term crisis of food production and distribution at the local level without major dislocations in the underlying structure of production and distribution. Given the vast extent of the disruption to subsistence uses and the way of life they support in the communities of the Exxon Valdez oil spill [EVOS] area, it is not surprising that the research documented a strong level of fear and uncertainty about the future.*
>
> *At the end of the first post-spill year, and extending well beyond it, residents expressed frustration and a feeling of loss. As a person from Nanwalek said, because of the lost subsistence opportunities, "it was like a year of memories being erased" (Fall 1999, as cited in (Braund and Kruse 2009).*

Keating, Koster et al. (2020) analyzed household-level and qualitative data to assess patterns and trends in subsistence use in five communities (including Nanwalek and Port Graham) 8 years after the *Exxon Valdez* oil spill. Data were considered in light of other factors such as resource population status, community demographics, household composition, incomes, involvement in commercial fishing, and other personal and cultural factors that affect subsistence use. This comprehensive analysis conducted by Keating, Koster et al. (2020) demonstrated that subsistence practices in the five communities have been influenced not only by the effects of the *Exxon Valdez* oil spill but a host of other complex factors including but not limited to participation in commercial fishing, cultural changes, social dynamics, the influence of digital technology, changes in the diversity of resources harvested, and varying harvest levels.

Concerns regarding new exploration or continued development in Cook Inlet remain. In April of 2019, a Tyonek resident noted the following (Holen 2019):

> *The oil and gas platforms are allowed to dump a certain amount of waste. Residents are concerned that over the years this has had a detrimental impact on marine mammals and fish, especially salmon. They said that they could smell the oil and methane on the shores for about a month after the discharge. They know that there is surface sampling done to ensure there is no detrimental impact but worried it is not enough. Besides what they can observe in the survey, they are worried about what is occurring in the deeper water strata where sampling is not taking place. They are also worried about air quality as well based on how intense the smell is from the oil and methane.*
>
> *They are observing more frequent deformations in salmon, what they call squiggle backs. They wonder if salmon have the deformed spine because of oil contamination.*
>
> *Last summer, they knew of six pipeline breaks in the marine environment. There is concern about old lines running in the inlet.*

Additionally, during the comment period for Lease Sale 244 in Cook Inlet, a comment regarding existing contamination was received from the Seldovia Village Tribe (Collier 2014), which stated “We would also like to point out already high levels of polycyclic aromatic hydrocarbons (PAHs) in Seldovia Bay, which may warrant further study.”

8.4.3. Observations from Cook Inlet Subsistence Users Regarding Climate Change

The bigger threat of climate change to marine mammals (such as beluga whales) in Cook Inlet may not be the direct change in climate, but rather the effect regional warming would have on increased human activity (NMFS 2017, NMFS 2019). Less ice would mean increased vessel activity with an associated increase in noise, pollution, and risk of ship strike. Other factors related to a warmer inlet with a reduced presence of sea ice include: 1) changing prey composition; 2) increased predation due to lack of ice refuge; 3) increased susceptibility to ice entrapment due to less predictable ice conditions; and 4) increased competition with co-predators. more rapid melting of glaciers might change the silt deposition in the Susitna Delta, potentially altering habitat for prey (NMFS 2008). However, the magnitude of these potential effects on marine mammals is unpredictable.

A specific comment on climate change was recorded by Holen (2019) from a Tyonek resident:

> *Basic changes due to climate shifts include the appearance of salmon sharks which began moving in the area in the early 2000s. Orca have also been spotted as well as porpoises, and pilot whales. All are species never observed before near Tyonek which is located relatively far up Cook Inlet.*

8.4.4. Observations from Subsistence Users Regarding Cumulative Effects in Cook Inlet

A 2016 comment letter from the Seldovia Village Tribe regarding Cook Inlet Lease Sale 244 suggested concerns about cumulative effects on the natural resources of Cook Inlet when considering additional oil and gas activities in the region. Concerns about allowing more oil and gas activities in Cook Inlet were expressed as follows (Collier 2014):

> *Ask some of the elders who have lived here all their lives what the resources used to be and what they have now. Do we really need to jeopardize this fragile environment so much more with fracking, drilling, and air cannons going off to find the oil and gas pockets.*
>
> *The resources of Cook Inlet are not only used by the Native Peoples that have lived here for millennia but the non-native (sic) peoples who have come to the state for a better life and cleaner healthier food resources.*

While not explicitly stated in public comment reports for oil and gas lease sales in Cook Inlet such, as MMS (2003) and BOEM (2016), summary statements seem to indicate residual concerns from the *Exxon Valdez* oil spill and the cumulative effects of future oil and gas activities on subsistence resources. For example, the 2003 Scoping Report for Cook Inlet Lease Sale 191 and 199 stated (MMS 2003):

> *A particular concern is the potential contamination of some of these resources from post-lease and other non-OCS activities. Commenters emphasized the impacts of the Exxon Valdez oil spill on subsistence.*

8.4.5. Social Indicators in Cook Inlet (Adapted from the Alaska North Slope)

As described in Section 8.3, the 2011 SICAA study funded by BOEM compared several studies that have defined terms referred to as “social indicators” used to help evaluate the health and overall well-being of indigenous communities (Stephen R. Braund & Associates 2017). The 2017 SICAA report provided a baseline of social indicators for communities on Alaska’s North Slope and while the report focuses on the

U.S. Arctic region, for the purposes of this synthesis and for consistency, the same social indicators described in Section 8.3 are referenced here for Cook Inlet. The literature review conducted for this report did not discover specific sources of information on social indicators for Cook Inlet; therefore, the following sections summarize what is available for EIS documents and similar types of reports specific to oil and gas activities. In addition, local control and education did not appear to be explicit topics in public comments, transcripts, scientific reports, or other literature related to proposed oil and gas activities in Cook Inlet, and therefore, are not addressed further in this section.

8.4.5.1. Economic Well-Being

Potential effects of oil and gas lease sales and related exploration and development activities in Cook Inlet were evaluated in terms of environmental justice[10] concerns for Lease Sale 244. (BOEM 2016) anticipated that no disproportionately high, adverse effects on environmental justice communities (specifically Alaska Native, subsistence-based communities in the affected area) were likely due to oil and gas activities in Cook Inlet.

8.4.5.2. Health and Safety

The potential for large oil spills are routinely listed as potential threats to community health and safety. The 2016 Final EIS for Cook Inlet Lease Sale 244 (BOEM 2016) states:

> *Large oil spills would most likely produce disproportionately high and adverse effects to environmental justice communities because of their reliance on subsistence foods for nutritional, social, and cultural well-being and because effects of large oil spills to subsistence harvest patterns and sociocultural systems are expected to be major. Oil-spill contamination of subsistence foods and related adverse effects to community well-being from distress and disruptions to social patterns and community cohesiveness would likely be the primary impacts on human health for environmental justice communities.*
>
> *The likelihood of a large spill occurring and affecting subsistence resources and harvest areas is relatively small; nevertheless, in the event that a large oil spill occurred and contaminated essential subsistence resources and harvest areas, high and adverse effects could occur when impacts from contamination of the shoreline, tainting concerns, spill response and cleanup disturbance, and disruption of subsistence practices are factored together.*

8.4.5.3. Cultural Continuity

NEPA assessments of oil and gas activities in Cook Inlet (*i.e.*, MMS (2003), BOEM (2015) and BOEM (2016)) generally report that impacts to sociocultural systems would be relatively minor due to their limited geographic extent and temporal effects. Sociocultural systems are expected to adapt and change to local changes in the environment due to continued oil and gas exploration (BOEM 2016).

8.4.5.4. Physical Environment

BOEM (2015) reported that subsistence use patterns may be affected due to space-use conflicts with oil and gas activities (specifically seismic surveys), which could preclude water-borne subsistence harvest activities. Space-use conflicts could occur nearshore within 9.6 km of the Kenai River and Anchor Point where seismic surveys were planned for 2015. However, the duration of seismic surveys was expected to

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[10] Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies; https://www.epa.gov/environmentaljustice/learn-about-environmental-justice; Accessed September 9, 2021.

last 3 to 5 days during slack tide. Therefore, the potential effects were expected to be short-term and temporary. With regard to subsistence resources, the 2015 EA for Cook Inlet seismic activities (BOEM 2015) stated:

> *Displacement of subsistence resources from an area could occur because of noise from seismic survey activities. For fish resources, displacement from seismic activities is not estimated to be measurable. Displacement of marine mammals along vessel transit routes is estimated to be very short (less than an hour) and very local (less than one mile). Displacement of marine mammals from seismic activities could occur, but the effect would be temporary; it is estimated that displaced animals would return to normal behavior and distribution after operations are complete.*

The 2016 Final EIS for Cook Inlet Lease Sale 244 (BOEM 2016) stated that access to subsistence resources and local hunting areas in the region could be affected due to oil and gas activities, likely caused by minor changes in harvest patterns.

8.4.5.5. Overall Well-Being

The 2015 EA for Cook Inlet seismic surveys (BOEM 2015) summarized that for Native villages of Kenai (Kenaitze), Salamatof, and Ninilchik, subsistence activities have persisted for millennia and would continue to provide sufficient resources for those communities despite the limited vessel traffic associated with seismic work in the region.

9. Effectiveness of Mitigation and Monitoring

Mitigation is a mechanism [or suite of mechanisms] intended to avoid or minimize effects of an action (CEQ 2011). It is important to quantify the effectiveness of proposed mitigation measures so that regulators can make informed decisions regarding activity authorizations and to select effective mitigation options that most effectively reduce risk (Leaper, Calderan et al. 2015). Within the context of compliance under the MMPA and ESA, monitoring during oil and gas activities is used to document the implementation and effectiveness of mitigation measures. This type of monitoring is distinct from other scientific- or research-oriented monitoring intended to collect data that may be used in marine mammal stock assessment reports. However, some oil and gas monitoring programs may contribute those types of data (*i.e.*, marine mammal presence/absence in a region).

As described in Chapter 5, Section 216.108 of the MMPA requires that holders of an IHA or LOA must monitor the impacts of their activity on marine mammals. Similarly, 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 USFWS[11] and NMFS[12] implementing regulations.

This chapter summarizes recent, general[13] literature on the efficacy of different methods used for mitigation and monitoring (as discussed in Chapter 6), followed by an overview of more specific information on the effectiveness of mitigation and monitoring measures implemented for oil and gas activities in the U.S. Arctic and Cook Inlet. For example, available data on sighting rates or comparison of monitoring methods is presented here, while Chapter 7 provides specific results in terms of the documented effects of activities on marine mammals based on monitoring programs.

Given the volume of data collected from marine mammal monitoring programs during oil and gas activities in the U.S. Arctic and Cook Inlet for the period 2000–2020, and for the purposes of discussing mitigation and monitoring efficacy for oil and gas activities on a broad scale, much of the information herein is based on comprehensive reports, even though many 90-day or annual reports are available. For an extensive list of monitoring reports available for these geographic areas for 2000–2020, please see Appendix C.

Since 2000, a number of papers have been published on the effectiveness of mitigation measures during seismic surveys (Weir and Dolman 2007, Moors-Murphy and Theriault 2017), general oil and gas operations (NMFS 2011), general anthropogenic underwater noise (MMOA 2012), ship strike (Leaper and Calderan 2014, NMFS 2021), and measures to protect endangered species (Li and Male 2021).

With regard to monitoring, as described in Verfuss, Gillespie et al. (2018), both "extrinsic" and "intrinsic" factors can influence the success of a monitoring program:

- Extrinsic factors cannot be influenced by the monitoring team and may include sea state, ocean subsurface conditions (*i.e.*, rocky versus sandy), light conditions, animal behavior or size, etc.
- Intrinsic factors can be influenced by the monitoring team and may include equipment quality and sophistication (*i.e.*, resolution), altitude or height of monitoring platform, method of deployment, PSO rest periods, etc.

[11] 50 CFR § 13.45 and 18.27 USFWS Implementing Regulations
[12] 50 CFR § 216.105 and 222.301(h) NMFS Implementing Regulations
[13] In other words, not necessarily specific to the U.S. Arctic or Cook Inlet

Verfuss, Gillespie et al. (2018) proposes that there are four possible outcomes of mitigation and monitoring:

- True positive: target species are detected and mitigation measures are implemented that prevent interactions that may cause harm;
- True negative: target species are not detected, no animals enter the defined mitigation zone, and no mitigation measures are taken;
- False positive: mitigation measures are implemented for detected animals, but no target species enter the defined mitigation zone; or
- False negative: target species enter the defined mitigation zone undetected and no mitigation measures are implemented.

Under some circumstances, physical monitoring may not be possible due to concerns for human safety, logistical constraints, or unforeseen events. In such cases, modeling may be used to project the number, type, and duration of industry-marine mammal interactions (*e.g.*, Erbe and Farmer (2000). However, using modeling to estimate industry-marine mammal interactions may over or underestimate what occurs; therefore, it is not typically the preferred approach.

In 2013, NMFS, with input from BOEM and BSEE, published National Standards for a Protected Species Observer and Data Management Program: A Model Using Geological and Geophysical Surveys (Baker, Epperson et al. 2013). The 2013 NMFS document provides guidance on PSO program infrastructure, support, training, and qualifications as well as suggestions for standardizing data collection and quality assurance. While monitoring requirements are project-specific, the following types of information are frequently collected during monitoring programs:

- Date, time, and general weather conditions;
- Marine mammal species observed (if identifiable) and number;
- Marine mammal behavior during observation (may include response to industrial activity)
- Industrial activity occurring at time of observation; and
- Mitigation implemented, if any (for example, shutdown, vessel speed reduction, vessel, or aircraft route alteration).

While not every method of mitigation or monitoring described in Chapter 6 is discussed in this chapter, the following subsections focus on the efficacy of some common mitigation and monitoring techniques.

9.1. Shutdown and Exclusion Zones

Exclusion and shutdown zones are some of the most frequently used mitigation measures to reduce potential effects of activities that may cause underwater sound levels to exceed noise thresholds that can harm marine mammal hearing (see Section 4.1.1) (*i.e.*, seismic surveys, pile-driving, or exploratory drilling). Exclusion zones and shutdown zones defined for oil and gas projects in Alaska are typically calculated using site-specific or modelled estimates based on local conditions, proposed equipment, species that may occur, and their potential for harm due to exposure to the noise. Therefore, (Weir and Dolman 2007) emphasizes the need for sound measurements *in-situ* to refine exclusion and shutdown zones.

As an example of mitigation efficacy, Ireland, Hannay et al. (2007) reported that shutdown of airguns was the only mitigation measure requested during Chukchi Sea seismic surveys on October 14, 2006, when three Pacific walruses were sighted by PSOs within 493 m of the starboard bow. The 2007 compliance report describes that the PSO requested the shutdown of 35 operating guns, which was immediately implemented. Therefore, the three walruses came within 622 m where underwater noise received levels were measured at 190 dB rms. Ireland, Hannay et al. (2007) stated:

> *After the shutdown, the walruses dove as a group and re-surfaced 317 m from the MMO[14] [PSO], off the starboard bow. They proceeded to dive again and re-surfaced 100 m from the MMO, but off the port bow. The group was last observed to the stern of the vessel at a distance of 606 m from the MMO (487 m from the shutdown airguns), leisurely swimming perpendicularly away from the vessel's trackline.*

9.2. Vessel Management Measures

Vessel management measures are described in Section 6.13. It is fairly standard for oil and gas activities that may pose risks to marine mammals due to ship strike in Cook Inlet and the Chukchi and Beaufort seas to implement vessel management measures including: speed reduction, route alteration, vessel shutdown (if it does not pose human safety concerns due to tides or currents) or avoidance of designated critical habitat (*i.e.*, North Pacific right whale critical habitat in the Bering Sea). In addition, projects using the marine transit route (*i.e.*, waters within the Bering, Chukchi, and Beaufort seas through which vessels transit between Dutch Harbor and the Alaska North Slope) are often required to implement vessel management measures (*i.e.*, (NMFS 2020)).

As summarized in Schoeman, Patterson-Abrolat et al. (2020), two mitigation measures stand out as the most effective vessel management: route alterations and speed reductions; though, the manuscript acknowledges that there is a paucity of data on the effectiveness of vessel management mitigation measures on smaller marine mammals (*i.e.*, other than large cetaceans). Rockwood, Adams et al. (2020) applied a ship strike model using whale density and Automated Identification System vessel data from the U.S. west coast and demonstrated that vessel speed reduction to 10 kts can result in a 5- and 4-fold reduction in blue whale and humpback whale mortality, respectively.

One of the primary mitigation measures implemented by vessel- and aerial-based PSOs during Shell's oil and gas activities 2006–2015 included vessel speed reductions and alterations in vessel headings. PSOs also requested changes in aircraft routes to minimize disturbance to marine mammals observed within harassment zones (Ireland, Bisson et al. 2016). Vessel-based PSOs requested certain actions during anchor handling and setting as well as during drilling. For example, when the vessel retrieving an anchor was positioned, PSOs would clear the area by observing a 500-m safety zone for 30 minutes; if a marine mammal(s) was observed within the 500-m zone during the clearing, the PSOs would continue to watch until the animal(s) was gone and had not returned for 15 minutes if the sighting was a pinniped, or 30 minutes if it was a cetacean. Once the PSOs cleared the area, anchor retrieval or ice management operations could commence. Efforts were made by Shell to maximize the distance between vessels and marine mammals and avoid separating groups of marine mammals during their oil and gas activities during their activities 2006–2015 (Ireland, Bisson et al. 2016).

9.3. Visual Monitoring

Visual monitoring has traditionally been implemented using PSOs stationed on land, vessels, or in aircraft. As described in Leaper, Calderan et al. (2015), many studies have been undertaken to evaluate the visual detection process during sighting surveys for cetaceans. The frequency with which an animal surfaces directly influences the probability of an animal or group being seen. In addition, the duration and strength of visual cues (*i.e.*, size and persistence of blows, splashes, or the amount of body visible at the surface [detectability]) as well as environmental conditions (*i.e.*, Beaufort state and glare) also affect monitoring results. Visual surveys are restricted to conditions favorable for viewing distances (*i.e.*, daylight hours and

[14] MMO is an abbreviation for marine mammal observer, which is now more frequently referred to as PSO.

good weather conditions). Fog, rain, sea state, glare or darkness can dramatically change the ability of PSOs to visually detect marine mammals (Leaper, Calderan et al. (2015) Verfuss, Gillespie et al. (2018) and citations therein). Equipment, such as reticle binoculars, is also essential for visual monitoring, particularly for farther distances. Certain species are also easier to detect than others, depending on characteristics such as body size, markings, behavior, habitat, and number of individuals (*i.e.*, groups versus single animals). More recently, UAS have been used to help conduct visual surveys by recording video or taking still photographs that may be reviewed after surveys are complete. Less frequently, live video is used (see Chapter 6).

Leaper, Calderan et al. (2015) simulated visual detection of marine mammals exposed to underwater sounds based on sighting data of several species from around the world as shown in Table 9-1. The expected number of whales (N) detected along transect length (L) is given where D is the density; therefore, g(0), the proportion of animals directly on the trackline that are detected, and effective strip half-width (eshw) were estimated independently (see Table 9-1).

Table 9-1. Examples of Estimates of g(0) and Effective Strip Half-Width (eshw) from Marine Mammal Sighting Surveys

Species	Region	g(0)	eshw	Survey Reference
Fin whale (*Balaenoptera physalus*)	NE Atlantic	0.81	1.1- 2.4 km	Vikingsson et al., 2009
	Antarctic		2.5-3.4 km	Branch & Butterworth, 2001
	West Greenland		0.9 km	Heide-Jørgensen et al., 2007
Blue whale (*Balaenoptera musculus*)	California coast	0.90	2.2 3.2 km	Calambokidis & Barlow, 2004
	NE Atlantic		2.1-3.4 km	Pike et al., 2004
	Antarctic		2.9-3.9 km	Branch & Butterworth, 2001
	Sri Lanka		1.3 km	Priyadarshana et al., 2014
Sperm whale (*Physeter macrocepalus*) (long-diving males)	Antarctic	0.32[1]	3.5 km	Kasamatsu & Joyce, 1995
Beaked (single)	Antarctic	0.27[1]	0.5 km	Kasamatsu & Joyce, 1995
Beaked (≥ 4)	Antarctic	0.27[1]	1.0 km	Kasamatsu & Joyce, 1995
Sperm whale (mainly female groups; 25 min. dive followed by 5 min. at surface). Two observers searching with Big Eye 25x binoculars	Eastern Tropical Pacific	0.87	3.6-4.6 km	Barlow & Taylor, 2005
Sperm whale	Antarctic	0.87	0.13-0.36 km	Branch & Butterworth, 2001
Harbor porpoise (*Phocoena phocoena*)	North Sea	0.34	0.13-0.36 km	Hammond et al., 2002
	North Sea	0.22		Hammond et al., 2013
Minke whale (*Balaenoptera acutorostrata*)	North Sea	0.82	0.23-0.42 km	Hammond et al., 2002
	NE Atlantic	0.43-0.51		Schweder et al., 1997
	NW Pacific	0.82[2]		Okamura et al., 2009
Antarctic minke whale (*Balaenoptera bonaerensis*)	Antarctic		0.7-1.1 km	Branch & Butterworth, 2001
	Antarctic	0.42-0.59	0.44-0.65 km	Okamura & Kitakado, 2007

[1] Model based estimate based on three dedicated observers searching with binoculars
[2] The estimates of g(0) were 0.754 (CV = 0.33) for top barrel, 0.668 (CV = 0.45) for IO platform, 0.447 (CV = 0.77) for upper bridge, and 0.822 (CV = 0.26) for top barrel and upper bridge
Source: Leaper, Calderan et al. (2015)

Leaper, Calderan et al. (2015) concluded that PSOs provide a useful level of risk reduction based on marine mammal sightings; however, poor sighting conditions due to wind, sea state or fog can reduce their effectiveness. For example, harbor porpoise sightings in Beaufort Sea states of 2 or 3 were only 11% of sightings reported when Beaufort Sea states were 0 or 1. Weir and Dolman (2007) also acknowledges the challenges using visual monitoring for mammals that are below the water surface, such as deep-diving sperm whales. Barlow and Gisiner (2006) suggested that for deep-diving species, reducing the detection probability by 0.23 to 0.45 for Cuvier's or *Mesoplodon* beaked whales, respectively, may account for differences in survey efficiency. Barlow and Gisiner (2006) also summarized information about recent technologies available such as radar, infrared, and hyper-spectral and satellite imagery, and Light Detection and Ranging.

Angliss, Ferguson et al. (2018) compared results of crewed (fixed-wing aircraft) and uncrewed (via UAS) aerial surveys for cetaceans in the Arctic. Particularly in Alaska, surveys conducted using manned aircraft may be limited due to inclement weather, remote locations, and logistical challenges. Thus, the use of UAS for scientific research on marine mammals has been gradually increasing. Table 9-2 from Angliss, Ferguson et al. (2018) summarizes key findings regarding successful data collection, improved safety or both, when UAS was used for monitoring.

Table 9-2. Critical Project Components that Directly Contributed to Successful Data Collection with UAS, Improved Safety, or Both

Project Component	Comments
Internet service	Critical for weather forecasting, access to air traffic information
Surface-based air traffic radar feed	Greatly improved flight safety because the UAS pilots could detect local air traffic; use required by the certificate of authorization
NOWcasting	Increased ability to predict local weather at a spatial and temporal scale unavailable from NWS forecasts.
ASAPS sensor	Helped UAS pilots know when they were likely approaching a cloud or measurable precipitation. Associated software designed to detect hypothetical carburetor icing conditions, not actual carburetor icing conditions.
Portable weather station	The cloud ceiling at the launch site was often hundreds of meters different from the ceiling at the airport.
Open land area with easy access and low traffic volume	Mitigated risks to the community of UAV flying over land.

Source: Angliss, Ferguson et al. (2018)

Analytical results from Angliss, Ferguson et al. (2018) indicated that long-range UAS surveys provide reliable information on marine mammal density comparable to information collected by crewed aerial surveys. However, long-range surveys using UAS were cited as "considerably more expensive" than crewed surveys due to increased data processing and because they can be logistically complicated. As of 2020, UAS surveys have yet to be used in the U.S. Arctic or Cook Inlet for real-time, live marine mammal compliance monitoring required during oil and gas activities.

9.4. Acoustic Monitoring

Visual detection methods have been supplemented, or in some cases, replaced entirely by acoustic systems that can be used to continually monitor underwater sound in real time (see Section 6.1). Acoustic monitoring can be used to record data on industrial sounds as well as marine mammal vocalizations, and has been used in the U.S. Arctic and Cook Inlet for decades to provide data for compliance (*i.e.*, (Kim and Richardson 2020)) as well as scientific research (*i.e.*, (Lammers, Castellote et al. 2013)). Acoustic monitoring allows detection of marine mammals at great distances because sound travels well underwater. While acoustic monitoring is a powerful method for detecting marine mammals that vocalize, animals that do not vocalize are not recorded. Thus, visual monitoring often accompanies acoustic monitoring so the two methods combined may support improved detection rates. Guan (2010) discussed how, as of 2010, reliably locating calling animals and effectively detecting low-frequency calls of baleen whales were challenging tasks if only relying on acoustic monitoring.

Whereas visual surveys may be challenged by poor visibility, acoustic monitoring may help compensate by recording vocalizations under the water surface regardless of visibility. Pyć, Geoffroy et al. (2016) reported 92% agreement between PSO sightings and active acoustic detections at ranges up to 2,000 m in challenging oceanographic conditions using an instrument called an SX90, a sonar used frequently in fisheries surveys.

9.5. Oil Spill Response

Oil spill response methods are summarized in a 2019 report by BOEM titled *Oil Spill Preparedness, Prevention, and Response on the Alaska OCS* (BOEM 2019). The National Response System established under the National Contingency Plan is a multi-tiered framework for coordinating federal response to an oil spill or release of a hazardous substance, pollutant, or contaminant within this framework, Regional Response Teams are responsible for regional planning and spill preparedness activities (i.e., simulated drills) before an incident occurs, providing guidance to federal, state and local authorities on response measures (BOEM 2019). For additional detailed information on the response framework, parties involved and organizational structure of regional and local response organizations, please see (BOEM 2019). Oil spill response activities are complex and involve many players from federal, state, and local organizations and response measures are unique to each region (i.e., U.S. Arctic and Cook Inlet). Alaska Clean Seas is a non-profit, incorporated oil spill response cooperative responsible for helping managing emergency response activities along the Alaska North Slope. Cook Inlet Spill Prevention & Response, Inc. (CISPRI) is a certified USCG Oil Spill Removal Organization and State of Alaska Primary Response Action Contractor serving the Cook Inlet region of Alaska. CISPRI is a member-owned, non-profit corporation providing oil spill planning, training, and response services to facilities and vessels throughout the Cook Inlet region.

Guidelines to protect marine mammals and other wildlife have been developed by NOAA, the Alaska Regional Response Team (ARRT) and others (Ziccardi, Wilkin et al. 2014, Ziccardi, Wilkin et al. 2015, Wilkin, Ziccardi et al. 2017, Wright, Wilkin et al. 2017, Ziccardi and Wilkin 2018, Dushane, Ziccardi et al. 2019, ARRT 2020). In general, these guidelines recommend methods for safely hazing wildlife, recovering and transporting oiled wildlife, stabilizing injured wildlife in the field, and documenting observations (Wilkin, Ziccardi et al. 2017). Wright, Wilkin et al. (2017) provides guidelines specific for Arctic marine mammals such as: developing methods for tissue sampling; including local experts in response efforts; designing and interactive approach for information exchange during the response; setting preparedness parameters; establishing an appropriate response structure; and developing strategies to address UMEs. NOAA has also developed oil spill guidelines specifically for pinnipeds and cetaceans (Ziccardi, Wilkin et al. 2015).

Extensive national and international research has focused on improving oil spill response capabilities in ice-covered conditions and is summarized in Sorstrom, Brandvik et al. (2010) and Arctic Oil Spill Response Technology Joint Industry Programme (2017) Sorstrom, Brandvik et al. (2010), Arctic Oil Spill Response Technology Joint Industry Programme (2017). The presence of ice, cold temperatures and darkness during winter months make managing an oil spill in sea ice different than other regions. However, while the presence of ice can complicate oil spill response, there are potential positive factors including that sea ice may constrain oil spreading and cold temperatures may also reduce spreading and weathering rates (Sorstrom, Brandvik et al. 2010). Nonetheless, the presence of sea ice limits or prevents the effective use of traditional mechanical methods of cleanup, low visibility due to weather or darkness, difficulty finding or recovering oil trapped under ice, and maintaining worker safety are just some of the challenges associated with a potential oil spill in ice-covered waters (NPC 2015).

In a 2015 report to Congress, the NPC prepared a report titled Arctic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources (NPC 2015). The report was prepared through a collaborative effort of over 250 representatives from government, industry, research groups, nongovernmental organizations, academia, consultancies, public interest groups, and financial institutions. In part, the report addressed "…what research the Department of Energy should pursue and what technology constraints must be addressed to ensure prudent development of Arctic oil and gas resources while ensuring environmental stewardship". Part 2 of the report provides a detailed assessment of current technologies available for oil spill prevention and response. In addition to the main report, a series of 46 topic papers were published and are available on the NPC webpage. Of interest for this marine mammal synthesis report is the topic paper Oil Spill Prevention, Control, and Response which provided a summary of research and an overview of the current (as of 2015) technologies available to respond to an accidental spill in Arctic waters. A 2010 Joint Industry Programme (JIP) Report on oil in ice (Sorstrom, Brandvik et al. 2010) as well as the 2015 NPC report and associated topic papers (NPC 2015) both acknowledge that while significant improvements have been made regarding oil spill response in ice-covered waters, current technology and clean-up protocols are less effective or ineffective at removing surface oil in areas were slush ice, fast ice, sheer zone ice, or pack-ice occur. In addition, the timing for using specific methods such as mechanical recovery or in situ burning changes with time and these are particularly affected in Arctic or ice-covered conditions (Sorstrom, Brandvik et al. 2010).

A 5-year research program was also conducted by the Arctic Oil Spill Response Technology JIP between 2012 and 2017 to address six key areas of oil spill response: dispersants, environmental effects, trajectory modeling, remote sensing, mechanical recovery, and *in situ* burning (Arctic Oil Spill Response Technology Joint Industry Programme 2017). Of specific relevance to this synthesis report is that the 2017 JIP supported improved oil spill trajectory modeling with higher-resolution ice drift models both in pack ice and the dynamic ice in the marginal ice zone. Thus, there is better understanding regarding how oil may disperse in different ice conditions, which will likely aid in spill response.

The effectiveness of clean-up efforts in response to a significant oil spill is highly seasonal (*i.e.*, depending on the presence or absence of sea ice). MMS (2000) noted a:

> *…'problem' could arise from the inadvertent engulfment of tar balls or large 'blobs' of oil, along with prey items. If such globular material would not liquefy due to body heat and/or digestive acids and enzymes, it might well contribute to a mechanical blockage in the stomach at the connecting channel. The connecting channel is quite narrow and is that part of the stomach that serves to connect the fundic chamber with the pyloric chamber (Tarpley 1985; Tarpley et al. 1987). Mechanical blockage could result from the swallowing of broken off baleen 'hairs' which have matted together into small 'balls' due to the oil.*

Additional research is needed to address specific challenges associated with oil spill response in the Arctic and in ice-covered conditions (see Section 11.2).

Additional detailed information on oil spill response in Alaska is available on the following websites:

- https://cispri.org/ (CISPRI)
- https://arctic-council.org/about/working-groups/eppr/ (Arctic Council – international coordination for oil spill response)
- https://oaarchive.arctic-council.org/handle/11374/529 (Agreement on Cooperation on Marine Oil Pollution and Preparedness and Response in the Arctic)

- https://response.restoration.noaa.gov/sites/default/files/NOAA-guidelines-ephemeral-data-collection_Arctic_December2014.pdf (Guidelines for collecting high priority ephemeral data for oil spills in the Arctic…)
- https://response.restoration.noaa.gov/about/media/bsee-and-noaa-complete-arctic-oil-spill-response-mapping-tool.html (Arctic ERMA – oil spill mapping tool – 2012)
- https://www.scientificamerican.com/article/the-u-s-is-not-ready-to-clean-up-an-arctic-oil-spill/ (Article in Scientific American 2017 – points to need for better charting information in Arctic)
- https://toolkit.climate.gov/case-studies/preparing-respond-oil-spills-arctic (U.S. Climate Resilience Toolkit 2018 article)
- http://www.alaskacleanseas.org/ (Alaska Clean Seas)
- https://osri.us/ (Oil Spill Recovery Institute)

9.6. Other Measures such as Time-Area Restrictions, Pre-Activity Clearance, Soft-Start, Mitigation Airguns, and Avoidance of Sensitive Areas

There is limited literature on the efficacy of time-area restrictions, pre-activity clearance (*i.e.*, visual surveys to ensure an area is "clear" of marine mammals before activities start), soft-start or ramp-up procedures, mitigation airguns or avoidance of sensitive areas; however, these are some of the most regularly used mitigation measures in the U.S. Arctic and Cook Inlet. Though not quantified from a statistical perspective, these methods appear to mitigate, at least in part, some of the effects of oil and gas activities on marine mammals, although additional evaluation of these methods may reveal additional improvements that could be made in the future as the environment continues to change. From a precautionary perspective, regulations that require the implementation of such methods are consistent with mandates codified in the MMPA and ESA.

One of the simplest methods to reduce or eliminate potential effects of anthropogenic activities on marine mammals is to avoid animals in space or time. Weir and Dolman (2007) stated that "Area closures and avoidance of key marine mammal habitat remain the most effective and precautionary mitigation".

A seasonal (timing) restriction for oil and gas activities is included in CAAs for oil and gas activities in the Chukchi and Beaufort seas to avoid impacts to subsistence hunting of bowhead whales (Levfevre 2013). Arctic ringed seals and their breeding habitat are protected by seasonal restrictions for ice road and trail development and operations (NMFS 2020). Exclusion from sensitive areas or critical habitat is also highly effective at reducing interactions between oil and gas activities and marine mammals. For example, in Cook Inlet, certain activities must cease noise producing activities within 16 km of the MHHW line of the Susitna Delta (Beluga River to the Little Susitna River) between April 15 and October 15, as well as cease activity within a defined distance (*i.e.*, Level B harassment isopleth) of the mouth of the Kasilof River between January 1 and May 31. These sensitive areas are known as high-value foraging habitat for belugas (NMFS 2019).

As reported in Weir and Dolman (2007), soft-start procedures are widely used during seismic surveys, and in some regions, is the only measure implemented during hours of darkness. A soft start or ramp up procedure is generally implemented as a common-sense precautionary procedure to mitigate the risk of hearing effects by triggering an avoidance response in the animal to allow enough time for it to move away from the sound sources, thereby avoiding the risk of adverse effects of exposure. Guidelines for standardizing soft-start procedures are limited; therefore, the application of this measure varies in terms of energy output or duration. Initiating a soft-start procedure is assumed to provide marine mammals a "warning" or signal to leave the area before being exposed to sounds that may cause harm. In a similar fashion, certain mitigation protocols for airgun usage may be used to effectively achieve the same result, providing animals a cue that activities producing noise are occurring or will continue in an area.

Specific literature on the efficacy of these measures is somewhat limited (Von Benda-Beckmann, Wensveen et al. 2014). Wensveen (2012) modeled the exposure of killer whales to sound levels from a generic sonar operation that was preceded by different ramp-up programs. The model results demonstrated that ramp-up procedures reduced the risk of exposure of killer whales to noise that was sufficiently intense to affect their hearing. The effectiveness of the ramp-up procedure differed with ramp-up duration and depended strongly on assumed response thresholds. Again, while specific literature on the efficacy of these measures is limited, the few studies that have been conducted on the subject, and the frequency with which these types of measures have been implemented in the U.S. Arctic and Cook Inlet, indicate they are effective at some level. At a minimum, it is reasonable to state that NMFS and USFWS consider compliance with these measures as a means to reduce effects or 'takes' of marine, as required by MMPA authorizations.

9.7. Overview of Mitigation and Monitoring in the Chukchi and Beaufort Seas

A list of major marine mammal monitoring and other related reports associated with major oil and gas activities (including both proposed and executed) in the Chukchi and Beaufort seas is shown in Table C-1 of Appendix C. Since 2000, there have been at least 34 monitoring reports and related assessments published for the Northstar acoustic monitoring program, while an additional 32 reports are available for activities in the Beaufort or Chukchi seas.

The >20-year Northstar acoustic monitoring program was primarily designed to record industrial sounds and bowhead whale calls within proximity to the island using PAM methods such as DASARs (see Section 6.1.1). As such, this program presents one of the longest datasets for acoustic monitoring of marine mammals and oil and gas in the world. During certain years, additional monitoring information was recorded for Northstar such as the number of ringed or bearded seals observed in the vicinity. Results of monitoring during the annual bowhead whale subsistence hunt from Cross Island (see also Section 8.1.1) have also been recorded for much of the 2000–2020 period. The Northstar acoustic monitoring program is ongoing, and results are published annually. These data have been used to support MMPA and ESA mitigation requirements.

Mitigation measures implemented during Shell's offshore exploratory drilling program in the Chukchi and Beaufort seas were specified in a series of MMPA incidental take authorizations over the period 2006–2015 (NMFS 2007, NMFS 2007, NMFS 2008, NMFS 2008, NMFS 2009, NMFS 2010, NMFS 2012, NMFS 2015, NMFS 2015, NMFS 2016). As part of fulfilling compliance requirements, the 2016 Comprehensive Report by Ireland, Bisson et al. (2016) for marine mammal monitoring and mitigation during Shell's oil and gas exploration activities in the Chukchi and Beaufort seas provides a summary of results for several years during the period 2006 and 2015. In addition, the report summarizes data on regional sea ice cover 2006–2015 as well as a chapter on climate change and potential effects on marine mammals in the region.

Chapter 5 of the Shell Comprehensive Report presents monitoring results, while Chapter 11 provides an assessment of those results in terms of potential effects of oil and gas exploration activities on marine mammals (Ireland, Bisson et al. 2016). Shell used PSOs to observe for marine mammals and implement mitigation measures in defined harassment zones, deployed acoustic monitoring devices, and conducted separate aerial[15] and vessel-based surveys to collect general presence/absence data for marine mammals in project areas. Based on data gathered from the monitoring program, (Ireland, Bisson et al. 2016) suggests that impacts to marine mammals were limited to localized and short-term effects.

[15] Aerial surveys only occurred in 2012 and 2015 when photographic methods were used.

While most mitigation and monitoring programs undertaken in the Chukchi and Beaufort seas were applicable to marine mammal species in general, the following subsections provide additional examples of mitigation and monitoring programs that were tailored to be more species-specific for bowhead whales and bowhead whale subsistence hunting, Arctic ringed seals, Pacific walruses, and polar bears.

9.7.1. Bowhead Whale-Specific Mitigation and Monitoring

Smultea, Fertl et al. (2012) noted that at least 189 systematic studies involving bowhead whales were conducted in the U.S. Beaufort and Chukchi seas from 1975 to 2008, including some from 2009. Most (67%) of these studies were associated with monitoring and mitigation relative to offshore oil and gas exploration and development. The focus of these studies included aerial surveys, photogrammetry, ice- and shore-based census operations, tagging, and monitoring. Table 1 of Smultea, Fertl et al. (2012) lists the scientific studies and associated publications by year for the period 1975–2008, including a brief description of the purpose of the survey, survey method, general location, and timeframe.

Based on the results described in more than 34 monitoring reports (see Appendix C), the Northstar acoustic monitoring program provides a long-term dataset for evaluating the significance of: 1) industrial sounds detectable underwater at specific distances from Northstar (*i.e.*, see Kim and Richardson (2020)); and 2) bowhead whale calls detectable at specific distances from the island (primarily at locations identified as C/EB approximately 15 km from the island). As described in Kim and Richardson (2020), post construction, near-island sounds are primarily associated with vessel activity (see also (Blackwell and Greene Jr. 2006)) including tug-and-barge operations and crew boats. Notably, the Northstar monitoring program also demonstrated that acoustic monitoring data may be confounded by other projects offshore that may produce underwater sound. In 2008, seismic surveys occurred in Harrison Bay and Camden Bay, which were not associated with Northstar operations but detected by Northstar DASARs (Aerts and Richardson 2009, Blackwell, Burgess et al. 2009). Section 7.1.4.2 provides additional details and results from the >20-year Northstar monitoring program. It should be recognized that these observations are consistent with recommendations for management agencies to focus on managing the “soundscape” rather than focusing on anthropogenic noise produced by specific activities.

In 2007, visual (aerial) and acoustic monitoring was undertaken during Shell’s deep-penetration seismic surveys (2006–2008 and 2010) and shallow hazards surveys (2009, 2011, 2013). Monitoring data were compared to data collected in 2014, when no offshore oil and gas activities occurred. Figure 9-1 presents these results, with the top and middle panels showing years with oil and gas activities. Based on these data, Ireland, Bisson et al. (2016) stated there is strong agreement between results from the three monitoring methods. In other words, highest concentrations of visual detections of bowhead whales from both vessel and aerial surveys, despite substantial effort elsewhere in the region, occur in locations where acoustic detections were also high.

Most visual detections of bowhead whales took place near the coast between Utqiaġvik and Wainwright or further offshore north of 71°N for the months of July through early November during open water. Acoustic detections showed a similar pattern with many fewer calls detected on recorders south of 71°N. In 2014, when no oil and gas activities occurred in the area, acoustic detections and non-industry aerial surveys (by Aerial Surveys of Arctic Marine Mammals [ASAMM]) showed similar patterns, with all visual and the most acoustic detections north of 71°N. Ireland, Bisson et al. (2016) stated that this consistency of monitoring results (periods of no activity vs. activity) support a conclusion that the bowhead whale migration through the northeastern Chukchi Sea was not substantially disrupted in years when seismic activity took place.

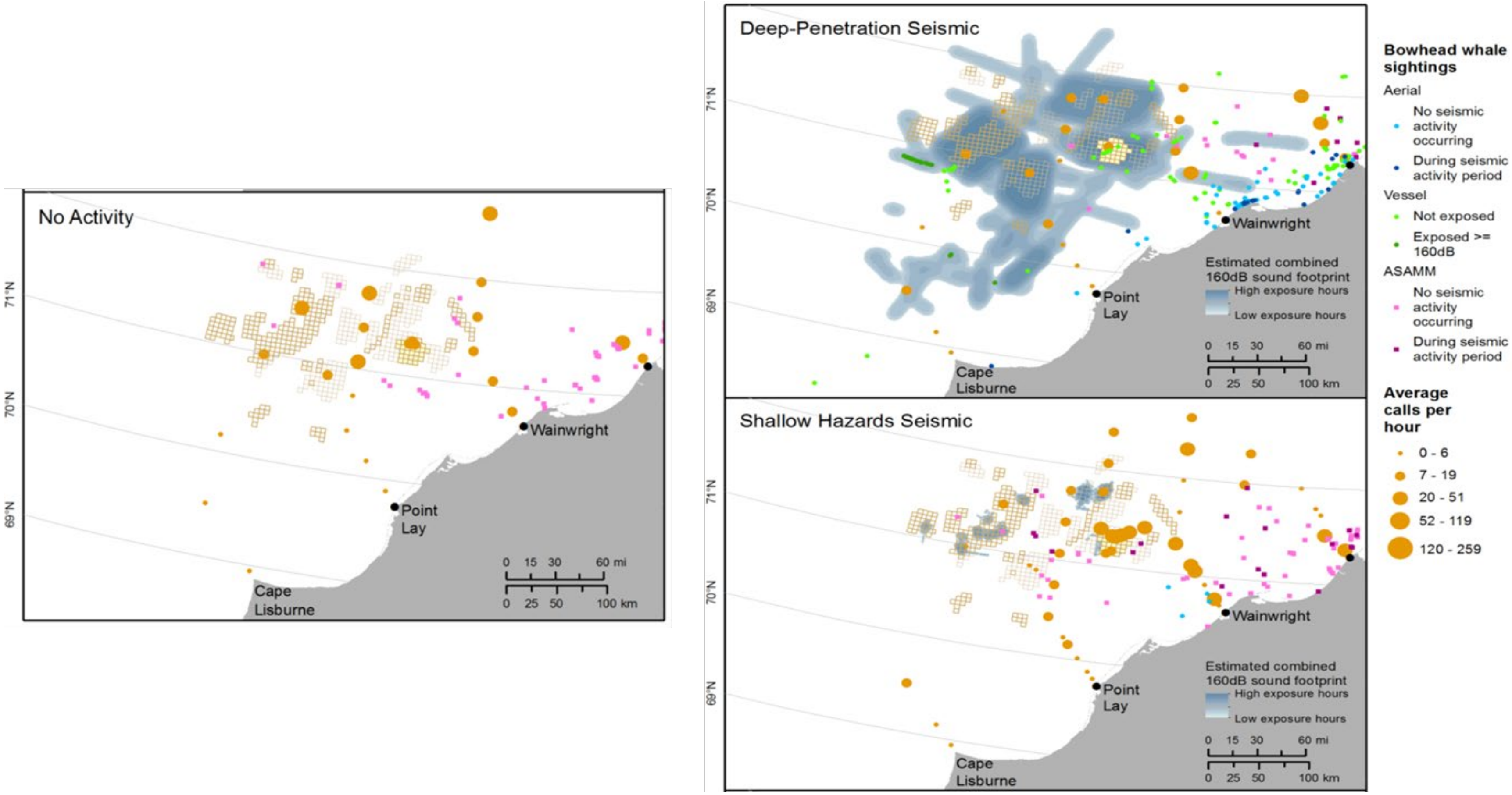

Figure 9-1. Bowhead Whale Vessel- and Aircraft-Based Sightings and Acoustic Detections as Average Calls Per Hour during Deep-Penetration Seismic (Top Panel: 2006-2008, 2010, 2012), Shallow Hazard Surveys (Middle Panel: 2009, 2011, 2013) Compared to 2014 When No Oil and Gas Activities Occurred in this Region of the Northeastern Chukchi Sea

Description: *In 2007, visual (aerial) and acoustic monitoring was undertaken during Shell's deep-penetration seismic surveys (2006–2008 and 2010) and shallow hazards surveys (2009, 2011, 2013). Monitoring data were compared to data collected in 2014, when no offshore oil and gas activities occurred. This figure presents these results. The left panel shows calls during no activity. The panel on top-right seems to show fewer marine mammal sightings or calls during deep penetration seismic activity.*

Source: Ireland, Bisson et al. (2016)

In addition to seismic and geohazard surveys in the Chukchi Sea, Shell conducted exploration drilling in 2012 and 2015 at the Burger Prospect. Prior to drilling, anchor handling and ice management were also necessary. Ireland, Bisson et al. (2016) reported greater temporal overlap of the 2012 activities with the bowhead whale fall migration through the area than in 2015, with 2012 activities beginning the first week of September versus mid-July in 2015. In 2012, there was also greater spatial overlap with the bowhead whale migration due to the location of drilling. Figure 9-2 shows the results presented in Ireland, Bisson et al. (2016) for marine mammal monitoring. The left panel shows vessel, aerial, and acoustic detection data for September 4-12, and soundscape for the Chukchi Sea from AMAR data during anchor handling activities September 6-9, 2012. The right panel shows the vessel, aerial, and acoustic detection data for September 13-21, 2012 during ice management.

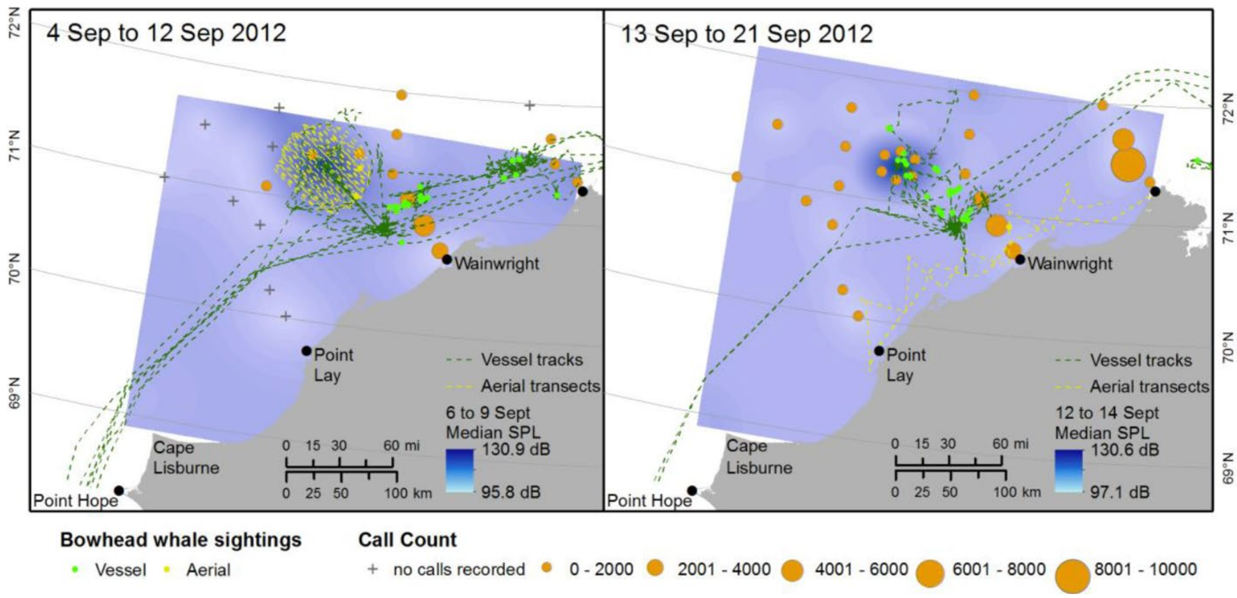

Figure 9-2. Vessel, Aerial and Acoustic Detection (Calls) of Bowhead Whales and Soundscape during Exploration Drill, Anchor Handling, and Ice Management in the Chukchi Sea in September 2012

Description: *This figure shows the results of marine mammal monitoring in the Chukchi Sea in 2012. The left panel shows vessel, aerial, and acoustic detection data for September 4-12, and soundscape for the Chukchi Sea from AMAR data during anchor handling activities September 6-9. The right panel shows the vessel, aerial, and acoustic detection data for September 13-21 during ice management. In the left panel whale calls were highest (4001-6000) nearshore off of Wainright with fewer recorded to the east near Utqiagvik (Barrow) (0-2000). the right panel shows that later in September the largest number of calls (8001-10000) were recorded off of Utqiagvik.*

Source: Ireland, Bisson et al. (2016)

Cetacean and non-cetacean sightings from ASAMM surveys conducted June 30 – September 30, 2012, as cited in Clarke 2013,[16] are consistent with the data presented in Ireland, Bisson et al. (2016), with bowhead whales distributed between Wainwright and Utqiaġvik during Shell's activities.

16 https://apps-afsc.fisheries.noaa.gov/Quarterly/jas2012/divrptsNMML1.htm; (Accessed August 5, 2021)

As reported in Ireland, Bisson et al. (2016), monitoring results from the Chukchi Sea exploration activities in 2012 and 2015 are consistent with data from 2014, when no oil and gas activities occurred. Figure 9-3 presents bowhead whale sightings from vessels and aircraft and the average number of bowhead whale calls per hour during drilling programs in 2012 and 2015 (left panel), as compared to 2014 with no activity (right panel). Based on these data, Ireland, Bisson et al. (2016) concluded that bowhead whales do not appear to show large-scale changes in migration due to these types of oil and gas activities.

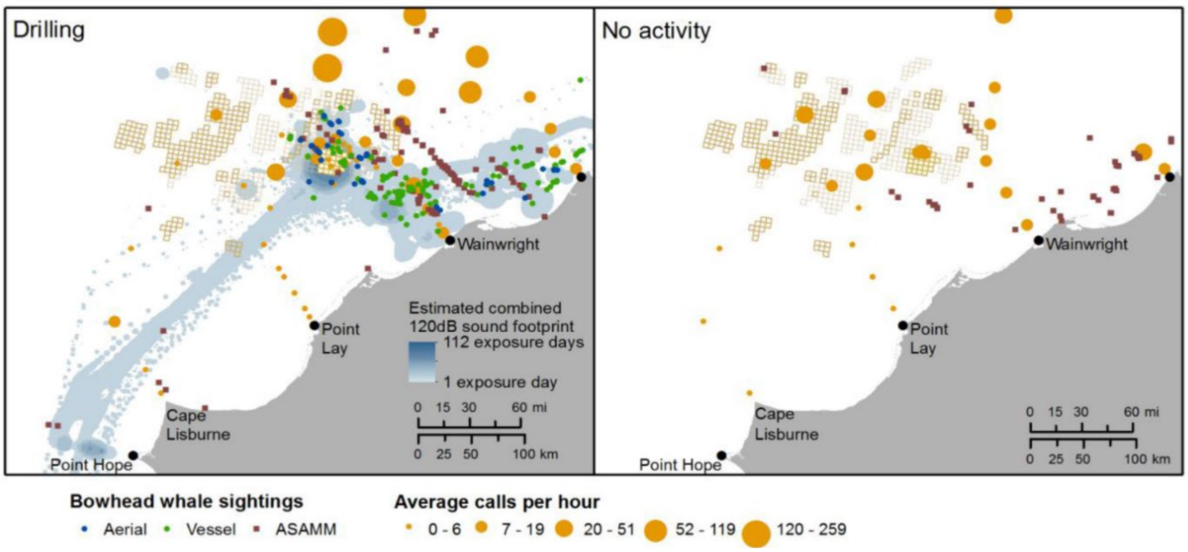

Figure 9-3. Vessel- and Aircraft-Based Bowhead Whale Sightings and Average Bowhead Whale Calls in 2012 and 2015 during Chukchi Sea Exploration Drilling (Left) Compared to 2014 during No Oil and Gas Activities

Description: *This figure presents bowhead whale sightings from vessels and aircraft and the average number of bowhead whale calls per hour during drilling programs in 2012 and 2015 (left panel), as compared to 2014 with no activity (right panel). The left panel shows large numbers of calls per hour (120-259) recorded offshore during drilling and fewer calls offshore when drilling was not occurring (7-51 per hour). Based on these data, Ireland et al. (2016a) concluded that bowhead whales do not appear to show large-scale changes in migration due to these types of oil and gas activities.*

Source: Ireland, Bisson et al. (2016)

Between 2006 and 2010, Shell conducted seismic and shallow hazard surveys in the central Beaufort Sea. Bowhead whale observations were recorded by vessel and aerial monitoring. DASARs were deployed to record bowhead whale calls and sounds produced during oil and gas activities (*i.e.*, deep-penetration seismic, shallow hazard surveys and anchor handling). Ireland, Bisson et al. (2016) reported that during drilling activities September 30 – October 8, 2012, bowhead whale sighting rates were relatively low, indicating the peak of migration had passed or was in a lull during the aerial survey effort (Figure 9-4).

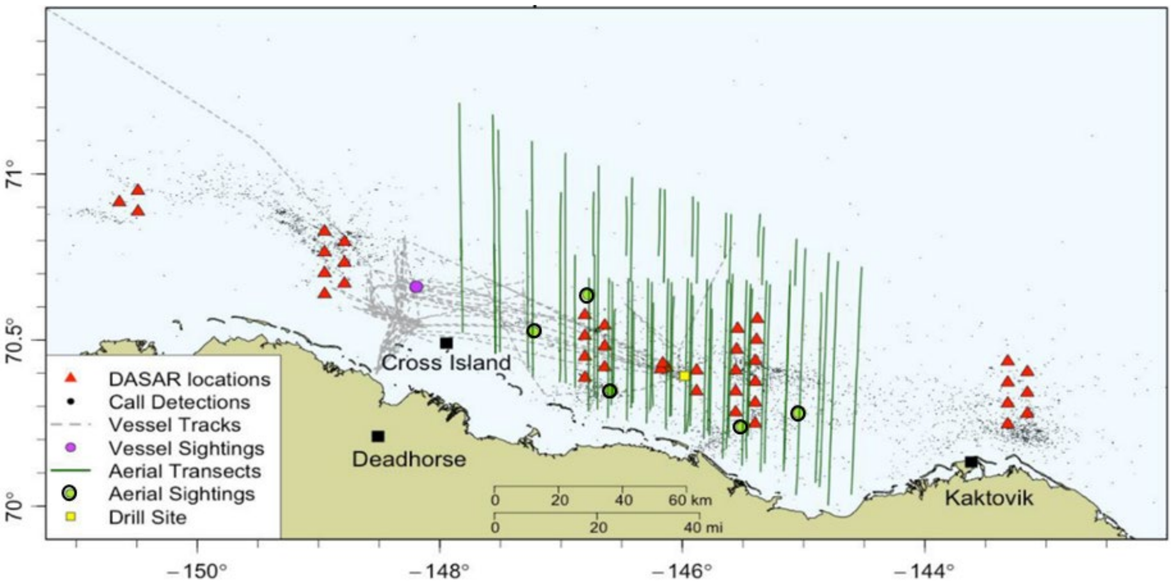

Figure 9-4. Bowhead Whale Vessel, Aerial, and Acoustic Data during Drilling Activities September 30 – October 8, 2012 in the Beaufort Sea

Source: Ireland, Bisson et al. (2016)

9.7.2. Specific Mitigation for Bowhead Whale Subsistence Hunters

As described in Section 6.5, a CAA has been one of the most effective tools for minimizing potential effects of industrial activities on subsistence hunters in the Beaufort and Chukchi seas (Levfevre 2013). Nuiqsut whalers expressed general concerns about oil and gas development based on their experiences in the 1980s and 1990s, but during the 12 years of study (2001-2012) Galginaitis (2014) did not find that oil and gas activities had any direct adverse effects on Cross Island whaling. During this period, the adverse effects associated with oil and gas activities (seismic work, exploratory drilling, associated vessel traffic, air traffic) were mostly managed by the CAA. According to Galginaitis (2014) commercial (but not petroleum industry) vessel traffic produced the only serious adverse effects on the Cross Island subsistence whale hunt in 2005 and 2009. Specifically, the CAAs outline strategies to support successful bowhead whale hunting by 12 communities in the U.S. Arctic by establishing restrictions on industry activities. Galginaitis (2021) stated:

> *Although a small number of individual incidents has been documented, none except perhaps the vessel interference event of 2005 directly affected the hunt, and ice conditions in 2005 were such that even without this incident the whalers would have had little access to the whales, although it is possible that this incident prevented landing a second whale. This overall positive result can be attributed to the success of the CAA and the ability of the whalers and industry to work together to minimize conflicts while working towards their separate goals.*

To minimize potential effects of their Chukchi and Beaufort seas program on subsistence activities, on April 23, 2015, Shell signed a CAA with the AEWC prior to starting exploratory drilling in the Burger Prospect in the Chukchi Sea in 2015. Shell implemented a communication program whereby each offshore vessel communicated with the nearest shore-based communication center (set up by Shell) every 6 hours, and conference calls with subsistence advisors from Chukchi Sea coastal villages were held twice daily during operations (Ireland, Bisson et al. 2016). Ireland, Bisson et al. (2016) stated that throughout all phases of Shell exploratory drilling program, consistent communication with subsistence hunters in the Chukchi and Beaufort seas, helped to avoid adverse impacts to the bowhead whale subsistence hunt.

9.7.3. Ringed Seal-Specific Mitigation and Monitoring

During aerial or vessel-based surveys, ringed seal densities may be underestimated due to animals being missed or not counted either because the animal is not available to be seen (*i.e.*, underwater or under ice) or are missed by the observer. Habitat-related variables, including water depth, location relative to the fast ice edge, and ice deformation, has shown to result in substantial and consistent effects on the distribution and abundance of seals (Frost, Lowry et al. 2004). Moulton, Richardson et al. (2003), Moulton, Williams et al. (2008) also reported that environmental factors, such as date, water depth, degree of ice deformation, presence of meltwater, and percent cloud cover, had more conspicuous and statistically significant effects on seal sighting rates than did any human-related factors. Due to intra- and interannual variability in survey conditions and ice characteristics and these other factors, monitoring of ice seals is challenging.

Several reports provide perspective on sighting rates, monitoring methods, and when possible, information on ringed seal behavior during oil and gas activities (*i.e.*, Richardson (2008), Richardson (2011), Ireland, Bisson et al. (2016); and Greeneridge Sciences Inc. (2017)). In some cases, multi-year monitoring studies were adapted based on results from a previous year. For example, the 2008 Northstar Comprehensive Report states:

> *The continued occurrence of ringed seals near Northstar each summer for five years suggests some combination of habituation and lack of sensitivity, possibly combined in some cases with curiosity. With the current level of open-water industrial activity at Northstar, there does not appear to be a need for further studies to elucidate potential effects of the low-to-moderate level, low-frequency industrial sounds from Northstar on ringed seals. However, BP is continuing to document seals near Northstar via procedures designed to obtain consistent daily counts, and continues to report on seal occurrence near Northstar (Richardson 2008).*

As summarized in Richardson and Williams (2000), approximately 6.6 km^2 were surveyed for ringed seals prior to initiation of ice road construction activities. Though much of the ice was flat and not optimal for seal lairs, surveys were conducted by biologists and Iñupiat hunters who used avalanche probes to identify potential breathing holes and lairs. No breathing holes or lairs were documented during this January 1999 survey. A follow-up survey for ringed seal breathing holes and lairs was conducted in May 1999 using trained dogs. The May survey did locate at least two, possibly three, open breathing holes within the area previously surveyed in January. Dogs surveyed for ringed seal structures (*i.e.*, breathing holes and lairs) in an area extending between 1 and 3.5 km from Northstar during a 3-year period 1999–2001. Surveys lasted 7 days in December 1999, 11 days in November and December in 2000, for 10 days in March 2001, and for 14 days in May 2001 (Moulton, Williams et al. 2008).

The following year, a subsequent survey was undertaken using dog-based searches, which found numerous seal structures within about 1 km of Northstar facilities before and after intensive construction activities in early and late winter. This may indicate that the survey method using avalanche probes and Iñupiat hunters was not effective or that ringed seals were unaffected by ice road/trail construction to such extent that it prevented them from establishing breathing holes in the project area (Richardson and Williams 2000).

Patterson, Blackwell et al. (2007) stated that monitoring for marine mammals during Shell's 2007 seismic survey during the Chukchi Sea open-water season demonstrated sighting rates during non-seismic periods declined with increasing Beaufort wind force. Increasing Beaufort wind force often results in decreasing sighting rates for marine mammal surveys considering that rougher sea conditions make it more difficult to detect animals, particularly small seals. Seals were only sighted when there was one (34% of 38 sightings) or two observers (66%) on-watch and were similar for both seismic (39.4 vs. 24.1 seals/1000 h of "daylight effort") and non-seismic periods (76.8 vs. 75.9 seals/1000 h of "daylight effort", respectively) when one versus two observers were on watch.

In 2020, NMFS published a final rule requiring implementation of specific mitigation and monitoring measures during sea ice road, trail and pad activities along the Beaufort Sea coast (NMFS 2020). The rule includes general measures to be implemented at all times as well as specific measures before and after March 1st to minimize disturbance during ringed seal pupping season. Measures include but are not limited to: vehicles do not stop within a 50 m radius of an identified seal lair or within 150 m of a seal; no initiation of ice road or trail construction if a ringed seal is observed within 50 m of the action area after March 1 through May 30 of each year; and monitoring of construction areas to detect the presence of seals before beginning construction activities. Monitoring results for 2020 were not publicly available at the time this report was prepared.

9.7.4. Walrus-Specific Mitigation and Monitoring

Pacific walruses are primarily found in the Chukchi Sea (Section 7.6.1). Thus, most monitoring data are based on oil and gas activities in the Chukchi Sea, as summarized here. Based on observations during the Shell exploratory drilling program in 2012 and 2015, walruses do not appear to exhibit large-scale changes in distribution or behavior when exposed to oil and gas activities, as shown in Figure 9-5. Ireland, Bisson et al. (2016) noted that variation in walrus distribution is closely tied to temporal and spatial distribution of sea ice in preferred foraging areas along the outer continental shelf. For example, in 2012, based on aerial surveys, walruses were only detected in September in the area around Shell's Burger Prospect, when the period of high ice concentrations were still persistent that year. During 2015, sea ice concentrations were lower near the Burger Prospect, and therefore, fewer walruses were observed during aerial surveys, preferring to remain on the ice further north of the site (96 % of walrus observations were associated with ice) (Ireland, Bisson et al. 2016).

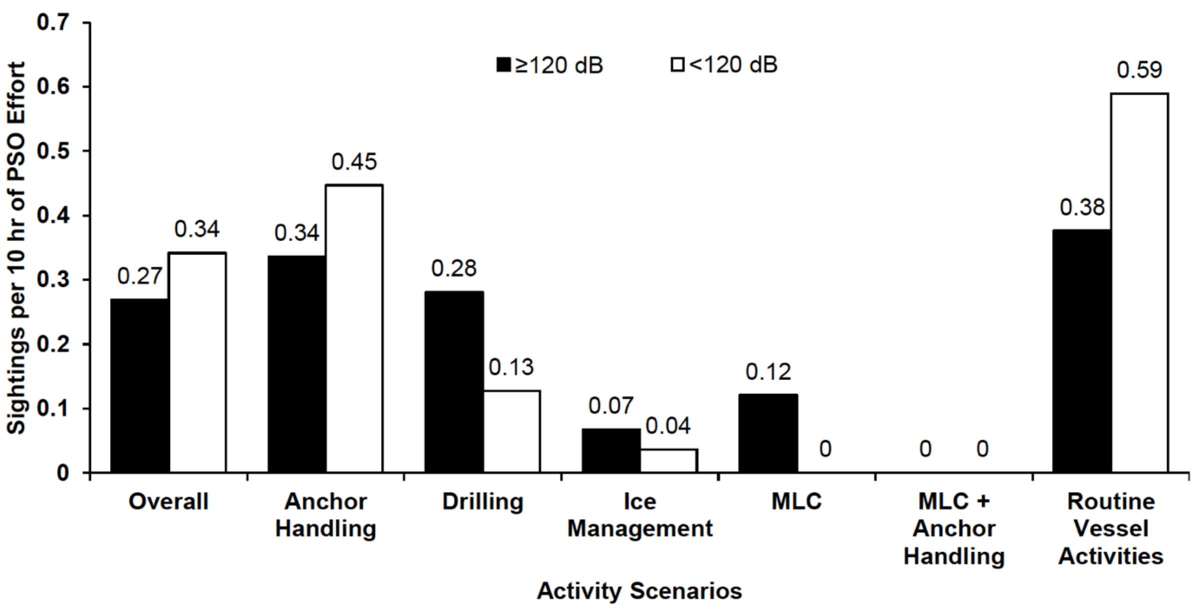

Figure 9-5. 2012 and 2015 Pacific Walrus Sighting Rates Per 10 Hours of Vessel-Based PSO Observation by Oil and Gas Activity including Received Sound Level in dB re 1 μPa

Source: Ireland (2016)

During the 2012 and 2015 Shell exploration activities in the Chukchi Sea, Ireland, Bisson et al. (2016) reported:

> *As a mitigation measure, industry-sponsored vessels maintained distances of >800 m from walrus observed on ice, which precludes meaningful conclusions about the distribution of walrus on ice. Mean CPA distances for walrus on ice were noticeably larger than those for walrus in water. This was likely driven by the minimum separation distance and the fact that walrus can be detected at greater distances on ice than in water. Observed distribution of walrus on ice during vessel encounters is primarily a result of vessel mitigation rather than walrus behavior.*

The 2016 Shell Comprehensive Report (Ireland, Bisson et al. 2016) goes on to state that limited aerial survey data were collected directly before or after ice management activities, making conclusions about walrus behavior during ice management difficult. However, some walruses were observed in the area during ice management activities, which may indicate some level of tolerance.

In recent years with the reduced presence of seasonal sea ice in the Chukchi and Beaufort seas, walrus haulout behavior has changed. This change in behavior has also been observed on the Russian side of the Chukchi Sea since the 1980s, absent suitable sea ice for hauling out in the summer and fall, walruses will use terrestrial sites for hauling out. Often, these haulout sites are used by 100s to 1,000s of animals. In these areas and during times of use by walruses, anthropogenic activities can cause hauled walruses to stampede into the water. This behavior has been associated with mortality of walruses due to crushing, especially of young animals. Therefore, regulations have been put in place by the USFWS to avoid disturbance of hauled walruses. Monitoring programs are required to identify areas where walruses haul out on land, and to subsequently establish adequate mitigation measures. To date, oil and gas activities have not been associated with disturbance of walruses hauled on terrestrial sites in large numbers.

On August 5, 2021, the USFWS published a final rule for incidental take of Pacific walruses (and polar bears) during oil and gas activities along the coast of Alaska's Beaufort Sea during the period 2021–2026 (USFWS 2021). Each year during the authorization period, USFWS will issue project-specific LOAs to industry for planned activities. The final rule requires future site-specific mitigation and monitoring plans during the authorization period including but not limited to POCs with Native communities, a walrus interaction plan, altitude restrictions for aircraft and vessel speed and movement restrictions. In addition, the rule requires industry to submit an after-action report on the monitoring and mitigation activities within 90 days after the LOA expires.

9.7.5. Polar Bear-Specific Mitigation and Monitoring

In March 2021, the Alaska Oil and Gas Association (AOGA) submitted an amended application for incidental harassment of polar bears due to oil and gas activities along the Beaufort Sea coast during the period 2021–2026 to USFWS (AOGA 2021). The AOGA application summarized an analysis of polar bear sighting records for 11 years (2009–2019), stating that 94% of industry sightings are instances of no behavioral response. Figure 9-6, taken from the application, presents the locations of polar bear-industry interactions 2009–2019. Table 9-3, from the application, is accompanied by the following text:

> *From 2009 to 2019, observed instances of incidental Level B harassment ranged from 1 to 29 per year, and the number of observations that resulted in no incidental Level B harassment ranged from 58 to 455 per year. During an average year in this period, 215 polar bears were observed by North Slope oil and gas industry operators, and 14 of these observations resulted in incidental Level B harassment. (AOGA 2021)*

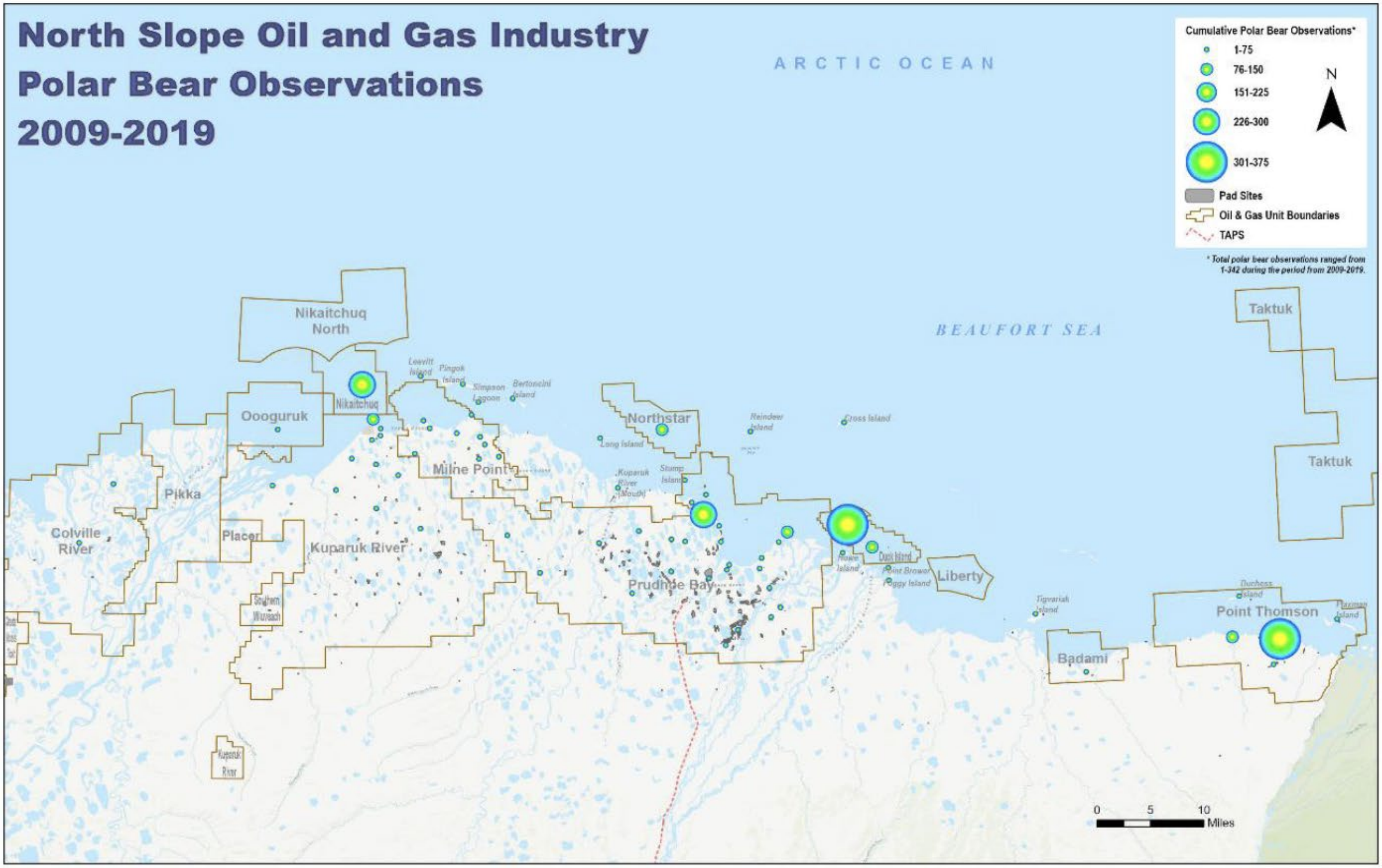

Figure 9-6. Alaska North Slope Oil and Gas Industry Polar Bear Observations 2009–2019

Source: AOGA (2021)

Table 9-3. Annual and Cumulative Total of Polar Bear Sighting, Observations, and Harassment Determinations 2009–2019

Year	Sighting Records	Bears Observed	Polar Bear Sighting Records, Observations, and Harassment Determinations (Resighting and Deterrence Events Excluded)			
			Sighting Records	Bears Observed	No Harassment	Incidental Level B Harassment
2009	173	322	123	231	205	26
2010	83	104	49	63	62	1
2011	155	233	93	135	128	7
2012	268	421	186	266	245	21
2013	221	307	132	169	154	15
2014	304	441	201	284	267	17
2015	91	103	57	66	58	8
2016	372	502	173	256	246	10
2017	207	344	113	161	154	7
2018	279	381	179	245	235	10
2019	545	810	316	484	455	29
Total	**2,698**	**3,968**	**1,622**	**2,360**	**2,209**	**151**
Annual Average	**245.3**	**360.7**	**147.5**	**214.5**	**200.8**	**13.7**

Source: AOGA (2021)

Wilson, Perham et al. (2018) evaluated how many polar bear dens might be disturbed by seismic surveys and the average distance activity came within simulated dens. The evaluation demonstrated that careful planning of the timing and distribution of seismic surveys had a major influence on the number of polar bear dens disturbed. In addition, pre-activity aerial surveys reduced the number of dens potentially disturbed by as much as 68% (Wilson, Perham et al. 2018).

In the 2021 final rule for oil and gas activities along the Beaufort Sea coast, the USFWS specifies certain mitigation and monitoring measures to be included in each project-specific mitigation and monitoring plan (USFWS 2021). For example, industry must provide estimates of human occupancy at project sites, a polar bear-specific interaction plan, a site-specific mitigation and monitoring plan—that specifies the frequency and dates of aerial infrared (AIR) surveys if required—and POCs with local Native communities.

From USFWS (2021):

> *Surveys utilize AIR cameras on fixed-wing aircrafts with flights typically flown between 245–457 m above ground level at a speed of <185 km/h. Surveys typically occur twice a day (weather permitting) during periods of darkness (civil twilight) across the North Slope for less than 4.5 hours per survey.*

As described in the rule, AIR surveys are to be performed in December or January to locate maternal polar bear dens to mitigate potential impacts to mothers and cubs during the period 2021–2026. Additionally, operators must maintain a 1.6 km operational exclusion zone around known polar bear dens during the denning season (November–April) or until the female and cubs have left the area.

9.8. Overview of Mitigation and Monitoring in Cook Inlet

In general, more monitoring reports are available for Cook Inlet oil and gas activities in the latter part of the period between 2000 and 2020, with many reports published beginning around 2012 (*i.e.*, (SAExploration 2012)). There are, however, several marine mammal monitoring reports from construction activities at the Port of Alaska associated with an expansion and re-construction project (*i.e.*, Prevel Ramos, Markowitz et al. (2006), Integrated Concepts & Research Corporation (2009), Integrated Concepts & Research Corporation (2010), Cornick and Seagars (2016)). The Port of Alaska monitoring reports provide useful information on the presence, absence, and behavior of marine mammals in Upper Cook Inlet.

As described in Lomac-MacNair, Smultea et al. (2014), as of 2014, very few Cook Inlet beluga aerial surveys had occurred in Upper Cook Inlet that have spanned multiple seasons. Based on marine mammal surveys conducted May–September 2012 for Apache Alaska Corporation's Cook Inlet 3D Seismic Program, 882 marine mammal sightings (approximately 5,232 individuals) were observed during 6,912 hours of monitoring in near- and offshore waters. During this period, approximately 1,842 hours of seismic activity took place, which equated to about 27% of the total monitoring effort. A total of six species were confirmed observed including Cook Inlet beluga whales, gray whales, harbor seals, harbor porpoise, and Steller and California sea lions. PSOs monitored from a helicopter or small plane (92 hours) within about 1 km from shore, a land-based station (916 hours), and three vessels (3,367 hours). Harbor seals were the most frequently observed marine mammal (563), followed by beluga whales (151), harbor porpoise (137), gray whales (9 single sightings), Steller sea lions (3) and California sea lions (1) (Lomac-MacNair, Smultea et al. 2014).

For the period June 1-30, 2012, during the seismic surveys in Upper Cook Inlet, SAExploration (2012) reported implementing 42 shutdowns, 16 power downs, and 68 clearing/safety zone delays due to marine mammal sightings. A total of 165 sightings that did not require mitigation measures were also reported. During the month of June, Apache Alaska reported zero takes of either Cook Inlet belugas or Steller sea lions during its 2012 operations, and only one Level B take of a harbor seal was reported during this period (SAExploration 2012). This is consistent with the conclusion that the mitigation measures were adequately effective at avoiding and minimizing adverse effects on marine mammals in the area.

In addition to visual surveys by Apache Alaska in 2012, approximately 2,537 hours of PAM occurred from one vessel during nighttime and most daytime operations. Data collected through PAM was not reported in Lomac-MacNair, Smultea et al. (2014). Apache also conducted 5,859 km of fixed-wing aerial surveys between May and October 2013 to establish a baseline when no seismic was occurring. These surveys aimed to understand finer-scale distribution, occurrence, habitat-use patterns, and behavior. Three species were sighted including 74 sightings of Cook Inlet belugas, 37 sightings of harbor seals, and one sighting of a harbor porpoise (Lomac-MacNair, Smultea et al. 2014).

In 2016, PAM was required by NMFS as mitigation for seismic surveys in Cook Inlet during non-daylight or low-visibility situations (*e.g.*, darkness, fog, and rain) (NMFS 2016). Following a shutdown exceeding 10 minutes during low-visibility conditions, survey operations were suspended until the return of good conditions, or PAM had to be implemented. Trained PSOs then listened for marine mammal vocalizations for 30 minutes. If no mammals were heard, operations could resume. If mammals were heard, operations were shut down and the process was re-started.

A 2018 monitoring survey by Sitkiewicz, Hetrick et al. (2018), details the results of a marine mammal monitoring program conducted during the Cook Inlet Pipeline Project between May 9 and September 18, 2018 between Ladd Landing near Beluga, Alaska and the Tyonek oil and gas platform. Project activities involved 11 vessels, including two tugs for anchor handling, one barge to install (pull) a pipeline, three dive support vessels, two offshore support vessels, two research survey vessels, and one crew vessel. PSOs (two) monitored from Ladd Landing on shore, while two PSOs were stationed on Tyonek Platform in Cook Inlet.

A total of 3,116 hours were spent on-effort monitoring with 84% during periods of no work, 8.5% during anchor handling, 4.8% during pipe pulling, 0.3% during obstruction removal and stabilization, 0% during in-water trenching, and 2.5% during other activities. Four hundred and ninety-three sightings (*i.e.*, groups) of approximately 1,184 individual marine mammals were observed from May 9 through September 15, 2018 (Table 9-4) (Sitkiewicz, 2018 #1170).

Table 9-4. Marine Mammal Sightings, Shutdowns, and Level B Exposures during the Cook Inlet Pipeline Project in 2018

Marine Mammal Species	No. of Sightings[1]	Estimated No. of Individuals[2]	No. of Shutdowns	No. Level B Exposures	No. of Allowable Level B Takes
Humpback whale	2	3	0	1	5
Gray whale	0	0	0	0	5
Beluga whale	143	814	1	0	40
Killer whale	0	0	0	0	10
Harbor porpoise	29	44	0	0	100
Stellar sea lion	1	2	0	0	6
California sea lion	0	0	0	0	5
Harbor seal	313	316	0	17	972
Other (carcass)	1	1	0	0	NA
Unidentified pinniped	3	3	0	0	NA
Unidentified marine mammal	1	1	0	0	NA
TOTAL	**493**	**1,184**	**1**	**18**	**1,144**

[1] One sighting equals one group.
[2] Resights of individual animals are not included in total counts.
Source: Sitkiewicz, Hetrick et al. (2018)

Mitigation measures during the Cook Inlet Pipeline Project included PSOs clearing the monitoring area 30 minutes prior to activities and requesting a delayed start if marine mammals were present. A shutdown was implemented if a marine mammal was observed within the safety zone during vessel activities. Over the course of the project, while clearing the safety zone, 25 marine mammal sightings occurred. Only one sighting resulted in a shutdown of vessel activities. Eighteen marine mammals were estimated to have been exposed to Level B acoustic harassment (*i.e.*, 120 dB re 1 µPa rms) in the safety zone during vessel activities (Sitkiewicz, Hetrick et al. 2018). Based on these results, the mitigation and monitoring program was successful in avoiding and minimizing effects on marine mammals from the project.

In addition to visual monitoring during the Cook Inlet Pipeline Project, PAM was conducted using a mooring deployed north of the pipeline corridor. An acoustic mooring package consisting of a recorder, echolocation logger (C-POD v1 Chelonia Ltd.), acoustical release, temperature and depth sensor, and subsurface float was deployed 1 km north of the pipeline approximately 1.3 nm from shore within the area visually monitored by PSOs (Castellote 2019). Due to interference from equipment rattling on the mooring, data collection of baseline noise levels (*i.e.*, before activity) was not successful. Acoustic data collected during project activities included, but was not limited to, vessel noise and pipeline pulling noise (considered both impulsive and continuous).

Figures 9-7 and 9-8 present data for vessels and pipeline pulling, respectively. Vessel noise not associated with the project is part of the ambient environment in Cook Inlet. The median SPL for vessel noise was 121.9 dB re 1µPa and the mean was 120.7 dB re 1µPa (standard deviation of 5.9 dB). Figure 9-7 also presents the 1-hour spectrogram for vessel noise recorded on May 1, 2018. On June 21, 2018, the median

SPL during pipeline pulling was 132.7 dB re 1µPa, while the mean was 130.3 dB re 1µPa (standard deviation of 5.9 dB re 1µPa) (Figure 9-8).

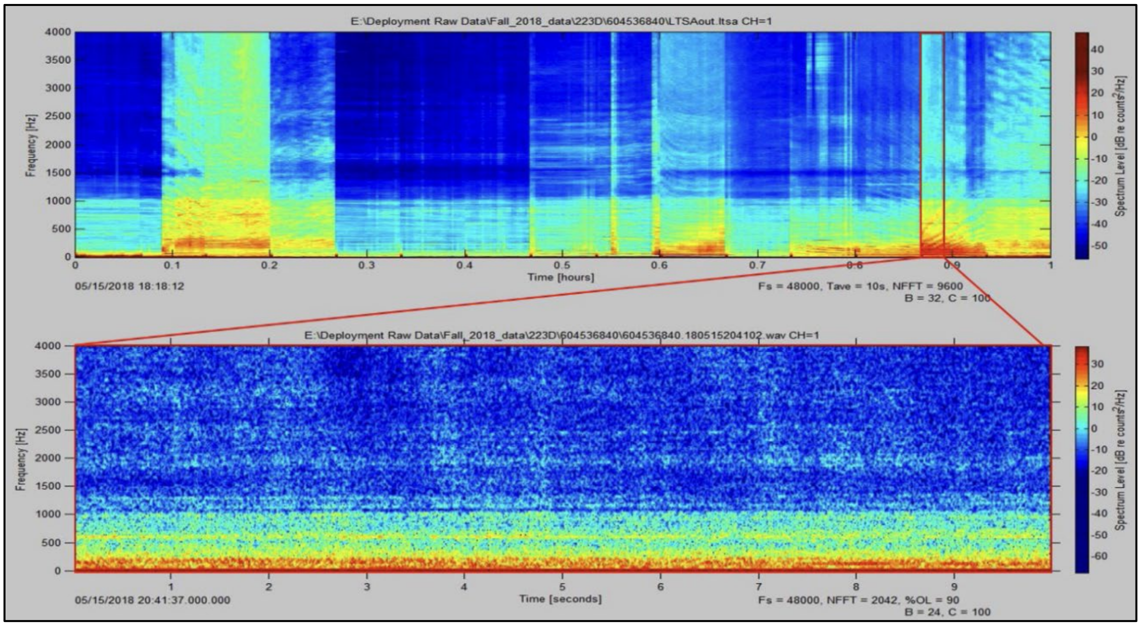

Figure 9-7. Vessel Noise Recorded (1 hour) May 15, 2018 during the Cook Inlet Pipeline Project

Description: *This figure shows that the median SPL for vessel noise recorded for one hour was 121. dB and the mean was 120.7 dB. The bottom spectrograph in this figure shows vessel noise with a low frequency (less than 500 Hz) was constant over the one-hour recording.*

Source: Castellote (2019)

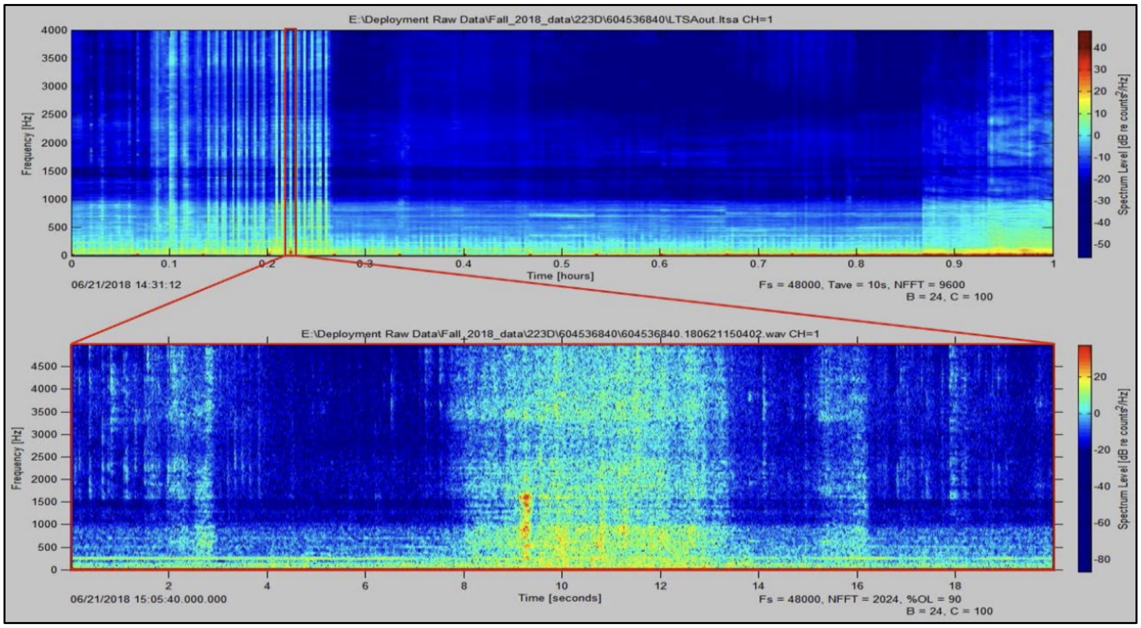

Figure 9-8. Pipeline Noise (Impulsive) Recorded for 1 Hour on June 21, 2018 during the Cook Inlet Pipeline Project

Description: *This figure shows Cook Inlet noise spectrographs during pipe pulling. On June 21, 2018, the median SPL during pipeline pulling was 132.7 dB, while the mean was 130.3 dB. The bottom spectrograph shows higher frequency sound (1500 Hz) pulses generated during the pulling.*

Source: Castellote (2019)

Comparing visual monitoring results to acoustic monitoring, all days with marine mammal sightings also had acoustic detections except for three (2.3%). As reported in Castellote (2019), based on concurrent visual and acoustic detections, the maximum acoustic detection range from the mooring was estimated as 6.7 km for vocalizations and 2.4 km for echolocation.

One of the most recent mitigation and monitoring reports was published in 2020 for the Hilcorp Alaska LCI seismic survey Fairweather Science (2020). The project occurred from September 10 through October 17, 2019 in central Lower Cook Inlet and involved 3D seismic data collection over a total of 790 km^2. The 14-gun dual airgun array was towed behind a source vessel at a speed of 7.41 km per hour to continuously collect data.

Initial monitoring zones were based on sound levels measured during the 2012 and 2013 Cook Inlet seismic projects conducted by Apache and SAExploration described at the beginning of this section. SSV was conducted during the LCI seismic project and monitoring zones were adjusted based on those results. Fairweather Science (2020) stated:

> *The results of the SSV data analysis established the recommended maximum distances to the Level A and Level B threshold levels for the 1,945 [cubic inch] airgun array. Based on the analyses, the distance to the NMFS Level B radius was reduced from 7,300 m to 7,100 m. The distance to the USFWS Level B radius was reduced from 7,300 m to 2,175 m. The difference between the two zones is because USFWS only considers sounds between 125 Hz and 38 kHz, so a good portion of the sound from seismic survey is below 125 Hz.*

Mitigation measures included mandatory exclusion zones for sea otters (50 m) and all other marine mammals (500 m), and Level B zones of 2,200 m for sea otters and 7,100 m for all marine mammals. Clearing zones (which evolved during the project) were initially established for mysticete whales (1,200 m), Dall's porpoises, minke whales, and Cook Inlet beluga whales (7,100 m). Additional specific detailed mitigation measures including but not limited to ramp up, shutdown, and protocols during low visibility or nighttime are described in Chapter 3 of Fairweather Science (2020).

A total of 1,368 hours of visual monitoring effort using PSOs was undertaken between September 10 and October 17, 2019. PSOs were stationed on the source and mitigation vessels and conducted aerial surveys (see Figure 7-14 in Section 7.2.1.5, which presents total vessel-based sightings during this monitoring program). Total marine mammal sighting rates during periods of no activity and seismic activity are shown in Table 9-5. Mitigation measures implemented during the 2019 LCI seismic project are presented in Table 9-6.

Table 9-5. Marine Mammal (Live) Sighting Rates during No Activity and Seismic Surveys for the Lower Cook Inlet Seismic Project in 2019

Species	No Activity				Seismic Activity			
	No. of Sightings[1]	Estimated No. Individuals[2]	Daytime sightings/ hour	Individuals/ hour	No. of Sightings[1]	Estimated No. Individuals[2]	Daytime sightings/ hour	Individuals/ hour
Dall's porpoise	5	15	0.027	0.082	5	15	0.052	0.017
Fin whale	4	18	0.022	0.099	4	5	0.017	0.014
Harbor porpoise	2	3	0.011	0.016	6	6	0.021	0.021
Harbor seal	3	3	0.016	0.016	6	6	0.021	0.021
Humpback whale	3	8	0.016	0.044	11	30	0.103	0.038
Killer whale	3	10	0.016	0.055	3	11	0.038	0.010
Minke whale	2	2	0.011	0.011	6	6	0.021	0.021
Sea otter	19	35	0.104	0.192	22	24	0.082	0.076
Steller sea lion	3	3	0.016	0.016	2	2	0.007	0.007
Unidentified dolphin or porpoise	1	1	0.005	0.005	1	3	0.01	0.003
Unidentified marine mammal	1	1	0.005	0.005	0	0	0	0
Unidentified Mysticete whale	2	2	0.011	0.011	6	6	0.021	0.021
Unidentified pinniped	0	0	0	0	2	2	0.007	0.007
Unidentified whale	5	7	0.027	0.038	8	9	0.031	0.027
TOTAL	**53**	**108**			**76**	**119**		

Source: Fairweather Science (2020)
[1] One sighting equals one group
[2] Totals do not include re-sightings

Table 9-6. Marine Mammal Mitigation Measures Implemented during the Lower Cook Inlet Seismic Project in 2019

Species	Mitigation Measure				
	None	Clearing	Delay Start Up	Shut Down	Total
Dall's porpoise	8	2	0	0	
Fin whale	4	3	0	1[1]	8
Harbor porpoise	0	2	0	0	2
Harbor seal	8	1	0	0	9
Humpback whale	13	1	0	0	14
Killer whale	6	0	0	0	6
Minke whale	8		0	0	8
Sea otter	29	12	0	0	41
Steller sea lion	1	3	0	1[1]	5
Unidentified dolphin or porpoise	1	1	0	0	2
Unidentified marine mammal	1	0	0	0	1
Unidentified Mysticete whale	8	0	0	0	8
Unidentified pinniped	2	0	0	0	2
Unidentified whale	13	0	0	0	13
TOTAL[2]	**102**	**25**	**0**	**2**	**129**

[1] The shutdown associated with this sighting occurred within a one-shot period in response to a single animal in the Level A zone.
[2] Total does not include deceased marine mammal sightings.
Source: Fairweather Science (2020)

Fairweather Science (2020) reported that during the LCI seismic project, PSOs were able to monitor at least 8% of the Level B zone during daytime operations. Near live-time tracking of marine mammal takes were calculated during the LCI project, a new approach to estimating takes under the MMPA LOA (as typically, takes are calculated post-project and then reported). As a result, an unexpected rapid approach to the Level B take limit for Dall's porpoise occurred during the course of the project, thereby necessitating a modification to the LOA issued by NMFS (NMFS 2019). However, as stated in Fairweather Science (2020):

> *This approach was not prompted by the raw count of Dall's porpoise sightings within the Level B zone during seismic operations; rather, the density value for Dall's porpoise that was used in the formula was driving the value upwards at a rate that did not accurately represent the actual number of sightings recorded. In response, NMFS approved the removal of the calculation method for species that were not listed in the ESA; exposure estimation for all ESA-listed species (beluga whale, fin whale, humpback whale, and Steller sea lion) continued. This issue highlighted the fundamental assumption within the formula, which is marine mammal density.*

Chapter 6 of the LCI Mitigation and Monitoring Report Fairweather Science (2020) provides additional insights on lessons learned during the monitoring program, including but not limited to, the following direct statements:

> *Effort and sightings data were collected on a tablet with a streamlined, user-friendly data collection app[lication]… The app[lication] was designed to capture critical marine mammal data and expedite data entry, in order to maximize the amount of time observers had eyes on the water. Supplemental data were collected with voice recorders. One suggested aerial app[lication] improvement would be to add fields previously dictated into the voice recorders.*

With regard to the monitoring app used during vessel-based surveys:

> *Particularly successful features included the real-time display of marine mammal sightings on the interactive map display, and ability to document and edit multiple sighting entries at once.*
>
> *Distance estimation offshore, where points of reference are limited, is often difficult…To address this potential issue, PSOs practiced distance estimation during the pre-deployment training and were instructed to continually practice this skill with each other in the in the field. The bridge equipment includes radar, which provides an accurate distance to land or other vessels in the area. Additionally, range finders were included in the PSO equipment kit and are useful to measure distances to objects close to the vessel.*

Considering that seismic projects are one of the more impactful activities during oil and gas projects due to increased underwater noise, the results of the LCI monitoring program indicate these effects can be mitigated through successful implementation (and careful pre-project planning) of a mitigation and monitoring program. Improvements, as noted in Chapter 6 of Fairweather Science (2020), can continue to be made to further reduce potential interactions between marine mammals and oil and gas activities.

9.9. Additional Considerations

Based on an evaluation of the numerous mitigation and monitoring reports, monitoring is an essential component of any mitigation protocol required by NMFS or USFWS. For example, the presence of PSOs or the implementation of PAM protocols provides important information needed by federal agencies to evaluate whether a given mitigation strategy is successful relative to the mandated goals in the MMPA and the ESA. As noted above, in many cases, the marine mammal sightings data from monitoring programs are inappropriate for use in estimating abundance or the phenology of migratory behavior. However, these same data are useful in describing the presence or absence of marine mammals in a given area and indicate, on some level, certain behaviors that could be further evaluated. Federal agencies and holders of LOAs and IHAs should continue improving monitoring data collection to continue assessing the status of marine mammal stocks and the effects of oil and gas activities on marine mammal populations. Continued improvements will require greater consistency in monitoring protocols both interannually and among holders of ITAs (*i.e.*, LOAs and IHAs). Where practical, rigorous application of state-of-the-art observation and recording practices should be implemented. Further, consistent with common practice, the absence of marine mammal sightings during periods of on-effort observations should be quantified and reported, given it serves as a valuable source of information.

10. Effects of Other Human Activities and Natural Factors on Marine Mammals by Region

As described in Section 4.7, marine mammals may be exposed to a variety of natural events and human activities that could result in stress. While there are many different stressors, this chapter focuses on those receiving the most attention in the literature for the period 2000–2020. For a discussion on cumulative effects on marine mammals associated with oil and gas activities in the U.S. Arctic and Cook Inlet, please refer to Sections 4.7, 7.10, and 8.2.6.

10.1. Climate Change

Climate change can affect physical aspects of the marine environment including: increased atmospheric temperatures leading to decreased sea ice and to changes in sea surface temperatures; oceanic pH; patterns of precipitation, and sea levels (Boveng, Ziel et al. 2020, NMFS 2020). Marine mammal individuals and populations respond to these climate-induced changes in their physical environment in a variety of ways including shifts in distribution, abundance, or phenology (Lettrich, Asaro et al. 2019). While the Arctic regions and changing patterns and duration of sea ice have been documented by numerous authors (*e.g.*, (George, Huntington et al. 2003, Hopcroft, Bluhm et al. 2008, Kovacs, Lydersen et al. 2010, USGS 2012, IPCC 2014, Bromaghin, McDonald et al. 2015, Atwood, Peacock et al. 2016, Huntington, Quakenbush et al. 2016, Huntington, Quakenbush et al. 2017, Udevitz, Chadwick V. J. et al. 2017, Mioduszewski, Vavrus et al. 2018), other more temperate regions, such as Cook Inlet waters, are affected by reduced duration of sea ice, rising sea levels (Vermeer and Rahmstorf 2009, Glick, Clough et al. 2010), and changes in water temperature (NMFS 2020). Appendix C (Bin 6) provides additional citations addressing climate change impacts on marine mammals and subsistence hunting efforts.

10.1.1. U.S. Arctic Region

In the Arctic, the loss of sea ice is altering water temperatures, water column stratification, primary productivity, and distribution and abundance of fishes, seabirds, and marine mammals. With the exception of a potential large oil spill which has not occurred in the study area, the incremental impact of oil and gas activities, when added to other past, present, and reasonably foreseeable future actions, are expected to be negligible to minor when compared to potential impacts from climate change (BOEM 2018). Climate change in the Arctic is the driving factor behind increased vessel traffic, air traffic, military activity, and some economic development and is expected to have substantial effects on Arctic marine mammals. Huntington, Danielson et al. (2020) acknowledged that extremely warm conditions in the Chukchi and Bering seas 2017–2019 were a marked change from other warm years, indicating that this state of change could alter ecosystem structure and function.

Climate-driven alterations in Arctic environments can influence habitat availability, marine mammal species distributions and interactions, and their breeding, foraging, and health (VanWormer, Mazet et al. 2019). From Huntington, Carmack et al. (2015):

> *Sea ice is forming later in fall, more open water can be found in winter, thickness has decreased and there is less multi-year ice, spring melt occurs earlier, and broken ice disappears more quickly than in the past (e.g., Kwok et al., 2009; Walsh, 2013; Perovich et al., 2016). These and related observations have been made by satellites, field studies, and indigenous peoples of the Arctic coasts (e.g., Gearheard et al., 2013; Johnson et al., 2015; Perovich et al., 2016).*

Climate change and the loss of Arctic sea ice can affect ice seal populations significantly; in response, NMFS in 2012 listed the Arctic subspecies of ringed seals and the Beringia DPS of bearded seals as threatened under the ESA (77 FR 76706; 77 FR 76740). Boveng, Ziel et al. (2020) recently reported declines in seal condition that coincided with recent pronounced Arctic warming. The authors concluded that "Warming conditions in the Arctic seem to be affecting the condition of individual seals in a way that could impact their populations."

Habitat loss due to declining Arctic sea ice throughout the polar bear's range has also been identified as the primary cause of population decline and is expected to continue for the foreseeable future (73 FR 28212). Patterns of increased temperatures, earlier spring thaw, later fall freeze-up, increased rain-on-snow events (which may cause polar bear dens and seal lairs to collapse), and potential reductions in snowfall are occurring (USFWS 2021). The timing of ice formation and breakup impacts seal distributions and abundance, and therefore, affects polar bears' efficiency in hunting seals (USFWS 2021). Research has linked declines in summer sea ice to reduced physical condition, growth, and survival of polar bears (Bromaghin *et al.* 2015, as cited in USFWS 2021).

Pacific walruses have apparently adapted their behaviors (e.g., migration patterns, coastal haulout locations, and feeding patterns) within a period less than one generation (MacCracken, Beatty et al. 2017). However, Udevitz, Chadwick V. J. et al. (2017) noted that the increased use of coastal haulouts caused by declining sea ice extent has led to a decrease in the use of more productive offshore feeding areas, and that "such climate-induced changes in distribution and behavior could ultimately affect the status of the population". Udevitz, Chadwick V. J. et al. (2017) suggest that as sea ice becomes less available in the Chukchi Sea, female walruses will spend more time in the southwestern region, less time resting, and less time foraging.

Arctic cetaceans are also affected by climate change. Open-water seasons become longer and more variable as Arctic sea-ice diminishes, thereby substantially changing habitat; many areas are now regularly ice-free when whales are present (Druckenmiller, Citta et al. 2018). Some bowhead whale subpopulations have shown increases in population growth concurrent with regional evidence of sea ice loss (Laidre, Stern et al. 2015). These subpopulation increases may be a result of thinner ice and a lesser extent of multi-year ice, both of which can increase feeding opportunities for bowhead whales (Huntington, Quakenbush et al. 2017). George *et al.* (2006, as cited in NMFS 2020) showed that harvested bowhead whales had better body condition during years of light ice cover.

As described in Section 7.4.1.1, sea ice also provides protection for Arctic cetaceans from predators such as killer whales (Willoughby, Ferguson et al. 2020). Increased presence of the killer whales and lack of sea ice protection could have significant impacts on endemic Arctic whales (and seals) in as sea ice is further reduced (Kovacs, Lydersen et al. 2010). As sea temperatures change, belugas whales have been seen at unusual times of the year in the Bering Sea and Bristol Bay. For example, in January 2015 near Elim, beluga whales were observed being pursued by killer whales; the authors noted that it was very rare to see belugas in January near Elim (Huntington, Quakenbush et al. 2017).

Decreased sea ice often also means an increased amount and duration of vessel traffic. The Northwest Passage (NWP) and Northern Sea Route (NSR) are now increasingly sea ice–free, with routine vessel transits expected by midcentury (Hauser, Laidre et al. 2018). As an indirect impact of reduced sea ice, Kovacs, Lydersen et al. (2010) noted that:

> *…it is highly likely that over the coming decades Arctic marine mammals will face increased impacts from human traffic and development in previously inaccessible, ice-covered areas (e.g., Kovacs and Lydersen 2008; Fuller et al. 2008; Ragen et al. 2008; AMSA 2009).*

As summer sea ice recedes, shipping lanes are likely to open, resulting in greater commercial and scientific vessel traffic passing through marine mammal habitat of many species. While some marine mammals may be able to detect and avoid commercial vessel traffic, vessel noise may result in short-term behavioral responses. Hauser, Laidre et al. (2018) assessed the vulnerability of seven Arctic marine mammal species to vessel traffic during the lengthened ice-free season. Table 10-1 provides the vulnerability assessment scores; higher numbers indicate higher vulnerability for the species. Regions with geographic bottlenecks, such as the Bering Strait and eastern Canadian Arctic were characterized by two to three times higher vulnerability than more remote regions (Hauser, Laidre et al. 2018).

Table 10-1. Vessel Strike Vulnerability of Arctic Marine Mammals

Marine Mammal Species	Proportion of subpopulations exposed	Exposure	Sensitivity	Vulnerability	Uncertainty
Beluga	0.33	2.13	2.38	5.06	1.77
Narwhal	0.50	2.29	2.45	5.59	2.12
Bowhead	0.50	2.22	2.31	5.16	1.50
Ringed seal	0.63	1.92	1.83	3.52	2.64
Bearded seal	0.78	2.12	1.89	4.01	2.80
Walrus	0.42	2.59	2.05	5.34	2.04
Polar bear	0.63	1.67	1.77	2.95	2.52
All AMMs	**0.53**	**2.05**	**2.02**	**4.20**	**2.32**

Note: Subpopulations with no exposure to the sea routes are excluded from the estimation of means.
Source: Hauser *et al.* (2018)

Changes in sea ice affect the ability of indigenous hunters to travel to hunting areas, the safety of traveling and hunting, and the duration of the hunting period (*e.g.*, Noongwook *et al.* 2007; Kapsch *et al.* 2010; Fienup-Riordan *et al.* 2013, all cited in (Huntington, Quakenbush et al. 2017). Subsistence success might also be reduced due to climate change if animals are less abundant or less available, if body condition worsens, or if novel diseases and parasites begin to appear in the subsistence species (Hovelsrud *et al.* 2008; Gadamus 2013; Huntington *et al.* 2016, all cited in (Huntington, Quakenbush et al. 2017). Not all changes are negative, however.

Huntington, Quakenbush et al. (2017) notes:

> *As one example, later fall freeze-up has allowed whalers on St. Lawrence Island in the northern Bering Sea to develop a fall bowhead hunt to compensate for poor spring hunting conditions during their traditional spring hunt (Noongwook et al., 2007). Whalers in Kaktovik have seen no changes to the timing of the fall migration of bowheads, nor to behaviors such as feeding near the shore. Kaktovik and Utqiaˋgvik whalers have seen an increase in the number of bowhead whales over the past several decades. In Utqiaˋgvik, the whales are coming earlier than they used to. Wainwright whalers have seen the spring bowhead migration begin earlier, perhaps due to the lack of multi-year ice as an obstacle. Formerly, the first group of bowhead whales, primarily small, young whales, could occur in late April, but now happens earlier in the month and even in March.*

However, even though St. Lawrence Island whalers are able to pursue a fall bowhead whale hunt, harvesting of other species has been impacted by climate change. Tempel (2019) documented decreased walrus harvests and limited access to walruses with increased hunting effort and limited crab harvests due to lack of shorefast ice.

10.1.2. Cook Inlet

The average global (“eustatic”) sea level rose about 178 mm (7 inches) over the 20th Century, which was 10 times faster than the average rate of sea-level rise during the last 3,000 years (IPCC 2007). Vermeer and Rahmstorf (2009) developed a model linking global sea level variations to global mean temperatures. They projected a global sea-level rise ranging from 75 to 190 cm for the period 1990–2100. In a study considering potential vulnerability of Cook Inlet waters to sea level rise, Glick, Clough et al. (2010) found that the "wetland habitat in the study region does not appear to be particularly vulnerable to sea-level rise and most impacts noted do not occur until after about a 1.5 meter rise in eustatic sea level" or about what Vermeer and Rahmstorf (2009) predicted by 2100:

> *The primary reasons for the relatively low vulnerability among these habitats are two-fold: 1) on the basis of current trends, significant land uplift in the region is predicted over the next century, which counteracts the regional impact of sea-level rise; and 2) the area experiences relatively high tidal ranges, which are significantly less vulnerable to sea-level rise than are microtidal regimes because marshes extend over a much wider vertical range and any increase in sea-level rise relative to the overall tide range is much lower (Glick, Clough et al. 2010).*

Glick, Clough et al. (2010) acknowledge that their model does not account for water quality changes, changes in the snow-free season, changes in wildlife ranges due to temperature changes, nor increased erosion due to climate change.

In addition to potential sea level changes, the physical environment of Cook Inlet is changing as the duration of seasonal sea ice is shorter. In Cook Inlet, mesozooplankton sampling from late 2006 to early 2007 suggested a decrease in biomass values attributed by the authors as driven by changes in climate (Batten and Mackas 2007, as cited in (NMFS 2019). Changes in temperature affect zooplankton abundance, which influences fish populations, and the quality and types of fish available for marine mammals (NMFS 2019). Increases in harmful algal blooms could also be a result of increases in sea surface temperature (Moore *et al.* 2008, as cited in (NMFS 2019).

These changes to prey availability negatively impact marine mammal population sustainability in sub-Arctic and temperate waters such as Cook Inlet (Simmonds and Eliott 2009, as cited in (NMFS 2020). For example, the poor growth and survival of Pacific cod, an important prey species for humpback whales and Steller sea lions, has been attributed to a mass of especially warm water in the North Pacific Ocean, referred to as "the blob" (NMFS 2019, NMFS 2020). Marine mammals in the Gulf of Alaska were likely impacted by the low prey availability associated with warm ocean temperatures that occurred in the Gulf during 2014–2016 (Bond *et al.* 2015; Peterson *et al.* 2016; Sweeney *et al.* 2018, all cited in (NMFS 2019, NMFS 2020).

Litzow, Hunsicker et al. (2020) conducted a study to evaluate ecological consequences of the extreme temperatures in the Gulf of Alaska 2014–2019. While these warm years were well outside the simulated pre-industrial conditions in terms of sea surface temperature, the paper notes that none of the statistical analyses indicated evidence of a post-2014 alternative ecosystem state. In other words, in spite of the anecdotal reports of dramatic biological responses to heatwave conditions, the results of the Litzow, Hunsicker et al. (2020) study are consistent with other research of available data that the ecological community is resilient to drastic changes from the 2014–2019 warming event.

10.2. Vessel Traffic

10.2.1. U.S. Arctic Region

Marine vessel traffic in the Chukchi and Beaufort seas is associated with supplying coastal communities, subsistence hunting, oil exploration and development, research, and military activities. Weather and ice typically limit marine vessel traffic in the Arctic to July through September (BOEM 2018). However, this time period is changing and extending as open water becomes more extensive during the summer months (NMFS 2015). The types of vessels operating in the U.S. Arctic include: barges; smaller vessels and skiffs with outboard motors used for hunting and local transportation; icebreakers; tour boats; scientific research vessels; large vessels associated with oil and gas and military activities; recreational vessels such as cruise ships; and a few ocean-going sailboats (NMFS 2015). Barges and small cargo vessels are used to transport machinery, fuel, building materials, and other commodities to coastal villages and industrial sites during the open water period. Vessel traffic supports the Arctic oil and gas industry, and some activity is the result of emergency-response drills in marine areas (NMFS 2015). While the smaller vessels and barges and some of the larger vessels, such as oil spill response ships and equipment, do remain in the Arctic area over winter, many supply and support ships transit to the Arctic along the marine transit route through the Bering Strait each year (see Section 3.2.7).

The USCG District 17 (USCG 2013, as cited in (BOEM 2018) reported annual vessel traffic transiting the Bering Strait to the Chukchi and Beaufort seas increased from 220 to 480 vessels a year between 2008 and 2012. The Office of Naval Intelligence (2014, as cited in (BOEM 2018) estimated that Bering Strait transits may exceed 1,000 vessels per year by 2025 due to changes in ice patterns across the NSRs. The same publication reports that in 2012, 96 vessel passages occurred in the NSR over Russia and the NWP through Canada combined. That level of activity may increase to 1,000 passages by 2025, due to an increase in open-water periods from approximately 2 to more than 5 weeks.

Seasonal ice will still occur, likely limiting vessel traffic to about 6 to 8 months a year. According to Khon *et al.* (2010, as cited in (BOEM 2015), by the end of the 21st Century, the NSR may be open for navigation 4.5 months per year, while the NWP may be open 2 to 4 months per year (Larsen *et al.* 2014, as cited in (BOEM 2015). However, Arctic shipping may or may not linearly increase; in 2014, there was a major reduction in shipping traffic in the NSR (BOEM 2015), but between 2008 and 2012, vessel activity in the U.S. Arctic increased from 120 vessels to 250 mostly due to oil and gas activity (BOEM 2015). For a discussion of ships using the marine transit route between Dutch Harbor and the Chukchi and Beaufort seas, see Section 3.2.7.

10.2.2. Cook Inlet

Vessel traffic in Cook Inlet transits through the Ports of Kodiak, Homer and Anchorage. OSVs, tug vessels, and tour boats represent 86% of the total operating days for vessels in Cook Inlet (BOEM 2016). Vessel traffic is concentrated along the eastern margin of Cook Inlet between the southern end of the Kenai Peninsula and Anchorage (Figure 10-1). During summer, vessel traffic in the portions of upper Cook Inlet used most extensively by Cook Inlet belugas (north of the Forelands) consists of large container ships and tankers, small recreational watercraft, and vessels associated with the oil and gas industry.

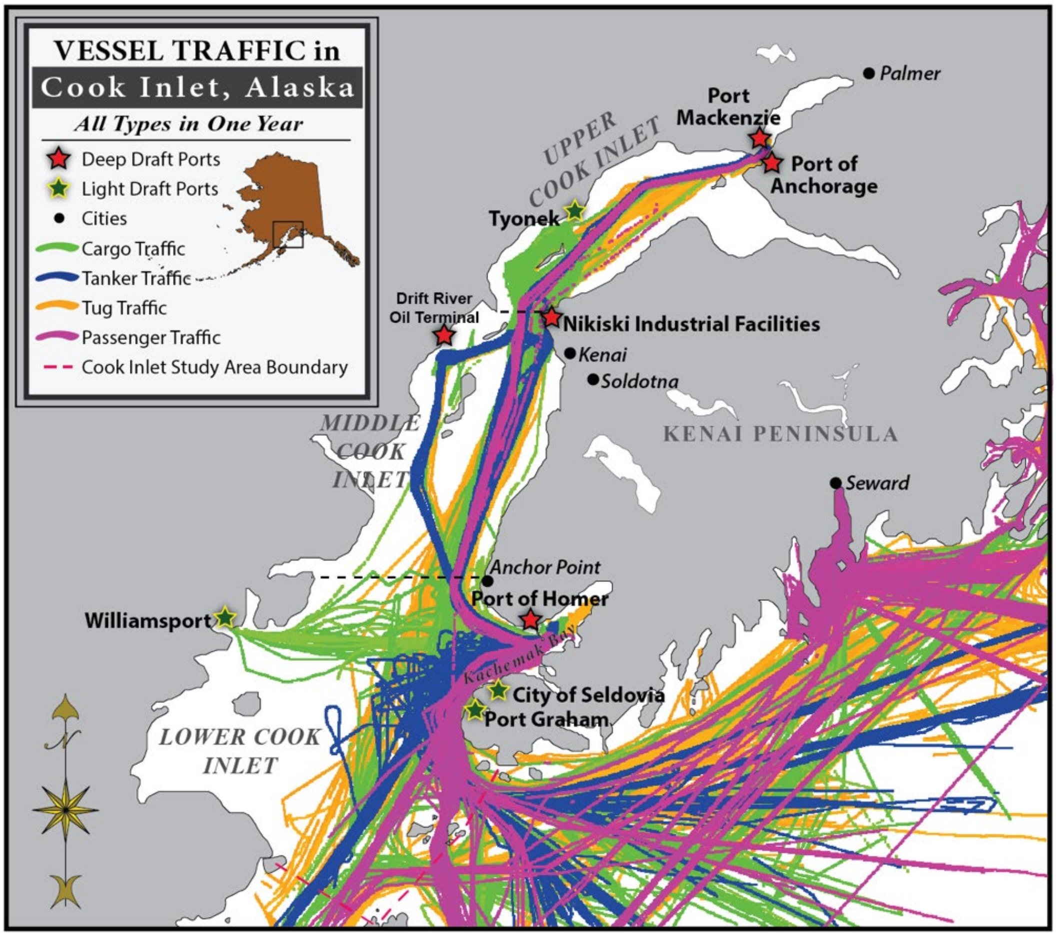

Figure 10-1. Cook Inlet Vessel Traffic by Vessel Type

Description: *This figure shows cargo, tanker, tug, and passenger traffic in Cook Inlet.*

Vessel traffic is concentrated along the eastern margin of Cook Inlet between the southern end of the Kenai Peninsula and Anchorage. Deep draft vessels generally transited along the eastern side of Cook Inlet. Shelikof Strait on the western entrance to Cook Inlet was used less frequently by large vessels. Vessel traffic was very consistent throughout the year along the Forelands. Kachemak Bay had the highest level of traffic activity in Cook Inlet. Tanker ships occasionally transited east to west and back between the Port of Nikiski and the Drift River Terminal Facility.

Source: Cape International (2012)

According to the Cook Inlet Vessel Traffic Study by Cape International (2012), the following vessel transit patterns were found for Cook Inlet:

- Deep draft vessels generally transited along the eastern side of Cook Inlet.
- Shelikof Strait on the western entrance to Cook Inlet was used less frequently by large vessels.
- Eighty percent of large ship operations were made by only 15 vessels that regularly called at Homer, Nikiski, or Anchorage.
- Vessel traffic was very consistent throughout the year along the Forelands.

- Kachemak Bay had the highest level of traffic activity in Cook Inlet with most large ships entering the mouth of the bay to pick up a marine pilot or await USCG inspection. The bay was also a frequent and preferred port of refuge for ships and tugs while waiting out bad weather.
- Tanker ships occasionally transited east to west and back between the Port of Nikiski and the Drift River Terminal Facility.

Oil service vessels accounted for most of the large vessel activity outside of the traditional north-south transit lines due to the servicing of oil and gas production platforms. In addition, these vessels' tracks frequently intersected the north-south transit lines.

10.2.3. Effects of Vessel Traffic on Marine Mammals

10.2.3.1. Collisions

The consequences of collisions between marine mammals and vessels include: injury to the animal struck. Animals incur sharp and blunt force injuries when colliding with a vessel. The impact can be immediately lethal or cause injuries that lead to the animal's death several hours, days, or weeks after the incident (Campbell-Malone *et al.* 2008; Martinez and Stockin 2013; Dwyer *et al.* 2014, as cited in (Schoeman, Patterson-Abrolat et al. 2020). Records of vessel collisions with large whales in Alaska indicate that strikes have involved cruise ships, recreational cruisers, whale watching catamarans, fishing vessels, and skiffs (NMFS 2015).

The probability of collision between a vessel and a marine mammal increases with an increased number of vessels or in areas with high animal densities. For this reason, it is important to identify high-risk areas where vessels and mammals may overlap (*e.g.*, shipping routes, shipping lanes approaches to ports and high use areas for marine mammals) (Schoeman, Patterson-Abrolat et al. 2020). Overall, there has been a focus on large vessels, because reports have shown that these pose a higher risk to whales (Laist, Knowlton et al. 2001, Jensen and Silber 2003). However, while collisions with large vessels do increase the risk of lethal injury, there is evidence that collisions with smaller vessels (<15 m) can cause fatal injury when those vessels are traveling a high rate of speed (Ritter 2012).

There are a variety of mitigation measures designed to reduce the risk of collisions between vessels and marine animals, and subsequent injury or mortality; most of which were developed with a focus on whales (Schoeman, Patterson-Abrolat et al. 2020). Table 10-2 summarizes typical measures use throughout the world to mitigate vessel strikes of marine mammals. Additional mitigation measures for vessel management are described in Section 6.13.

Table 10-2. Worldwide Ship Strike Mitigation Measures

Measure	Situation to Which it Might Be Applied	Implementation Process (and Observations)	Examples
Keeping Vessels Away from Whales			
Permanent routing measures through traffic separation scheme (TSS), areas to be avoided (ATBA), or port approach routes	Long-term patterns of whale distribution are sufficiently predictable and well understood to enable a robust analysis of the risk reduction that might be achieved	Implemented through IMO or national regulation if within territorial sea. Proposals should follow the IMO process including data on the problem, the risk reduction achieved and implications for shipping (Generally well respected by industry)	Bay of Fundy, Canada Boston, USA California, USA Panama Cabo de Gata, Spain

Measure	Situation to Which it Might Be Applied	Implementation Process (and Observations)	Examples
Seasonal routing measures	Similar requirements to permanent routing but applicable where there are strong seasonal patterns in whale distribution	As above	Roseway Basin, Canada Great South Channel, USA
Recommended (voluntary) routes	Similar requirements to permanent routing through TSS or ATBA, but not mandatory	Implemented by IMO or coastal state as a non-mandatory measure	Peninsula Valdez, Argentina Hauraki Gulf, New Zealand Glacier Bay, USA Ports on U.S. east coast
Short-term (days to weeks) and Dynamic Management Area (DMA) routing measures	Implemented in response to short- term observations of whale aggregations or known high-risk areas. Need almost real-time reporting systems that can identify such aggregations	Voluntary measures that need to be communicated to mariners (can be difficult to encourage compliance)	DMAs off U.S. east coast Gibraltar Strait, Spain
Slowing Vessels Down			
Permanent speed restriction zones	Long-term patterns of whale distribution are predictable and well understood but routing measures are not practicable	Can be voluntary or mandatory, if implemented in national waters	East coast of USA (mandatory) Glacier Bay, USA Hauraki Gulf, New Zealand
Seasonal speed restriction zones	As above but applicable where there are strong seasonal patterns in distribution	As above	Panama California, U.S. Peninsula Valdez, Argentina
DMAs for speed restrictions	Implemented in response to short-term observations of whale aggregations or known high-risk areas. Need reporting systems that can identify such aggregations	Voluntary measures that need to be communicated to mariners (can be difficult to encourage compliance)	U.S. east coast
Avoidance Maneuvers			
Real-time alerting tools to warn vessels of the presence of whales or aggregations that allow vessels to alter course or slow down	A rapid reporting network of whale sightings or acoustic detections alerts all vessels transiting an area to the locations of whales so that they can alter course or slow down	Individually designed and implemented reporting systems	REPCET, ACCOBAMS, Mediterranean Sea WhaleAlert, Boston USA
Observations from the vessel that allow avoiding action to be taken	Only effective for vessels capable of rapid maneuvers to avoid whale sightings (*e.g.*, vessels of a few thousand GT or less)	Additional dedicated observers, education, and outreach to mariners	Many initiatives

Source: https://iwc.int/ship-strikes (Accessed Sept 13, 2021)

10.2.3.2. Acoustic Disturbance

Noise associated with human activities can cause stress on marine mammals. As described in (Duarte, Chapuis et al. 2021), ocean soundscapes are changing rapidly due to human activities, geophysical processes, changes in the frequency of storms and wind patterns, and alterations in sea ice (associated with climate change), as well as declines in an abundance of sound-producing animals. Major changes in ocean soundscapes can have widespread adverse effects on ocean ecology including pervasive effects on all taxonomic and trophic levels, which in turn, can be compounded by other stressors, such as ocean warming, acidification, habitat loss, and overfishing (Duarte, Chapuis et al. 2021). Watercraft are the primary source of chronic noise exposure in marine mammals (Erbe, Marley et al. 2019). Commercial shipping traffic is a major source of low-frequency (5 to 500 Hz) human-generated sound in the oceans (NRC 2003). Source levels of 130–160 dB re 1 μPa m have been reported for small watercraft such as jet skis and rigid-hulled inflatable boats (Erbe 2013, Erbe, Liong et al. 2016). Recorded source levels for large and powerful watercraft, such as ferries, container ships, and icebreakers, are around 200 dB re 1 μPa m and louder (Erbe and Farmer 2000, Simard, Roy et al. 2016, Gassmann, Wiggins et al. 2017). In shallow water, vessels more than 10 km from a receiver generally contribute only to background-sound levels (Greene and Moore 1995, as cited in (NMFS 2015). Icebreaking vessels used in the Arctic for activities including research and oil and gas activities produce louder, but also more variable sounds, than those associated with other vessels of similar power and size (Greene and Moore 1995, as cited in (NMFS 2015).

In the early 1980s, concern about the effects of shipping and hydrocarbon development in the Arctic led to several multiyear studies on underwater noise effects on bowhead whales (Richardson, Würsig et al. 1986, Greene 1987, Richardson, Würsig et al. 1990, Richardson, Greene Jr. et al. 1995). These and other studies, (*e.g.*, Richardson *et al.*, 1982; Greene, 1985; Johnson *et al.*, 1986, all cited in (Erbe, Marley et al. 2019) showed that bowhead whales approached by small vessels at high speed generally moved away, interrupting foraging, socializing, and playing behavior, while spending less time at the surface.

Because ship noise peaks in the low frequencies, these early studies primarily focused on mysticetes (baleen whales) (*e.g.*, Eberhardt and Evans 1962; Cummings and Thompson 1971, as cited in (Erbe, Marley et al. 2019). Mysticetes produce and use sound at the frequencies emitted by large ships, and therefore, are considered to be more sensitive to low-frequency noise, as compared other marine mammals (Parks, Ketten et al. 2007, Cranford and Krysl 2015). However, ships also emit a considerable amount energy at higher frequencies (Arveson and Vendittis 2000, Hermannsen, Beedholm et al. 2014, Veirs, Veirs et al. 2016), potentially affecting odontocetes (*i.e.*, toothed whales, dolphins, and porpoises), which specialize in high-frequency sound usage (Marley, Kent et al. 2017).

Au and Green (2000) studied the response of humpback whales to four different whale-watching vessels approaching to 91 m distance; each vessel had its own acoustic signature. Individual whales responded with abrupt changes in direction and longer dive durations to the vessel with the highest received level (127 dB re 1 μPa, 1/3 octave band level at 315 Hz). Changes in behavioral state and respiratory behavior were also observed (Jahoda *et al.* 2003; Morete *et al.* 2007, as cited in (Erbe, Marley et al. 2019), with mother-calf pairs eliciting stronger responses than adults (Morete *et al.* 2007, as cited in (Erbe, Marley et al. 2019). Tsujii *et al.* (2018, as cited in (Erbe, Marley et al. 2019) found that humpback whales moved away from large vessels, while others noted changes in respiratory behavior (Baker and Herman 1989; Frankel and Clark 2002, as cited in (Erbe, Marley et al. 2019) and a cessation of foraging activities (Blair *et al.* 2016, as cited in (Erbe, Marley et al. 2019).

Conversely, North Atlantic right whales did not respond to ship noise at received levels of 132–142 dB re 1 μPa rms from large ships passing within 1 nm distance, nor to received levels of 129–139 dB re 1 μPa rms (main energy between 50 and 500 Hz) from ship noise playback (Nowacek, Johnson et al. 2004). A lack of behavioral response of right whales to ship noise is particularly concerning due to the high levels of ship strike in this species (Laist, Knowlton et al. 2001).

Disturbance to pinnipeds is often due to in air noise or close approach of vessels. Common reactions of pinnipeds to approaching vessels include flushing off haul-out sites into the sea (Jansen *et al.* 2010; Andersen *et al.* 2012; Blundell and Pendleton 2015, all cited in (Erbe, Marley et al. 2019), increased alertness (Henry and Hammill 2001), and head raising (Niemi, Auttila et al. 2013).

Mitigation measures to protect marine mammals from exposure to vessel noise include spatial and temporal avoidance, avoiding feeding aggregations and cow/calf pairs, and using PSOs to uphold these measures (see Sections 6.3, 6.9, and 6.13).

10.3. Unusual Mortality Events

Under the MMPA, a UME is defined as "a stranding that is unexpected; involves a substantial die-off of any marine mammal population; and demands immediate response".

10.3.1. U.S. Arctic Region

The first UME involving subsistence species essential to coastal Alaskan communities occurred in 2011, when beginning mid-July, high numbers of sick or dead seals with skin lesions were discovered in the Arctic and Bering Strait regions of Alaska.[17] By December of 2011, more than 100 pinnipeds in northern and western Alaska had been affected; NOAA and USFWS declared this to be a UME on December 20, 2011. By 2013, disease surveillance efforts indicated no new cases similar to those observed in 2011. This UME was closed in 2016 with more than 650 pinnipeds affected and the overall cause undetermined.

Beginning in June of 2018, a larger than expected number ice seal strandings have occurred in the Bering and Chukchi seas (Table 10-3 and Figure 10-2). This event has been declared an UME and as of the preparation of this report, is still ongoing. All age classes of seals have been reported. NMFS is currently undertaking sampling of a subset of stranded seals for genetics and harmful algal bloom exposure. The results may provide information on the cause of this UME. This is the only currently active UME exclusively in the U.S. Arctic.[18]

Since January 1, 2019, elevated gray whale strandings have occurred along the west coast of North America from Mexico to Alaska, including locations in southcentral Alaska and the Bering and Chukchi seas. In 2019, 48 gray whales were found stranded in Alaska coastal areas, 45 were found in 2020 and 22 have stranded as of October 1, 2021.[19] As of the preparation of this report, this UME is ongoing and the cause is undetermined.

Table 10-3. Ice Seal Strandings as of October 1, 2021

Year	Bearded	Ringed	Spotted	Unidentified	Total
2018 (June 1 - December 31)	35	29	20	28	112
2019	49	36	23	57	165
2020	10	9	8	11	38
2021 (as of October 1)	14	13	5	39	71
Total	108	87	56	135	386

Source: https://www.fisheries.noaa.gov/alaska/marine-life-distress/2018-2021-ice-seal-unusual-mortality-event-alaska

[17] https://media.fisheries.noaa.gov/dam-migration/ume-factsheet062016-akr.pdf

[18] https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events

[19] https://www.fisheries.noaa.gov/national/marine-life-distress/2019-2021-gray-whale-unusual-mortality-event-along-west-coast-and

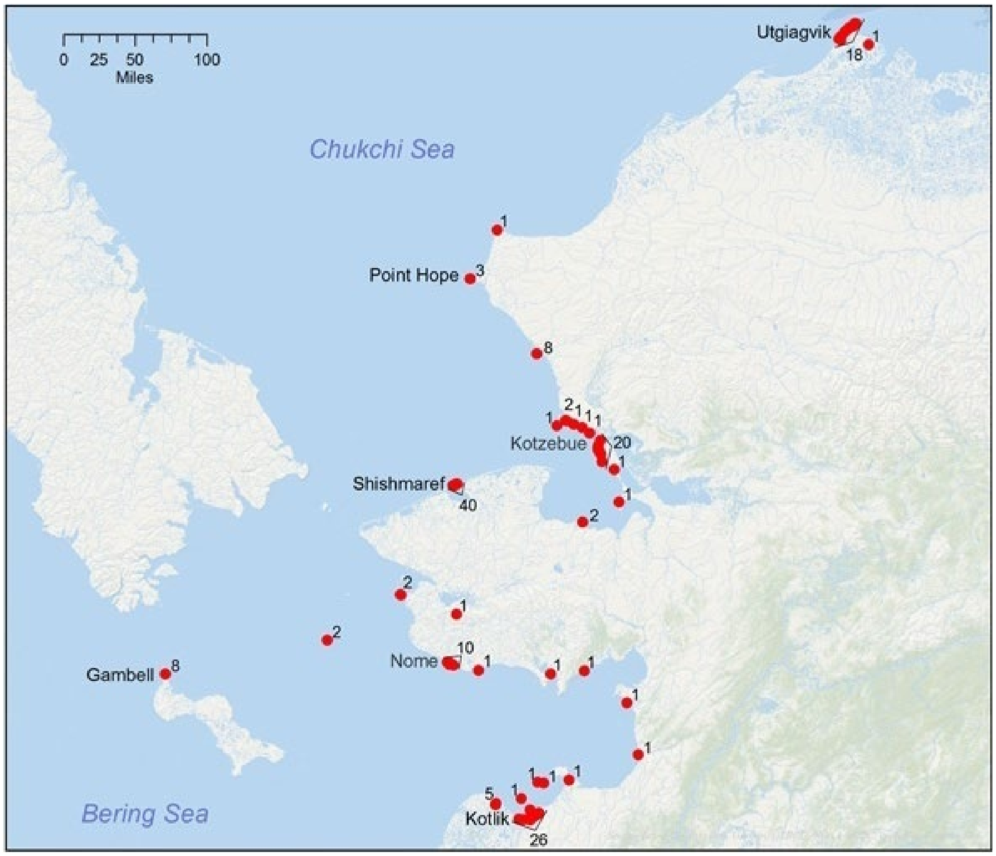

Figure 10-2. Ice Seal Stranding Locations in the Bering and Chukchi Seas, February 12 – September 4, 2019

Source: https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events

10.3.2. Cook Inlet

In 2006, NMFS declared a UME for northern sea otters in southcentral Alaska. Necropsies showed a prevalence of endocarditis and septicemia in stranded individuals (Goldstein, Mazet et al. 2009), but the overall cause for the event was undetermined. About 490 sea otters were stranded before the event closed in 2012.[20]

Although, outside of Cook Inlet, between May 22 and June 17, 2015, 12 fin whales and 22 humpback whales were observed stranded around Kodiak Island and the western Gulf of Alaska.[21] The cause of the UME, which closed in April of 2016, was undetermined but secondary ecological factors were identified.

As of January 2022, there were no active UMEs exclusive to the Cook Inlet region, but gray whales stranded during the West Coast Gray Whale UME described in Section 10.3.1 have been found in Cook Inlet or adjacent waters.

[20] https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events

[21] https://www.fisheries.noaa.gov/resource/document/alaska-and-british-columbia-large-whale-unusual-mortality-event-summary-report

10.4. Contaminants

As described in Section 6.4, waste streams into the marine environment are regulated by BSEE, EPA, and APDES. For a specific discussion on oil spills, please see Section 4.6.

10.4.1. U.S. Arctic

The water quality of the Chukchi and Beaufort seas meets the qualitative criteria for protection of marine life described in Section 403 of the Clean Water Act (CWA). As of 2014, no waterbodies are identified as impaired within the U.S. Arctic region (ADEC 2014, as cited in (NMFS 2015). Most anthropogenic pollution in the Chukchi and Beaufort seas has primarily originated outside of the region, and has been transported there by water, sea ice, air or biota (NMFS 2015). However, existing development in the U.S. Arctic has provided multiple sources of contaminants that may be bioavailable (NMFS 2013c, as cited in (NMFS 2015). Melting sea ice may also be a source of contaminants to the environment. Obbard *et al.* (2014, as cited in (BOEM 2015) identified the increased release of microplastics from melting sea ice at concentrations two times those of the Pacific gyre.

Although drilling fluids and cuttings from oil exploration and development can be disposed of through on-site injection into a permitted disposal well or transported off site to a permitted disposal location (see Section 6.12.3), some drilling fluids are discharged at the sea floor before well casings are in place. Drill cuttings and fluids contain relatively high concentrations of contaminants that have high potential for bioaccumulation, such as dibenzofuran and PAHs. Historically, drill cuttings and fluids have been discharged from oil and gas developments in the Beaufort Sea, and residues from historical discharges may be present in the affected environment (Brown *et al.* 2010, as cited in (NMFS 2015). BOEM estimated that drill cuttings and exploration fluids from one exploration well would be 5,800 bbl and 3,200 bbl, respectively (BOEM 2015a, as cited in (NMFS 2015).

As of 2014, sediments in the northeastern Chukchi Sea were pristine with respect to trace metals of anthropogenic origin, excluding the areas immediately around drilling sites (Trefry *et al.* 2014, as cited in (NMFS 2015). Trefry and Neff (2019) found that in the Beaufort Sea, barium, chromium, copper, mercury, and lead concentrations were above background, but variable, within 250 m of some offshore sites where drilling occurred between 1981 and 2001. Given that seafloor sediments repeatedly re-suspend, metal concentrations in the seafloor sediments introduce and elevate total-metal concentrations into the bottom water (BOEM 2015a, as cited in (NMFS 2015). With the exception of hydrocarbon concentrations in sediments at historical drill sites, hydrocarbon concentrations at the other sites sampled within the prospects were within the range of background concentrations reported by other studies in Alaskan coastal and shelf sediments (Neff & Associates LLC and Battelle 2010) (Durrell and Neff 2019).

10.4.2. Cook Inlet

The Cook Inlet region is the most populated and industrialized region of Alaska. Its waters receive various discharges from sources such as: oil and gas activities (*e.g.*, discharges of drilling muds and cuttings, production waters, treated sewage effluent, deck drainage); municipal sewage treatment plants; runoff from urban, agriculture, and mining; airport deicing, military training at Eagle Bay; oil and other chemical spills and leaks; fish processing waste; and other regulated discharges (NMFS 2017). Intentional discharges are regulated by either the EPA or the ADEC (National Pollutant Discharge Elimination System/APDES; Section 402 of the CWA). There are ten wastewater treatment facilities that discharge either directly into Cook Inlet, or into waters that flow into Cook Inlet (NMFS 2019). Wastewater entering these plants may contain a variety of organic and inorganic pollutants, metals, nutrients, sediments, bacteria and viruses, and other emerging pollutants of concern (Norman, Hobbs et al. 2015). Wastewater from the Municipality of Anchorage, Nanwalek, Port Graham, Seldovia, and Tyonek receive primary treatment; wastewater from Homer, Kenai, and Palmer receive secondary treatment; and wastewater from Eagle River and Girdwood receive tertiary treatment (Norman, Hobbs et al. 2015). Ballast water discharge from ships is another source of potential pollution as well as potential release of non-indigenous organisms into Cook Inlet (NMFS 2017).

From 1994 to 2011, there were 255 events in or near Cook Inlet that released more than 378.5 liters or 45.4 kg of reportable substances (ADNR, Division of Oil and Gas 2011, unpublished data, as cited in NMFS (2016). These spills included 90 events releasing a total of 318,713 liters of various types of oils (*i.e.*, diesel, hydraulic, gasoline, engine lubricants, aviation fuel, and natural gas); 48 events releasing a total of 96,165 liters and 11,364,847 kg of hazardous materials (bases or alkaline substances, drilling muds, glycols, and urea); and 73 events releasing 110,332 kg and 5,958 liters of extremely hazardous substances (*i.e.*, anhydrous ammonia, hydrochloric acid, and sulfur dioxide).

Upper Cook Inlet waters are designated as Category 3 on the CWA Section 303(d) list of impaired waterbodies by the ADEC, indicating there is insufficient data to determine whether the water quality standards for any designated uses are attained (NMFS 2019). Lower Cook Inlet is also not listed as an impaired waterbody due to lack of information to the contrary; however, the ADEC determined that the overall condition of Southcentral Alaska coastal waters, including Cook Inlet, were rated as good based on examining water quality, sediment quality, and fish tissue contaminants collected from 55 sites in the survey area (ADEC 2013, as cited in (NMFS 2017).

As described in NMFS (2017) Cook Inlet waters are generally free of toxins and other agents of a type and concentration to be directly harmful to Cook Inlet beluga whales, and by extension other marine mammals. However, in addition to direct water column impacts, contaminants can affect the benthic habitat and community and fish and invertebrates that may be prey species of marine mammals (NMFS 2019).

For fish and pelagic species an analysis completed by NMFS (2019) for Cook Inlet mixing zones indicated that a low level of mortality could be expected when fish and invertebrates are in close proximity to a point of discharge. Lower trophic level organisms would be most affected. Species that are sessile or have small home ranges, such as shrimps and prawn or drifters such as amphipods, could experience acute and chronic effects depending on their proximity to the discharge and duration of exposure. However, it is unlikely that adult pelagic fish would experience acute or chronic effects from exposure due to their mobility (NMFS 2019). Demersal species also have a closer association with potentially contaminated sediments and may experience greater effects (NMFS 2019).

10.5. Interaction with Fisheries

10.5.1. U.S. Arctic Region

There are currently no commercial fisheries in the Arctic high seas. As previously ice-covered areas of the Arctic become seasonally ice-free, there has been interest in expanding U.S.-based fishing efforts north of the Bering Strait. However, the current Arctic Fishery Management Plan (NPFMC 2009) prohibits commercial fishing in the Arctic Management Area, until scientists and fisheries managers have a better understanding of the changing Arctic ecosystem.

Outside of U.S. EEZ waters, there has been no commercial fishing efforts in the Central Arctic. An international agreement temporarily prohibiting commercial fishing in the international waters of the Central Arctic Ocean took effect on June 25, 2021.[22] Ten signatories, including Arctic and non-Arctic

[22] https://www.state.gov/the-agreement-to-prevent-unregulated-high-seas-fisheries-in-the-central-arctic-ocean-enters-into-force/

nations as well as the European Union, "vowed not to fish commercially in the region until the ecosystem is better understood and sustainable regulations are in place".

10.5.2. Cook Inlet

Commercial, personal use, recreational, and subsistence fisheries all occur within Cook Inlet waters. Fishers harvest all five Alaska Pacific salmon species, halibut and other groundfish species, and eulachon (NMFS 2019). ADF&G has management responsibility for most of the commercial fisheries in Cook Inlet, except for halibut and a few federally managed fisheries in Lower Cook Inlet. The largest fisheries in Cook Inlet, in terms of participant numbers and landed biomass, are the state-managed salmon drift and set gillnet fisheries concentrated in the Central and Northern districts (NMFS 2019).

Direct effects on Cook Inlet marine mammals from fisheries could occur if they become entangled and killed or seriously injured by encounters with fishing gear. Unfortunately, fishery observers have been rarely used in the Cook Inlet gillnet fisheries. According to Muto, Helker et al. (2021), a fishery observer program was conducted for only 2 years (1999–2000) in the Cook Inlet salmon drift gillnet and set gillnet fisheries. In data from these observations summarized by Manly (2006), no interactions with beluga whales were observed in the Cook Inlet fisheries in 1999 and 2000. The only marine mammal incidental take of importance was of one dead harbor porpoise in the Upper Cook Inlet driftnet fishery in 2000 (Manly 2006). Manly (2006) reported two harbor porpoises were entangled in nets but released unharmed 1999; in 2000, in addition to the fatally injured harbor porpoise, one additional harbor porpoise and one minke whale were entangled and release alive. No marine mammal mortalities or serious injuries were observed in the setnet fisheries, but one harbor porpoise was entangled and released alive in 1999 as was one harbor seal in 2000.

Indirect effects on belugas and other marine mammals can occur from the operation of watercraft used by commercial or recreational fishers near the mouths and deltas of rivers entering Cook Inlet, Turnagain Arm, and Knik Arm (NMFS 2019). Disturbance can hinder belugas from using these waters in pursuit of eulachon and salmon. Belugas made regular use of the Kenai River during late March through April 2018, often traveling upriver more than 9.7 km (NMFS unpublished data, as cited in NMFS (2019). However, in recent years, belugas have not been observed in the Kenai River when salmon runs were strong and fishing activity (commercial, recreational, and personal use) was high (Castellote, Small et al. 2015, Shelden, Goetz et al. 2015).

In addition, there is a strong indication that beluga whales are dependent on access to dense concentrations of high value prey species throughout the summer months (Norman, Hobbs et al. 2015). Beluga recovery may be impacted if there is a notable reduction in the amount of available prey, or if the whales are unable to reach or utilize feeding habitat (NMFS 2016). However the effects of the existing levels of fisheries harvest in Cook Inlet remain undetermined (NMFS 2019), but the overall impacts from subsistence, personal use, and recreational fishing on the recovery of the Cook Inlet population of Beluga whales is thought to be low (NMFS 2008).

11. Key Findings and Information Needs

As described in Chapter 1, the purpose of this synthesis is to provide: 1) an enhanced understanding of the potential direct, indirect, and cumulative effects of oil and gas resource development on marine mammals in the U.S. Arctic and Cook Inlet, and 2) an overall assessment of the efficacy of mitigation measures used to protect these marine mammals given the currently available information. To identify effects and to assess mitigation efforts, 615 articles covering more than 230 topics organized into 8 categories or "Bins" were reviewed and annotated (see Figure 2-1). These articles, along with additional citations obtained after the annotation process was competed, were used to prepare Chapters 1 through 10 of this report.

Section 11.1 summarizes key findings by species (see also Tables 11-1 and 11-2), while Section 11.2 provides a short summary of information needs identified through the literature review. Many of the summary statements in this section are supported by numerous citations described in previous sections of this report. Refer to Table 11-1 for specific reference to sections of this report where detailed citations may be listed.

11.1. Key Findings by Marine Mammal Species

The following information is summarized from more detailed descriptions of the documented effects, or lack thereof, of oil and gas activities on marine mammals in the Chukchi and Beaufort seas and Cook Inlet, Alaska during the period 2000–2020. Observations from marine mammal subsistence hunters (see Chapter 8) are included throughout this section and are summarized in Section 11.1.9.

11.1.1. Bowhead and Other Baleen Whales Key Findings

Mortality and Serious Injury

- NMFS and USFWS have developed mitigation and monitoring requirements to ensure that authorized takes of marine mammals (including bowhead whales) do not result in serious injury or mortality. Based on a comprehensive review of more than 40 MMPA monitoring reports (Richardson and Williams 2001, Richardson 2008, Funk, Ireland et al. 2010, Aerts, Hetrick et al. 2013, Fairweather Science 2020) and published literature for the period 2000–2020, no mortality or serious injury of bowhead or other baleen whales has been documented as a result of interactions with oil and gas activities in the U.S. Arctic or Cook Inlet.

Threshold Shift (PTS/TTS)

- Current regulatory thresholds (NMFS 2018) for acoustic disturbance are used to identify and minimize potential threshold shift.
- The effect of Level B harassment to bowhead whales and other marine mammal species beyond the immediate behavioral response is a matter of ongoing investigation (Blackwell, Thode et al. 2021). Southall, Nowacek et al. (2021) acknowledge that thresholds attempting to relate single noise exposure parameters and marine mammal behavior across broad taxonomic groups is still problematic and additional research is needed.
- In the Chukchi Sea in 2006 and 2008, 13 cetaceans were sighted within a ≥180 dB re 1 µPa rms modeled radius before mitigation measures could be implemented. Most of these cetaceans exhibited no reaction or a minimal behavioral response (Haley *et al.* 2010, as cited in NMFS (2013) regardless of received sound levels (approximately 96% of sightings).
- Frankel and Stein (2020) reported behavioral responses of gray whales during exposure to sonar off the California coast. The sonar had a maximum source level of 215 dB re 1 µPa m, where the frequency ranged from 21–25 kHz. Change in behavior was measured as a function of swimming

speed and relative orientation, as well as distance offshore; 532 whale groups were tracked over 119.7 hours of observation. One key finding was that migrating gray whales moved inshore during periods of sonar transmission relative to control periods.

Disturbance Due to Oil and Gas Activities

- Seismic noise during surveys, as well as some vessel noise associated with oil and gas activities, have been shown to influence the behavior of bowhead whales during migration.
- As cited in Patterson, Blackwell et al. (2007), bowhead whales generally avoid areas around operating seismic vessels, but the distance of avoidance is variable and depends on the time of year, location, and whale activity during the exposure.
- Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn showed avoidance out to 20 to 30 km from a medium-sized airgun source at received sound levels of around 120 to 130 dB re 1 µPa rms (Miller *et al.* 1999 and Richardson *et al.* 1999, as cited in Patterson, Blackwell et al. (2007). Avoidance of the area did not last more than 12 to 24 hours after seismic shooting stopped.
- Koski, Ireland et al. (2008) reported evidence of small-scale avoidance of the seismic operation, but one group of three whales tolerated received levels of seismic sounds approximately 180 dB re 1 µPa, three groups (five individuals) tolerated levels >170 dB re 1µPa, and at least 12 groups (19 individuals) tolerated levels 150 to 170 dB re 1µPa. These levels are much higher than the 120 to 130 dB re 1µPa levels that migrating bowhead whales avoided during seismic operations near the same location in 1996– 1998.
- In contrast to the general trend of avoidance, minke whales have occasionally been observed to approach active airgun arrays where received sound levels were estimated to be near 170–180 dB re 1 µPa (NMFS 2010).
- Fin whales have also been shown to demonstrate very little behavioral change resulting from exposure to noise from seismic surveys. Sightings by observers on seismic vessels during many large-source seismic surveys off the U.K. from 1997 to 2000 suggest that, during times of good visibility, sighting rates for fin and sei whales were similar when large arrays of airguns were shooting versus when they were silent (Stone and Tasker 2006).
- Kim and Richardson (2020) present results from the multi-year Northstar Acoustic Monitoring Program. When considering the data in the series of Northstar reports, it is important to note that changes in whale calls (*i.e.*, number or direction) does not necessarily mean a change in behavior. Also, only whales that call can be detected by the DASARs. Whales that pass through the area that are silent are not detectable using passive acoustics, which could result in biases. Therefore, the number of calls detected using PAM is not indicative of the number of whales in the area and whales may have higher or lower rates of calling during certain periods. There could also be different calling rates and varying distances offshore, irrespective of bowhead distribution.
- The 2014 long-term monitoring report prepared by BPXA (Bishop and Streever 2016) compared data collected on bowhead whale calls 2001–2014. This comparison showed that the highest call detection rate occurred in 2008 (1,337 calls per day), while the years 2003, 2004, 2013, and 2014 were similar in terms of an average number of calls per day (*i.e.*, approximately 684 in 2014). Heavy pack ice occurred in the offshore in 2005, 2006, and 2010 when the lowest number of bowhead whale calls were recorded.
- Ireland, Bisson et al. (2016) presented a broadscale comparison of sighting rates during periods of drilling activity versus non-activity during Shell's exploratory drilling in the Beaufort Sea. Figure 7-7 appears to indicate some level of avoidance response by bowhead whales.

- Ireland, Bisson et al. (2016) reported:

  > Cetaceans observed from moving and stationary vessels were most often recorded as having no observable reaction (94%, n=89, and 98%, n=96, respectively). Observable reactions for cetaceans from moving vessels included change of direction (4%), increase in speed (1%), and splash (1%). The only observable reaction for cetaceans from stationary vessels was change of direction (2%).

- Based on the evidence available, North Pacific right whales are not likely to be exposed to active seismic, active sonar, drilling operation noise, or pollutants and contaminants because this species only occurs in the Bering Sea, far from the exposure zones of the other stressors.

Changes in Habitat

- A 2007 paper by Noongwook, The Native Village of Savoonga et al. (2007) documented traditional knowledge from Yupik whalers of St. Lawrence Island stating that changes in environmental conditions appeared to influence the distribution of bowhead whales relative to the Island.
- Upon review of the more than 50 MMPA authorizations and associated BiOps for oil and gas activities that have been authorized in the Beaufort and Chukchi seas between 2000 and 2020, no notable adverse effects on baleen whale habitat have been documented.
- A very large oil spill would likely result in adverse effects on marine habitats; however, such an event has not been documented in the U.S. Arctic or Cook Inlet during the period 2000–2020.
- Moore, George et al. (2021) reported that with decreased sea ice in the Arctic, observations of tagged bowhead whales lingering in the Chukchi Sea through December have been noted. The distribution and movements of other baleen whales as relative to prey and oceanographic conditions would likely be similar.
- Zooplankton are food sources for bowhead, fin, and humpback whales. Sound energy generated from seismic operations has not been observed to negatively impact the diversity and abundance of zooplankton for these species. Any mortality or impacts on zooplankton as a result of seismic operations is minimal, as compared to the naturally occurring reproductive and mortality rates of these species. This is consistent with previous conclusions that crustaceans (such as zooplankton) are not particularly sensitive to sound produced by seismic surveys (Wiese 1996).
- Based on results from monitoring programs during oil and gas activities in the Chukchi and Beaufort seas, the most likely manner in which oil and gas activities can affect bowhead whale habitat is by acoustically limiting their "communication space" due to increased noise levels (Clark, Ellison et al. 2009). Seismic surveys appear to result in some level of avoidance by bowhead whales while vessel noise (Blackwell and Greene Jr. 2006) is likely to also result in changes in acoustic habitat that bowhead whales may avoid depending on location, duration and what the whale(s) is doing at the time of exposure (see Section 7.1.6).
- Increased anthropogenic noise, including but not limited to oil and gas activities, may affect the acoustic habitat available to baleen whales by limiting their "communication space" (Blackwell, Thode et al. 2021).

11.1.2. Beluga Whales Key Findings

Mortality and Serious Injury

- The most recent information shows there was no human-caused mortality or serious injury of Cook Inlet beluga whales between 2014 and 2018 (Muto, Helker et al. 2020).

Threshold Shift (PTS/TTS)

- Blackwell and Greene Jr. (2003) recorded underwater noise produced at an oil platform (now the Tyonek platform; Figure 3-9) at distances ranging from 0.3 to 19 km. The highest recorded sound level was 119 dB re 1µPa at a distance of 1.2 km. Sounds at frequencies between 2 and 10 kHz were measured as high as 85 dB re 1µPa at 19 kilometers from the source. Beluga whales are in the mid-frequency hearing group with a generalized hearing range of 150 Hz to 160 kHz (Southall, Bowles et al. 2007). This noise is audible to beluga whales but unlikely to cause TTS (NMFS 2017, NMFS 2019).

Disturbance Due to Oil and Gas Activities

- Belugas have good hearing sensitivity across a relatively wide frequency band. They are known to be sensitive to noise from human activities (Castellote, Thayre et al. 2019). Traditionally, village residents were required to stay away from the shoreline and maintain silence near the shoreline as the time for beluga hunting approached, so as not to deflect the belugas away (ABWC 2007).
- As noted by the ABWC (in comments by Willie Goodwin at the public scoping meeting for the Arctic Seismic EIS):

  > Now, in the belugas that we tag or the research that we've done, we know that the belugas are sensitive to noise, any noise. And I am concerned about that, because until we know exactly when they had their young, any kind of noise would cause stress in the female beluga and may abort their young beluga, or the mother may just not want to nurse it. So there's some involvement that noise affects the belugas, and we are concerned about that. *(NMFS 2016)*

- While not specifically related to oil and gas activities, Enoch Adams Jr. made the following statement regarding beluga whales: *"I have evidence but it is anecdotal. In 1989, Red Dog*[23] *became operational. Before the port was built, every summer a beluga was harvested in July. Since 1989, Kivalina has never gotten whales in July"*, Kivalina Open Water Meeting in Anchorage on March 7, 2011.
- Hunters in Kotzebue Sound, south of Kasegaluk Lagoon, have observed belugas avoiding areas of high boat traffic, noise from the shore, or areas where there are frequent overflights by aircraft (ABWC 2007).
- Cook Inlet has a long history of oil and gas activities including seismic exploration, geophysical and geotechnical surveys, exploratory drilling, associated vessel and air traffic, and platform production operation with decades of spatial and temporal overlap between oil and gas activities and marine mammals, and their habitats (see Figure 3-9).
- NMFS (2019) stated that scientific studies and opportunistic sightings suggest beluga whales are tolerant of many types of in-water noise. Cook Inlet beluga whales use habitat in Knik Arm despite disturbance and underwater noise from many sources including maritime operations, maintenance dredging, aircraft operations, and pile-driving.
- In the Mackenzie Estuary during summer, belugas were observed regularly within 99.9 m (328 feet) to 149.9 m (492 feet) of artificial drilling islands (Fraker 1977a, 1977b; Fraker and Fraker 1979, as cited in BOEM (2018) suggesting that animals were not overtly disturbed by noise produced during drilling operations.

[23] Red Dog Operations is one of the world's largest zinc mines, located in northwest Alaska.

- Erbe and Farmer (2000) reported that the Canadian Coast Guard ship, *Henry Larsen*, ramming ice in the Beaufort Sea, masked recordings of beluga vocalizations at a signal-to-noise ratio of 18 dB re 1µPa. At least six of 17 groups of beluga whales appeared to alter their migration path in response to underwater playbacks of icebreaker sound (Richardson, Greene Jr. et al. 1995).
- Patenaude, Richardson et al. (2002) recorded reactions of bowhead and beluga whales to a Bell 212 helicopter and Twin Otter fixed-wing aircraft during four spring seasons (1989 through 1991, and 1994) in the western Beaufort Sea. Responses were more common to the helicopter than to the fixed-wing aircraft and included immediate dives, changes in heading, changes in behavioral state, and apparent displacement of belugas (Patenaude, Richardson et al. 2002).

Changes in Habitat

- NMFS designated critical habitat for Cook Inlet beluga whales on April 8, 2011 (Figure 7-18; 76 FR 20180). Critical Habitat Area 1 contains shallow tidal flats or mudflats and mouths of rivers that provide important areas for foraging, calving, molting, and escape from predation. Critical Habitat Area 2 includes nearshore areas along western Cook Inlet and Kachemak Bay. Area 2 includes known fall and winter foraging and transit habitat as well as spring and summer habitat for smaller concentrations of beluga whales. Timing and area restrictions on exploration drilling in beluga whale critical habitat have reduced impacts on beluga whales (NMFS 2017).

  Castellote, Thayre et al. (2019) reported nine sources of anthropogenic noise in Cook Inlet including ships, aircrafts, dredging, pile-driving, and sub-bottom profilers. Anthropogenic noise was high and variable throughout the inlet, but was loudest and most common in the vicinity of the Port of Alaska and lower Knik Arm. This area is an important passageway for belugas moving into Knik Arm to seasonally forage.

11.1.3. Other Cetaceans Key Findings

Mortality and Serious Injury

- Incidences of serious injury or mortality of other cetacean species (killer whales, Dall's porpoise, harbor porpoise, and sperm whales) due to oil and gas operations have not been recorded.

Disturbance Due to Oil and Gas Activities

- The majority of monitoring reports from oil and gas activities in the Chukchi and Beaufort seas do not ascribe any behavioral response of these species due to noise from oil and gas activities or presence of vessels.
- Toothed cetaceans typically display similar behavior to baleen whales in response to noise generated from seismic surveys. Various studies have shown that toothed whales head away or maintain a somewhat greater distance from the vessel, and stay farther away from seismic sources, during periods of airgun operation versus silent periods (Stone and Tasker 2006, Weir 2008).
- During monitoring for the LCI seismic survey, Fairweather Science (2020) noted Dall's porpoises performed most (60%) behaviors at a vigorous pace, and 50% of Dall's porpoise sightings occurred during periods of non-seismic activity, and 50% were recorded during seismic operations including ramp up and full array. Two reactions: bowride and splash, were described during gun testing and seismic activity, respectively. No visible reactions of killer whales or harbor porpoises were recorded by PSOs during the monitoring program.
- Regarding potential vessel interactions along the Marine Transit Route, based on the limited annual number of vessel trips between Dutch Harbor and the Alaska North Slope, the transitory nature of this vessel traffic, mitigation measures in place to minimize or avoid effects of transiting vessels

on cetaceans and decades of vessels transiting in the Bering and Chukchi seas with only a single report of a ship strike (non-oil and gas related), impacts on large cetaceans from oil and gas vessels in the transit route are not likely.

Changes in Habitat

- As described in Section 7.1.5, assessments of impacts due to oil and gas activities on marine mammal Arctic habitat are general and focus on the ambient acoustic environment. Other impacts on Arctic habitat due to noise effects on prey species, changes in sea ice, and impacts from oil spills are described in Sections 7.1.5 and 7.3.1.5.

11.1.4. Ice Seals (Ringed, Bearded and Spotted) Key Findings

Mortality and Serious Injury

- As stated in the 2020 final rule for ice road construction, operation, and maintenance NMFS (2020):

> *Based on a review of literature and monitoring reports from Northstar and other North Slope projects, there is documentation of one seal mortality associated with a vibroseis program outside the barrier islands east of Bullen Point in the eastern Beaufort Sea (MacLean 1998). During a 1999 NMFS workshop to review on-ice monitoring and research, Dr. Brendan Kelly (then of the University of Alaska), also indicated that a dead ringed seal pup was found during his research using trained dogs to locate seal structures in the ice. The dead ringed seal pup was located approximately 1.5 km (0.9 mi) from the Northstar ice road. No data on the age of the pup, date of death, necropsy results, or cause of death are available.*

- No other mortality or serious injury of ringed, bearded, or spotted seals has been documented during oil and gas activity monitoring during the period 2000–2020.

Disturbance Due to Oil and Gas Activities

- Earl Kingik of Point Hope, Alaska NMFS (2010) stated:

> In Pt. Hope we're abundant with seals and during the last few years, after seismic operations up north, we are noticing that tomcod aren't coming back. The nursery for Bristol Bay fisheries are up north and we are losing lots of fish, maybe due to the seismic activity.

- An open-water seismic survey in the Chukchi Sea by Shell in 2007 Patterson, Blackwell et al. (2007) reported:

> *Sighting rates for bearded, spotted, and unidentified seals were greater during non-seismic than seismic periods, and, for most species, post-seismic sighting rates were also greater than those during seismic periods. No ringed seals were sighted during non-seismic periods for comparisons. Considering all species combined, the seal sighting rate for non-seismic periods (67.1 seals/1000 h of "daylight effort") was significantly greater than the seismic rate (~31.1 seals/1000 h of "daylight effort" $\chi 2 = 13.22$, $df = 1$, $p < 0.005$.*

- In-ice seismic occurs in late September through December prior to the occupation of breeding sites important in allowing ringed seals to accumulate enough fat stores to support estrus and lactation (Kelly, Bengtson et al. 2010). Avoidance by ringed seals of important feeding areas is possible if icebreaking activities are occurring in the same vicinity. However, *"…there was no major displacement of seals away from on-ice seismic operations reported by (Frost and Lowry 1999).*

Seals exposed to sound levels ≥160 dB re 1µPa rms were recorded swimming away from active seismic vessels as compared to monitoring vessels" (G = 6.42, df = 1, p = 0.011) (Funk, Ireland et al. 2010).

- Kelly, Quakenbush et al. (1986) evaluated several types of anthropogenic noise on ringed seal behavior in terms of whether seals abandoned subnivean lairs or breathing holes. Snowmachines at distances 0.5 to 2.8 km resulted in seals departing lairs, while vibroseis and associated equipment at a distance of 644 m caused a seal to exit a lair. In all cases, seals that departed lairs, eventually returned and hauled out, indicating the disturbance was likely short-term and minor.
- Williams, Nations et al. (2006) reported that within a few meters of Northstar Island, ringed seal breathing holes and lairs were established in the landfast ice before and during development and construction activities. The 2006 Northstar study documented that of 181 ringed seal lairs, 118 (65%) were still actively used by late May.
- Blackwell, Lawson et al. (2004) observed 12 ringed seals during low-altitude overflights of a Bell 212 helicopter at BPXA's Northstar Island in June and July 2000 (nine observations took place concurrent with pipe-driving activities). One seal showed no reaction to the aircraft while the remaining 11 (92%) reacted, either by looking at the helicopter (n=10) or by departing from their basking site (n=1).
- In the Chukchi Sea, most oil and gas activities do not start until late June to early July, minimizing the potential overlap with the bearded seal breeding season. Considering that vessels largely avoid areas of pack ice, where communication and mating occurs for this species, or transit these areas outside the breeding season, effects were determined to not be significant (NMFS 2015).
- Spotted seals hauled out on land in summer are unusually sensitive to aircraft overflights compared to other species. They have been observed to rush into the water when an aircraft flies by at altitudes up to 300 to 750 m, and occasionally react to aircraft flying as high as 1,370 m at lateral distances as far as 2 km or more (Rugh, Shelden et al. 1997).

Changes in Habitat

- Environmental factors, such as date, water depth, degree of ice deformation, presence of meltwater, and percent cloud cover, had the most notable effects on seal sighting rates compared to any anthropogenic impact of industrial activities on ringed seals (Moulton, Richardson et al. 2003, Moulton, Richardson et al. 2005).
- Minor changes in ringed seal habitat due to Northstar activities were documented in Richardson (2008) reporting that during the peak of construction in early 2000, the physically altered ice may have covered about 10 km^2, whereas during the first winter of drilling, it was much smaller at about 3 km^2, just a small fraction of the sea ice habitat available in the Beaufort Sea for ringed seals. Such small-scale effects to habitat have been considered negligible compared to natural factors.
- Effects of contact with, and ingestion of, crude oil included temporary soiling of the pelage, eye irritation, kidney lesions, and possible liver damage (Geraci and St. Aubin 1988).
- Changes in climate are likely a major factor for long-term habitat availability and quality for ice seals (Kelly, Bengtson et al. 2010, Muto, Helker et al. 2021). The NMFS (2019) BiOp for Liberty Development in the Beaufort Sea states:

  > *The main concern about the conservation status of ringed and bearded seals stems from the likelihood that their sea ice habitat has been modified by the warming climate and, more so, that the scientific consensus projects accelerated warming in the foreseeable future. A second concern, related by the common driver of carbon dioxide emissions, is the modification of habitat by ocean acidification,*

which may alter prey populations and other important aspects of the marine ecosystem.

- Other impacts on habitat due to noise effects on prey species, changes in sea ice, and impacts from oil spills are described in Chapter 7.

11.1.5. Pacific Walruses Key Findings

Mortality and Serious Injury

- No Pacific walruses have been seriously injured or killed by oil and gas activities in the U.S. Arctic. From 2009 through 2020, industry reported no direct interactions with walruses at all (USFWS 2021).

Disturbance Due to Oil and Gas Activities

- Ireland, Bisson et al. (2016) summarized movement behavior during the 2012 and 2015 drilling seasons in the Chukchi Sea. The most common observation of walruses was "no response" to vessel activities regardless of sound levels recorded. While reactions did include splash, change in direction, or increase in swimming speed, there did not appear to be a meaningful difference based on the received sound levels either >120 dB re 1 µPa rms SPL or <120 dB re 1 µPa rms SPL.
- Brueggeman *et al.* (1991, as cited in MacCracken, Beatty et al. (2017) reported that 75% of Pacific walruses within 1 km of vessels in the Chukchi Sea exhibited no reaction. Fay *et al.* (1984, as cited in MacCracken, Beatty et al. (2017) also reported observations that Pacific walruses in water generally show little concern about potential disturbance from approaching vessels, but will dive or swim away if a vessel is nearing them.
- **Richardson, Greene Jr. et al. (1995)** reviewed responses of walruses to aircraft and summarized that individual responses to aircraft can range from orientation (*i.e.*, looking at the aircraft) to leaving a haulout. In general, small herds on haulout sites (terrestrial and pack ice) seem more easily disturbed than large groups, and adult females with calves are more likely to enter the water during an aircraft disturbance. Stronger reactions occur when the aircraft is flying low, passes overhead, or causes abrupt changes in sound.

Changes in Habitat

- The low density of walruses in the Beaufort Sea where offshore oil development has occurred, and the ability of benthic habitats to recover from disturbance due to oil industry dredging or screeding activities, or discharge of drilling fluids during exploration activities, indicates that there have been limited effect on walruses through direct impacts to their prey species (USFWS 2021) in this area.
- As reported by USFWS (2014) and based on recent observations, a high number (i.e., thousands) of Pacific walruses haulout on land in the northeastern Chukchi Sea. Concerns have been raised that this aggregation of walruses could be easily disturbed by anthropogenic activity (though not specifically attributed to oil and gas activities), such as aerial or vessel traffic.
- Generally, there have been no appreciable adverse impacts on benthic invertebrate populations that provide prey for Pacific walruses due to the large reproductive capacities and naturally high levels of predation and mortality of these populations.
- Other impacts on habitat due to noise effects on prey species, changes in sea ice, and impacts from oil spills are described in Chapter 7.

11.1.6. Other Pinnipeds (Steller and California sea lions and Harbor Seals) Key Findings

Mortality and Serious Injury

- Despite all the vessel traffic in and around rookery and haulout locations near Dutch Harbor, there have been no reported incidents of ship strike of Steller sea lions in Alaska.
- No California sea lion or harbor seal mortalities or series injuries have been reported during oil and gas activities for the period 2000–2020.

Disturbance Due to Oil and Gas Activities

- Sixty percent of Steller sea lion sightings in LCI occurred during periods of no seismic activity, while 40% of sightings were observed during seismic activity including full array. Two of the Steller sea lions showed detectable reactions, but these occurred during periods of no work; both animals exhibited a "look" reaction that appeared to be in response to vessel presence (Fairweather Science 2020).
- Thirty-three percent of live harbor seal sightings in LCI occurred during periods of no seismic activity, while 67% of live sightings occurred during periods of seismic activity, including full array. PSOs on board the mitigation vessel observed one reaction ("look") from a harbor seal while the mitigation vessel was anchored; it is likely that the animal was reacting to vessel presence (Fairweather Science 2020).
- Marine mammal sighting data during the Apache seismic surveys in Cook Inlet reported the most common behavior of harbor seals during non-seismic periods was "look/sink" followed by "travel," whereas during periods of active seismic shooting, "travel" was more common than "look/sink" (Lomac-MacNair, Smultea et al. 2014).
- Cook Inlet is generally out of the range of California sea lions. Only one sighting of one California sea lion was reported during Apache's 3D seismic study (SAExploration 2012). No California sea lions were observed during monitoring for the LCI seismic survey in 2019 (Fairweather Science 2020) or the CIPL project in 2018 (Sitkiewicz, Hetrick et al. 2018).

Changes in Habitat

- No direct evidence is available from the literature regarding changes in acoustic habitat as related to oil and gas and potential effects on sea lions and harbor seals. Similarly, there is no direct evidence that oil and gas activities in Cook Inlet have affected Steller sea lion or harbor seal prey species.

11.1.7. Polar Bear Key Findings

Mortality and Serious Injury

- Five polar bears have been killed at oil and gas industrial sites in Alaska since the late 1960s: one in winter 1969, another in 1990 at the Stinson exploration site in western Camden Bay, north of the planning area (USFWS 2006), one bear in 2011 (killed accidentally during a hazing event), and two in 2012 (Miller, Crokus et al. 2018). No polar bears were lethally taken by industry from 2013–2017 (Miller, Crokus et al. 2018).

Disturbance Due to Oil and Gas Activities

- Polar bears are not commonly observed during open-water seismic surveys in the Chukchi Sea (Patterson, Blackwell et al. 2007, Brueggeman 2009, Hartin, Bisson et al. 2011). Brueggeman

(2009) reported one polar bear sighting during open-water shallow hazard surveys September 7 to October 31, 2008 in the Chukchi Sea.

- In the Chukchi Sea, marine mammal observers were on watch for 9,745 km of seismic survey and shallow hazard and site clearance lines surveyed by Shell Offshore Inc. in the Chukchi Sea in 2008 and no polar bears were observed by either the seismic vessel or its support vessels (USFWS 2009).
- In 2006, three seismic surveys were conducted at different times in the Chukchi Sea, with a total survey line length of 26,029 km (Ireland, Koski et al. 2009). Four polar bears were observed on these surveys, three of which responded to the vessels by moving away. The polar bears were closely associated with ice and were observed by vessels transiting to the survey areas and not during the surveys, which occurred in relatively ice-free areas.
- During seismic studies in the Chukchi Sea in 2015, four polar bear movements relative to the vessel were recorded as "neutral" and one was recorded as "swimming away" from the vessel (Ireland, Bisson et al. 2016).
- In the Beaufort Sea during an open-water seismic survey along 4,912 km of ship trackline near Spy Island Hauser, Moulton, Williams et al. (2008) reported:

  > *There were never any strong behavioral reactions by polar bears to the presence of seismic source vessels. Additionally, no polar bears were observed within the ≥190 dB safety radius, but one polar bear was estimated to have potentially received sound levels ≥160 dB before the above mentioned shut-down was implemented.*

- In the Beaufort Sea, surveys occur close to shore and the majority of bears observed have been near barrier islands. Marine mammal observers reported that 50% of polar bears observed did not respond to vessel presence, while 50% looked at the vessel. One polar bear swam towards the vessel and the seismic air gun array was shut down to prevent possible effects from noise (USFWS 2009).
- USFWS (2016) reported that in 2006, 2009, 2010, and 2011, polar bears established dens prior to the onset of industry activity within 500 m or less of the den site but remained in the den through the normal denning cycle and later left with cubs, apparently undisturbed despite the proximity of industrial activity.
- Although reports are rare, polar bears have exhibited den abandonment due to noise disturbance from human activity [not specifically oil and gas] (Belikov 1976, Lentfer and Hensel 1980 and Amstrup 1993, as cited in Owen, Pagano et al. (2020) and Larson, Smith et al. (2020). However, the attenuation of sound propagation into the den and reduced sensitivity of polar bears to sound energy below 125 Hz reduces the potential for audibility of certain industrial sources tested (Owen, Pagano et al. 2020).
- Owen, Pagano et al. (2020) found that within a closed den, polar bears had a high probability of detecting aircraft (≥75%) at distances ≤1.6 km, and ground-based noise sources also had high probabilities of detection at distances ≤0.8 km. On average, closed dens reduced noise levels by 15 dB relative to open dens.
- Prolonged or repeated overflights of fixed-wing aircraft for monitoring purposes, or helicopters used in support of offshore operations could disturb transient polar bears if flights occur at low altitudes. However, aircraft operations during oil and gas activities are to an altitude of 457.2 m (1,500 feet), unless it is not safe to do so. Flights at this altitude are not anticipated to result in behavioral response or adverse effects to polar bears (USFWS 2021).

Changes in Habitat

- Transcripts from a public meeting in Kaktovik, Alaska held on February 5, 2019 for the Final EIS on the Coastal Plain of the Arctic National Wildlife Refuge Oil and Gas Leasing Program (BLM 2019) included a comment regarding climate change and polar bears stating:

  > *The polar bear situation is because of climate change. The ocean is opened up right now out there. It's been open a lot. The bears are coming ashore because of climate change. It's not the problem that they are getting used to us being around them. It's they don't have a habitat. They are coming ashore, and that's directly related to the oil situation. The fact that we have climate change, the oil is open—the ocean is open, and the bears have to come ashore. So you know—and some of it could be mitigated by the whaling captains. They took a lot of blubber this year and threw in (sic) the ocean. That could have been food for the bears.*

- Potential effects of temporary habitat loss or alteration are expected to be somewhat reduced by the mitigation measures described in BLM (2020) and the current USFWS ITRs for 2021–2026 (USFWS 2021). Surveys to locate polar bear dens are required before activities begin and activities are excluded 1.6 km around dens. Areas where gravel is placed for pads or roads would likely be avoided as potential maternal denning habitat because of the presence of the facilities and associated human activity (BLM 2020).
- BLM (2020) also includes requirements to minimize the development footprint to limit coastal habitat alteration or loss.
- Other impacts on habitat due to noise effects on prey species, changes in sea ice, and impacts from oil spills are described in Chapter 7.

11.1.8. Sea Otter Key Findings

Mortality and Serious Injury

- There have been no recorded deaths or severe injury of sea otters directly attributed to oil and gas operations in Cook Inlet or in the vicinity Dutch Harbor. A dead sea otter was encountered during a period of no work during the 2019 LCI seismic survey (Fairweather Science 2020), and the cause of death was not known.

Disturbance Due to Oil and Gas Activities

- The potential for take by harassment varied depending on the survey location and timing. Given sea otters' underwater hearing ability and limited time spent below the water's surface, seismic survey noises are expected to result in only localized and temporary disturbance effects to a few individual sea otters (USFWS 2017).
- Behaviors exhibited by sea otters during a seismic survey in Lower Cook Inlet included: mill, travel, swim, look, rest, feed, surface active, and dive (Fairweather Science 2020). Before ramping up the airguns during the seismic work, a PSO or trained crewmember cleared a 50-m sea otter exclusion zone using vessel lights. Forty-six percent of live sea otter sightings were recorded during periods of no seismic activity, while 54% were observed during periods of seismic activity, including full array. Minor and short-term behavioral responses of mustelids (i.e., otters) to helicopters have been documented in several locations including Alaska (BOEM 2016).
- Sea otters have been shown to avoid areas with high vessel traffic but return when seasonal traffic subsides; for example, sea otters in the water were prone to swim away, hauled out sea otters entered the water and dispersed, and feeding sea otters began to periscope or dive (USFWS 2017).

Changes in Habitat

- Vessel traffic (which may include oil and gas) has not likely impacted or caused destruction of northern sea otter critical habitat around Dutch Harbor, where habitat is already degraded due to the presence of infrastructure (USFWS 2015).
- Vella *et al.* (2001, as cited in USFWS (2017) concluded that there are generally few behavioral or physiological effects on invertebrates (see otter food sources) unless the organisms are very close (within a meter) to a powerful noise source. Consequently, noises from seismic airguns are not likely to decrease the availability of invertebrate crustaceans, bivalves, or mollusks or modify otter critical habitat.
- The availability of invertebrate food sources could be altered some by seismic noise; however, there are generally few behavioral or physiological effects unless the organisms are very close (within a meter) to a powerful noise source (USFWS 2017).
- Long-term adverse effects of the 1989 Exxon Valdez oil spill in Prince William Sound (outside of Cook Inlet) on sea otter habitat were documented by Bodkin, Ballachey et al. (2012), Harwell and Gentile (2014) and others. Bodkin, Ballachey et al. (2012) documented the presence of oil in the intertidal zone where sea otters spend time foraging, thereby providing evidence of a pathway of exposure from lingering intertidal oil. However, Harwell and Gentile (2014) concluded that residual PAHs have continued to diminish in the decades after the spill to a point where the remaining risks are exceedingly small. No large oil spill has occurred in Cook Inlet during the period 2000–2020.

11.1.9. Key Findings on Effects to Subsistence

- Observations regarding marine mammal behavior by subsistence users in the U.S. Arctic have been documented through various methods over the past 20+ years (see Section 8.2).
- AEWC first started development of an Open Water Season CAA in 1985 for the 1986 operating season (Levfevre 2013). As described in Section 6.5, a CAA has been one of the most effective tools for minimizing potential effects of industrial activities on subsistence hunters in the Beaufort and Chukchi seas (Levfevre 2013).
- Yearly bowhead harvests are affected by environmental conditions (*e.g.*, wind speed and direction, fog, and temperature), stability of shorefast ice, and sea ice concentration, type, and movement. The success of each hunt, and therefore, the yearly totals are affected by these environmental factors, and show considerable annual and regional variation (Galginaitis 2014, Suydam, George et al. 2019).
- An investigation summarized in MMS (2000) documented evidence of harvest disruption from oil and gas activities in Kaktovik and Nuiqsut based on respondent data collected in 1985, 1986, 1992, 1993, and 1998. Unsuccessful harvest of a bowhead whales was documented in Kaktovik in 1985. Since 2000, Galginaitis (2021) reported that a while small number of individual incidents were documented, none except a vessel interference event in 2005 directly affected the hunt. Ice conditions in 2005 were also such that even without the vessel incident, the whalers would have had little access to the whales due to ice conditions that year.
- Nuiqsut whalers expressed general concerns about oil and gas development based on their experiences in the 1980s and 1990s, but since that time an overall positive effect of mitigation during the period 2000–2020 can be attributed to the success of the CAA and the ability of the whalers and industry to work together.

- 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, and described in Section 6.5) 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, NMFS 2003, NMFS 2006, NMFS 2008, NMFS 2008, BP Exploration Alaska 2009, NMFS 2013, NMFS 2019).

11.1.10. Conclusions

This synthesis of 20+ years of available literature has identified evidence of the following primary effects of oil and gas activities on marine mammals in the Chukchi and Beaufort seas and Cook Inlet:

- No mortality or serious injury of most marine mammal species except for five polar bears and potentially one ringed seal, although the cause of death of the ringed seal was not confirmed. This is due, at least in part, to the mitigation measures implemented under MMPA authorizations for oil and gas activities for the period 2000–2020.
- Avoidance behavior occurs during seismic activities, although the degree and duration of avoidance varies across species. However, there is no evidence that the magnitude of avoidance behavior is resulting in population-level effects on marine mammals exposed. Impact pile-driving may also result in similar avoidance behavior, although due to shutdown measures during pile-driving, marine mammal exposures (and therefore, data on behavioral responses) are limited.
- Disturbance due to underwater sounds occurs, although behavioral reaction is highly variable across species and there is no current evidence of long-term population-level effects. These sounds may include exploration drilling, operational drilling, vessel and aircraft traffic, or geotechnical surveys among other sources (see Chapters 4 and 7).
- It is generally recognized that changes in behavior do not necessarily equate to biologically meaningful effects on marine mammals. However, research regarding changes in marine mammal behavior due to exposure to human-induced stressors is ongoing.
- Changes in habitat use by marine mammals are primarily driven by broader-scale ecological forcing, such as those associated with loss of sea ice, ocean warming and ocean acidification.
- For those species with sufficient data to indicate population status and trends, there do not seem to be adverse effects from oil and gas that are biologically meaningful to overall population status. However, for species such as Pacific walruses or ice seals, population status and trends are unknown, and definitive conclusions regarding potential effects are uncertain.
- Due in large part to mitigation measures outlined in the CAAs for oil and gas activities, subsistence communities continue to successfully hunt bowhead whales, seals, and walruses in the Chukchi and Beaufort seas. Harbor seals and sea otters continue to be successfully hunted in Cook Inlet regardless of oil and gas activities.
- The potential threat of a very large oil spill is cause for anxiety among subsistence communities along the U.S. Arctic coast.
- Concerns that oil and gas activities are affecting marine mammal subsistence hunting are still expressed during public comment periods and other public forums related to oil and gas activities.
- Cumulative effects and climate change are common concerns expressed by communities that subsistence hunt for marine mammals, particularly those located in the U.S. Arctic. At present, cumulative effects on marine mammal populations associated with oil and gas activities are poorly understood. Research designed to address long-term, cumulative effects is needed.

- Quantitative methods for assessing cumulative effects are currently lacking. At present, for marine mammal species where adequate information exists, trends in abundance or changes in use patterns are likely the best indicator of cumulative effects not otherwise detected. This finding makes continuation of monitoring presence and absence of marine mammal species over time an important component of any protocol developed to assess the interactions between oil and gas activities and marine mammals.

As described in Chapter 9, the effects of oil and gas activities can be minimized or avoided by the implementation of effective mitigation and monitoring measures. Based on the available data reviewed during the period 2000–2020, the following observations are made regarding mitigation and monitoring:

- Monitoring reports provide useful information regarding presence or absence of species, seasonal distribution, or migratory behavior, and may provide data on behavioral response to human activities; and
- Monitoring data are valuable for assessing the efficacy of mitigation.

Improvements and standardization of monitoring protocols for future activities will promote continued assessment of the effects of oil and gas activities on marine mammals, building on more than 20 years of monitoring data.

Anthropogenic activities, including oil and gas activities, in the Chukchi and Beaufort seas and Cook Inlet likely cause some level of stress on marine mammals that may contribute to an overall cumulative effect. The relative contribution of each human-induced stressor to cumulative effects on marine mammals is not currently quantifiable. Large-scale changes in marine ecosystems due to climate change are prompting agencies and research institutions to develop vulnerability assessments such as the NOAA Method for Assessing the Vulnerability of Marine Mammals to a Changing Climate (Lettrich, Asaro et al. 2019) to help evaluate the vulnerability of specific marine mammal stocks, particularly for stocks with insufficient data on abundance or phenology. The ability to measure and assess the magnitude and consequences of cumulative effects on marine mammals continues to be a major topic of interest for future research. In addition to climate change and cumulative effects, Section 11.2 presents other information needs identified based on the extensive literature review conducted for this report.

Tables 11-1 and 11-2 provide cross-references for sections in this document that describe the four main categories of potential effects to marine mammals (i.e., behavioral disturbance, physiological effects, mortality, and habitat alteration), their mechanisms, effects actually documented, subsistence information, and mitigation measures to individual sections and subsections of this report. These tables allow the report user to quickly find specific information related to an effect, mitigation measure, or species.

Table 11-1. Beaufort and Chukchi Seas Key Findings Cross-Reference

Potential Effects *(Chapter 4)*	Mechanisms of Effects *(Chapters 3 and 4)*	Arctic Species Potentially Affected *(Chapter 7)*	Documented Effects Due to Oil and Gas Activities in the U.S. Arctic *(Chapter 7)*	Observed Effects on Subsistence Species *(Chapter 8)*	Mitigation Measures *(Chapter 6)*
Mortality (4.3)	Vessel Strikes *(4.3.1)* Marine Transit Route *(3.2.7)* Crushing *(4.3.2)* Entanglement *(4.3.3)* Vibroseis *(3.2.3)* Hazing *(4.5.1)* Oil spills/Blowouts *(4.6.1)*	Bowhead whales *(7.1.2)* Other baleen whales *(7.2.2)* North Pacific right whales *(7.2.1.4)* Beluga whales *(7.3.1.2)* Other cetaceans *(7.4.2)* Ice seals *(7.5.2)* Pacific walruses *(7.6.2)* Polar bear *(7.8.2)*	• No impacts on whales from oil and gas vessels in the transit route *(7.4.3.2)* • During a vibroseis study in 1998 one seal pup was killed *(7.5.2)*; no other mortality or serious injury of marine mammals • To protect life and property, five polar bears have been killed at oil and gas industrial sites in Alaska since the late 1960s *(7.8.2)*	Bowhead whales *(8.1.1)* Beluga whales *(8.1.2)* Ice seals *(8.1.4)* Pacific walruses *(8.1.5)* Polar bear *(8.1.6)*	Visual Monitoring-PSOs *(6.9)* Vessel management *(6.13)* Blow Out Prevention *(6.6.3)* Double hulled vessels *(6.6.2)*
Physiological Effects (4.2)	Seismic Surveys *(3.2.1)* Site Clearance *(3.2.2)* Vibroseis *(3.2.3)* Exploratory Drilling *(3.2.4)* Infrastructure Construction *(3.2.5)* Drilling and Production *(3.2.6)*	Bowhead whales *(7.1.3)* Beluga whales *(7.3.2.3)*	• No evidence of physiological effects *(7.1.3)* • No obvious reaction to recorded drilling noise *(7.3.2.3)*	Bowhead whales *(8.1.1)* Beluga whales *(8.1.2)*	Acoustic Monitoring *(6.1)* Visual Monitoring-PSOs *(6.9)* Acoustic Modelling *(6.1.2)* Exclusion and Safety Zones *(6.7)* Ramp Up and Soft Start *(6.10)* Power Down and Shutdown *(6.8)* Conflict Avoidance Agreements *(6.5)*
Behavioral Disturbance (4.1)	Seismic Surveys *(3.2.1)* Site Clearance *(3.2.2)* Vibroseis *(3.2.3)* Exploratory Drilling *(3.2.4)* Drillships *(3.2.4.1)* Anchor handling *(3.2.4.2)* Support vessels *(3.2.4.4)* Ice breaking *(3.2.4.5)* Aircraft Support *(3.2.4.6)* Infrastructure Construction *(3.2.5)* Drilling and Production *(3.2.6)* Marine Transit Route *(3.2.7)* Exercises and Spill Drills *(3.2.8)* Decommissioning *(3.2.9)*	Bowhead whales *(7.1.4)* Other baleen whales *(7.2.3)* Beluga whales *(7.3.2.4)* Other cetaceans *(7.4.3)* Ice seals *(7.5.3)* Pacific walruses *(7.6.3)* Polar bear *(7.8.3)*	• Avoidance *(7.1.4.1, 7.1.4.2, 7.3.2.3, 7.2.3.4, 7.5.3.1, 7.5.2)* • Leaving the ice and entering the water *(7.5.3.4)* • Changes in whale calling rates *(7.1.4.1, 7.1.4.2, 7.2.3.4)* • Changes in Migratory patterns *(7.2.3)* • Habituation *(7.2.4)*	Bowhead whales *(8.1.1)* Beluga whales *(8.1.2)* Ice seals *(8.1.4)* Pacific walruses *(8.1.5)* Polar bear *(8.1.6)*	Acoustic Monitoring *(6.1)* Visual Monitoring-PSOs *(6.9)* Acoustic Modelling *(6.1.2)* Exclusion and Safety Zones *(6.7)* Ramp Up and Soft Start *(6.10)* Power Down and Shutdown *(6.8)* Conflict Avoidance Agreements *(6.5)*
Habitat Alteration (4.4)	Changes in Soundscape *(4.1.2)* Prey disturbance *(4.4.2)* Vessel and Drilling Discharges *(4.6)* Oil spills/Blowouts *(4.6.1)*	Bowhead whales *(7.1.5, 7.1.6)* Other baleen whales *(7.2.2)* Beluga whales *(7.3.1.2)* Ice seals *(7.5.2)* Pacific walruses *(7.6.2)* Polar bear *(7.8.2)*	• No notable adverse effects on whale habitat have been documented *(7.1.5, 7.2.4, 7.3.2.5)* • Small-scale effects to ice seal habitat have been negligible at Northstar *(7.5.4)* • There have been limited effects on walrus prey species *(7.6.4)* • No Oil spills affecting large-scale marine mammal habitats have occurred *(7.1.5, 7.2.4, 7.6.4, 7.8.4)*.	Bowhead whales *(8.1.1)* Beluga whales *(8.1.2)* Ice seals *(8.1.4)* Pacific walruses *(8.1.5)* Polar bear *(8.1.6)*	Directional Drilling *(6.6.1)* Blow out prevention *(6.6.3)* Double hulled vessels *(6.6.2)* Waste stream management (*6.12*)

Note - Section cross-references are provided within parentheses.

Table 11-2. Cook Inlet Key Findings Cross-Reference

Potential Effects *(Chapter 4)*	Mechanisms of Effects *(Chapters 3 and 4)*	Arctic Species Potentially Affected *(Chapter 7)*	Documented Effects Due to Oil and Gas Activities in Cook Inlet *(Chapter 7)*	Observed Effects on Subsistence Species *(Chapter 8)*	Mitigation Measures *(Chapter 6)*
Mortality (4.3)	Vessel Strikes *(4.3.1)* Entanglement *(4.3.3)* Oil spills/Blowouts *(4.6.1)*	Minke whales *(7.2.1.2)* Fin whales *(7.2.1.3)* Humpback whales *(7.2.1.5)* Beluga whales *(7.3.1)* Killer whales *(7.4.1.1)* Harbor porpoise *(7.4.1.3)* Dall's porpoise *(7.4.1.4)* Steller sea lion *(7.7.1.1)* California sea lion *(7.7.1.2)* Harbor seals *(7.7.1.3)* Sea otter *(7.9)*	No mortality or serious injury of marine mammals in Cook Inlet has been attributed to oil and gas activities *(7.2.2, 7.3.1.2. 7.4.2, 7.7.2, 7.9.2)*	Beluga whales *(8.3.1)* Harbor seals *(8.3.3)* Beluga whales *(8.3.1)* Harbor seals *(8.3.3)* Sea otter *(8.3.4)* Steller sea lion *(8.3.5)*	Visual Monitoring-PSOs *(6.9)* Vessel management *(6.13)* Blow Out Prevention *(6.6.3)* Double hulled vessels *(6.6.2)*
Physiological Effects (4.2)	Seismic Surveys *(3.2.1)* Site Clearance *(3.2.2)* Exploratory Drilling *(3.2.4)* Infrastructure Construction *(3.2.5)* Drilling and Production *(3.2.6)*	Beluga whales *(7.3.1.3)*	Drilling noise is audible to beluga whales, but unlikely to cause TTS *(7.3.1.3)*	Beluga whales *(8.3.1)*	Acoustic Monitoring *(6.1)* Visual Monitoring-PSOs *(6.9)* Acoustic Modelling *(6.1.2)* Exclusion and Safety Zones *(6.7)* Ramp Up and Soft Start *(6.10)* Power Down and Shutdown *(6.8)*
Behavioral Disturbance (4.1)	Seismic Surveys *(3.2.1)* Site Clearance *(3.2.2)* Exploratory Drilling *(3.2.4)* Drillships *(3.2.4.1)* Anchor Handling *(3.2.4.2)* Jack up rigs *(3.2.4.3)* Support vessels *(3.2.4.4)* Aircraft Support *(3.2.4.6)* Infrastructure Construction *(3.2.5)* Drilling and Production *(3.2.6)* Exercises and Spill Drills *(3.2.8)* Decommissioning *(3.2.9)*	Minke whales *(7.2.1.2)* Fin whales (7.2.1.3) Humpback whales *(7.2.1.5)* Beluga whales *(7.3.1)* Killer whales *(7.4.1.1)* Harbor porpoise *(7.4.1.3)* Dall's porpoise *(7.4.1.4)* Steller sea lion *(7.7.1.1)* California sea lion *(7.7.1.2)* Harbor seals *(7.7.1.3)* Sea otter *(7.9)*	Avoidance *(7.2.3.1, 7.3.1.4, 7.7.3, 7.9.3)*	Beluga whales *(8.3.1)* Harbor seals *(8.3.3)* Sea otter *(8.3.4)* Steller sea lion *(8.3.5)*	Acoustic Monitoring *(6.1)* Visual Monitoring-PSOs *(6.9)* Acoustic Modelling *(6.1.2)* Exclusion and Safety Zones *(6.7)* Ramp Up and Soft Start *(6.10)* Power Down and Shutdown *(6.8)*
Habitat Alteration (4.4)	Changes in Soundscape *(4.1.2)* Prey disturbance *(4.4.2)* Vessel and Drilling Discharges *(4.6)* Oil spills/Blowouts *(4.6.1)*	Fin whales *(7.2.1.3)* Humpback whales *(7.2.1.5)* Beluga whales *(7.3.1)* Killer whales *(7.4.1.1)* Harbor porpoise *(7.4.1.3)* Dall's porpoise *(7.4.1.4)* Steller sea lion *(7.7.1.1)* California sea lion *(7.7.1.2)* Harbor seals *(7.7.1.3)* Sea otter *(7.9)*	• No major adverse effects on cetacean habitat have been documented *(7.2.4, 7.3.1.5, 7.4.4, 7.7.4, 7.9.4)* • The effects of noise on Cook Inlet beluga prey species must be addressed; fish could experience temporary behavioral reactions due to noise from seismic airguns *(7.3.1.5)* • Oil spills affecting large-scale marine mammal habitats have not occurred in Cook Inlet to date *(7.2.4, 7.4.4, 7.7.3, 7.9.4)*.	Beluga whales *(8.3.1)* Harbor seals *(8.3.3)* Beluga whales *(8.3.1)* Harbor seals *(8.3.3)* Sea otter *(8.3.4)* Steller sea lion *(8.3.5)*	Blow out prevention *(6.6.3)* Double hulled vessels *(6.6.2)* Waste stream management (*6.12*)

11.2. Information Needs

This section describes information needs related to assessing the potential effects of oil and gas activities on marine mammals in the U.S. Arctic and Cook Inlet that were identified based on a review and synthesis of literature for the period 2000–2020 (see Section 1). The large volume (800+ sources) of scientific literature, assessments (i.e., NEPA or BiOps), and marine mammal monitoring reports, demonstrates a concerted effort to predict and assess the potential interactions between marine mammals and oil and gas activities and any associated effects of those interactions. The following key themes were identified as information needs:

- Sufficient marine mammal abundance, density, and population trend data to assess the health and sustainability of marine mammal populations and the potential effects of human activities. These data need to be species specific and designed to be able to detect changes in abundance or density on the order of 50% over a specified period of time (*e.g.*, 5 years).
- Sufficient species-specific information on total human-related mortality events to provide for assessment of population-level impacts.
- Data to assess the biological significance of marine mammal behavioral responses to underwater sounds associated with oil and gas activities, as well as other anthropogenic sources.
- Underwater sound measurements of anthropogenic activities including but not limited to vessel traffic (shipping), oil and gas activities and construction.
- Additional social science data on marine mammal subsistence practices (*i.e.*, distances to resources, environmental conditions during hunting, and other factors) and results by species over time. Comprehensive (*i.e.*, every 3 years) evaluation of subsistence hunting results by region and by species.
- Additional social science data to monitor community perceptions regarding potential effects on marine mammal subsistence species or practices due to external stressors (*i.e.,* anthropogenic activities and climate change).
- Periodic (*i.e.*, every 3 years) comprehensive evaluation across all marine mammal monitoring programs conducted for oil and gas and reporting of results by region (*i.e.*, Chukchi Sea, Beaufort Sea and Cook Inlet) and species. If possible, using artificial intelligence systems (machine learning algorithms) may be able to automatically analyze monitoring data to uncover hidden trends and insights by species, region of activity or both.
- Geospatial and temporal visualizations of anthropogenic activities in the Chukchi and Beaufort seas and Cook Inlet overlain with marine mammal distribution patterns and habitats to assess the potential for increased interactions.
- Continued development of emergency response protocols and communications related to mitigating the impacts of a large oil spill in the U.S. Arctic or Cook Inlet. Development of techniques to mitigate the impacts of a large oil spill in sea ice should be a high priority (see additional detail below).
- Quantitative methods for assessing cumulative effects on marine mammal populations in the Chukchi and Beaufort seas and Cook Inlet.

In addition to these key themes, two overarching topics stand out as higher priority needs moving forward. Apparent through this review is the need for improved coordination among federal and state agencies, industry, regional subsistence organizations, and local communities[24] when designing and implementing monitoring and research programs. Coordination promotes a transparent approach to data sharing and a more comprehensive perspective across regions and marine mammal species. Suggested improvements to future monitoring programs include but are not limited to:

- Standardizing marine mammal monitoring (sighting) forms (*i.e.*, compatible with forms used by state, federal and local research organizations);
- Communicating monitoring plans (*i.e.*, dates, times and locations of aerial, ground, or vessel surveys) with local communities;
- Integrating industry monitoring programs with scientific research programs to evaluate potential patterns (*i.e.*, species habitat use, behavioral response, seasonal variation, etc.); as well as consideration of the statistical power of program designs to detect potential effects of oil and gas activities on marine mammal behavior, populations, and distribution;
- Cooperating on the use of aircraft, vessels, and ground transportation; and
- Holding a planning meeting for the purpose of communicating and coordinating monitoring and research plans at least every 3 years. The results of this meeting would support developing a 3-year comprehensive review of monitoring and research programs as well as facilitate an adaptive management approach for future programs. The nature and extent of the previous monitoring period would be reviewed along with suggested modifications to monitoring to improve data collection. The future 3-year monitoring plans would also be shared.

In addition to improving coordination of research and monitoring programs, a coordinated effort to improve emergency response capabilities and effectiveness for potential oil spills in ice-covered waters is needed. Concerns regarding large oil spills have been expressed by Alaska Native communities including the following comment on the Chukchi Lease Sale 193 from the village of Point Hope (Cannon 2011):

> *We also urge BOEMRE to discuss more deeply the shortcomings of oil spill response in the Arctic Ocean, with its harsh and remote conditions…*

As described in Section 4.6.1, extensive national and international research has focused on improving oil spill response capabilities in ice-covered conditions and is summarized in Sorstrom, Brandvik et al. (2010), NPC (2015), Arctic Oil Spill Response Technology Joint Industry Programme (2017). Progress has been made with regard to modeling oil dispersion in variable ice conditions and specific technologies that can be used to recover oil (see Section 4.6.1). Future research is needed to improve mitigation efforts including but not limited to: 1) oil recovery methods in ice-covered waters; 2) timing for *in-situ* burning of surface oils or mechanical recovery; and 3) hazing of marine mammals for the purpose of moving them to regions outside of the discharge zone. As other Arctic nations have similar concerns, an effort to coordinate this work with international partners (*e.g.*, Norway, Russia, Canada, and Denmark/Greenland) would be important.

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[24] Partial list of cooperating organizations: BOEM, NMFS, USFWS, USGS, MMC, North Pacific Research Board, USCG, NSF, University of Alaska, ADF&G, oil and gas industry operators and other State organizations as appropriate, NSB, and marine mammal co-management representatives.

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