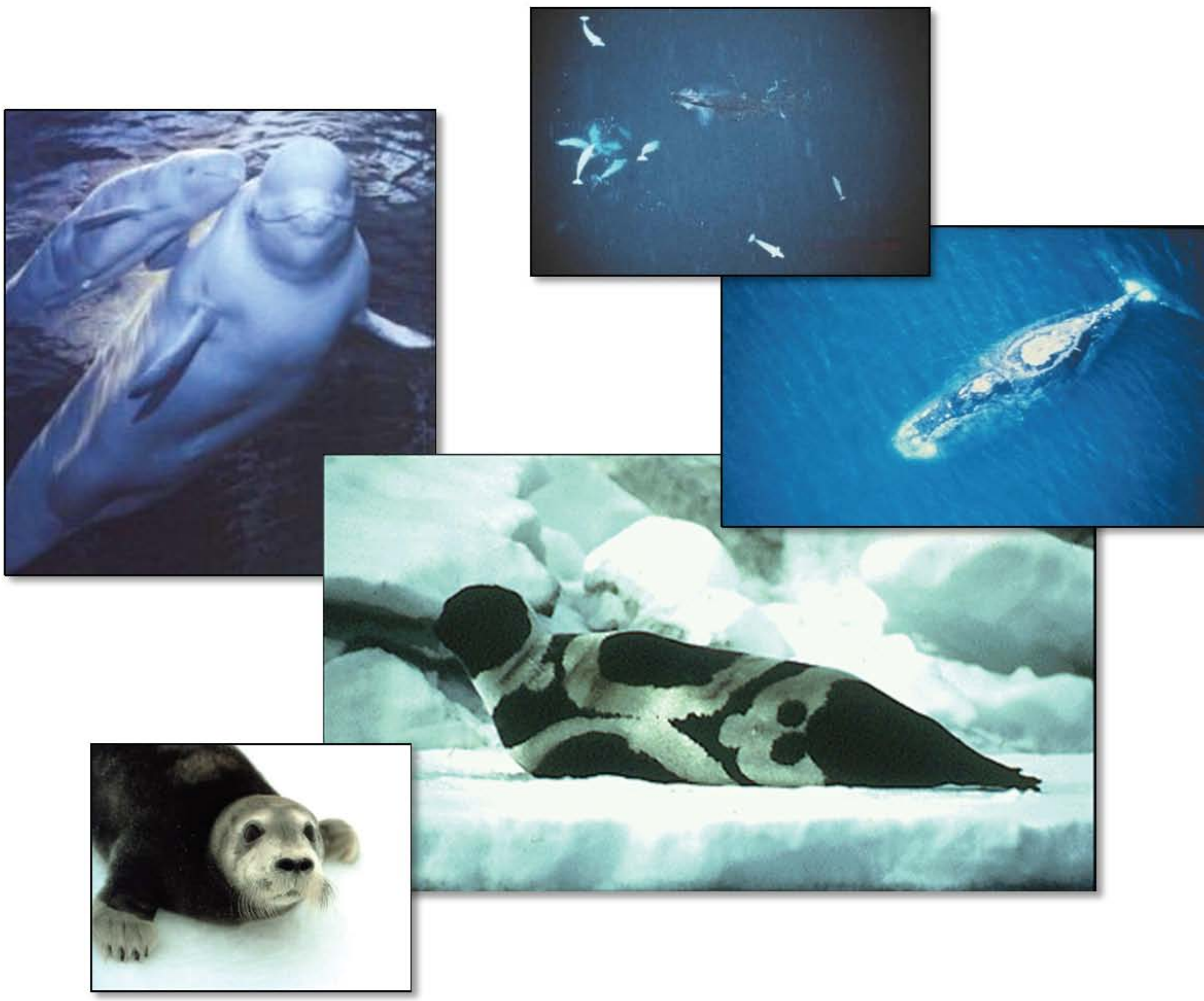
Effects of Oil and Gas Activities in the Arctic Ocean

Supplemental Draft Environmental Impact Statement

Volume 3: Chapters 7-8, Figures, and Appendices



March 2013

United States Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Protected Resources

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Prepared by:
U.S. Department of Commerce
National Oceanic and Atmospheric Administration
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LIST OF ACRONYMS AND ABBREVIATIONS

1D	One-dimensional
2D	Two-dimensional
3D	Three-dimensional
4D	Four-dimensional
AAC	Alaska Administrative Code
ACP	Arctic Coastal Plain Physiographic Province
ACMP	Alaska Coastal Management Act of 1977
ACP	Arctic Coastal Plain
ADCCED	Alaska Department of Commerce, Community, and Economic Development
ADCP	Acoustic Doppler Current Profile
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
ADLWD	Alaska Department of Labor and Workforce Development
ADNR	Alaska Department of Natural Resources
AEWC	Alaska Eskimo Whaling Commission
AF	Arctic Foothills Physiographic Province
AHRS	Alaska Heritage Resource
AMNWR	Alaska Maritime National Wildlife Refuge
AN(SW)T	Ambient-Noise (Surface-Wave) Tomography
ANCSA	Alaska Native Claims Settlement Act
ANIMIDA	Arctic Nearshore Impact Monitoring in Development Area
ANILCA	Alaska National Interest Lands Conservation Act
ANOs	Alaska Native Organizations
ANWR	Arctic National Wildlife Refuge
AO	Arctic Oscillation
AOOS	Alaskan Ocean Observing system
APD	Application for Permit to Drill
APP	Alaska Pipeline Project
AQRV	air quality related values
ARRT	Alaska Regional Response Team

ASNA	Arctic Slope Native Association
ASRC	Arctic Slope Regional Corporation
BACT	Best Available Control Technology
bbl	barrels
BIA	U.S. Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BOEMRE	U.S. Bureau of Ocean Energy Management, Regulation and Enforcement
BOWFEST	Bowhead Whale Feeding Ecology Study
BSEE	Bureau of Safety and Environmental Enforcement
BWASP	Bowhead Whale Aerial Survey Program
°C	Degrees-Celcious (spelling?)
CAA	Conflict Avoidance Agreement
CAH	Central Arctic Caribou Herd
cANIMIDA	Continuation of Arctic Nearshore Impact Monitoring in Development Area
CAR	Comment Analysis Report
CatExs	Categorically Excludes
CDS	conical drilling unit
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
CH_4	Methane
CBS	Chukchi/Bering Seas stock
CIDS	Concrete Island Drilling Structure
CLRD	Chronic lower respiratory disease
cm	Centimeter
cm^3	Cubic centimeter
cm/s	Centimeters per second
CO	carbon monoxide
CO_2	Carbon Dioxide
CO_2e	carbon dioxide equivalent
COA	corresponding onshore area

COMIDA	Chukchi Offshore Monitoring in Drilling Area Survey Project
CSPA	Chukchi Sea Planning Area
CPAI	ConocoPhillips Alaska, Inc
CPUE	Catch Per Unit Effort
CSEM	Controlled Source Electromagnetic
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
D	Drilling
DAO	Department Administrative Order
dB	Decibel
dBA	A-weighted sound level
dB re 1 µPa rms	Decibels Relative to 1 micropascal Root Mean Square
DCOM	Division of Coastal and Ocean Management
DCRA	Division of Community and Regional Affairs
DDT	dichlorodiphenyltrichloroethane
deg.	Degrees
DEIS	Draft Environmental Impact Statement
Detritus	Dead
DEW	Distant Early Warning
DLI	Daylight Imaging
DMLW	Division of Mining, Land and Water
DO&G	Department of Oil and Gas
DOC	U.S. Department of Commerce
DPEIS	Draft Programmatic Environmental Impact Statement
DS	Deep Seismic Survey
DTAGS	Deep-towed Acoustics/Geophysics System
DPP	Development and Production Plan
DWG	Supplemental Final EIS
EA	Environmental Assessment
Ecotone	salinity transition zone
EEZ	Exclusive Economic Zone

EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EP	Exploration Plan
EPA	U.S. Environmental Protection Agency
EMS	Emergency Medical Services
EO	Executive Order
EP	Exploration Plan
EPA	U.S. Environmental Protection Agency
ERD	Extended Reach Drilling
ERM	Effects Range Median
ERL	Effects Range Low
ESA	Endangered Species Act
ESP	Environmental Studies Program
EVOS	Exxon Valdez Oil Spill
°F	Degrees-Fahrenheit
FEIS	Final Environmental Impact Statement
FLIR	Forward Looking Infrared
FM	frequency-modulated
FMPs	Fishery management plans
FOSC	Federal On-Scene Coordinator
FONSI	Finding of No Significant Impact
FR	Federal Register
ft	Feet
FY	fiscal year
g	gram
G&G	Geological and Geophysical
GAO	Government Accountability Office
GHG	Greenhouse Gas
GIS	Geographic Information System
Gm	geographic mile
GPS	Global Positioning System

GTP	gas treatment plant
HAP	hazardous air pollutants
Hg	elemental mercury
$HgCl_2$	Mercuric chloride
HIV	Human Immunodeficiency Virus
HRS	High Resolution Seismic
HyMAS	Hydrocarbon Microtremor Analysis
Hz	Hertz
IAP	Integrated Activity Plan
IB	Icebreaking
ICAS	Inupiat Community of the Arctic Slope
IHA	Incidental Harassment Authorization
in	Inch
in^3	Cubic Inch
IMPROVE	Interagency Monitoring of Protected Visual
ISER	Social and Economic Research
ITA	Incidental Take Authorization
IVI	Industrial Vehicle International
IWC	International Whaling Commission
Kg	kilograms
kHz	kilohertz
KIC	Kikiktagruk Inupiat Corporation
km	Kilometer
km_2	square kilometers
kn	Knot
LACS	Low Level Acoustic Combustion Source
Lb	pounds
LBCHU	Ledyard Bay Critical Habitat Unit
LCU	Lower Cretaceous Unconformity
L_{eq}	Equivalent sound level
LET	Local Earthquake Tomography

LME	Large Marine Ecosystem
L_{min}	RMS maximum noise level
L_{min}	RMS minimum noise level
LOA	Letters of Authorization
LFS	Low-Frequency Spectroscopy
LRI	lower respiratory tract infections
m	Meter
mg/kg	milligrams per kilograms
Mg/L	Milligrams per liter
Mg/m^3	Milligrams per cubic meter
mi	Mile
min.	Minutes
MIRIS	Michigan Resource Information System
mm	Millimeter
MMbbls	million barrels
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MMt	million metric tons
MODU	Mobile Offshore Drilling Unit
Mph	Miles per hour
MSFCMA	Magnuson Stevens Fishery Conservation and Management Act
my	million years
myBP	million years before present
µPa	Micro Pascal
NAAQS	National Ambient Air Quality Standards
NAB	Northwest Arctic Borough
NANA	NANA Regional Corporation
NAO	North Atlantic Oscillation
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEP-A	National Environmental Policy Act

Ng/L	parts per trillion
NGO	non-governmental organization
NH	ammonia
NM	Nautical Miles
NMFS	National Marine Fisheries Service
NMI	nautical miles
NO	nitrogen oxides
N_2O	Nitrous Oxide
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPFMC	North Pacific Fisheries Management Council
NPR-A	National Petroleum Reserve–Alaska
NRC	National Research Council
NSR	New Source Review
NTL	Notice to Lessees
NTU	Nephelometric Turbidity Units
NVDs	Night Vision Devices
NPFMC	North Pacific Fisheries Management Council
NPS	National Park Service
NRHP	National Register of Historic Places
NSB	North Slope Borough
NSB DHHS	North Slope Borough Department of Health and Social Services
NSR	New Source Review
O_3	ozone
OBC	Ocean-bottom-cable
OBN	ocean bottom node
OCRM	Office of Ocean and Coastal Resource Management
OCS	Outer Continental Shelf
ODPCP	Oil Discharge Prevention and Contingency Plan
OMB	U.S. Office of Management and Budget

OPEC	Organization of Petroleum-Exporting Countries
OSRB	Oil Spill Response Barge
OSRO	Oil Spill Removal Organizations
OSRP	Oil Spill Response Plan
OSRV	Oil Spill Response Vessels
Pa	Pascals
PAH	polycyclic aromatic hydrocarbons
Pb	lead
PCB	Polychlorinated Biphenyl
PCH	Porcupine Caribou Herd
PDO	Pacific Decadal Oscillation
PEA	Programmatic Environmental Assessment
PEIS	Programmatic Environmental Impact Statement
PILT	payment in lieu of tax
PGS	Petroleum Geo-Services
$PM_{2.5}$	Particulate matter 10 microns in diameter
PM_{10}	Particulate matter 10 microns in diameter
P	Pressure
P_1	Sound having pressure
POC	Plan of Cooperation
P_{ref}	Standard Reference Pressure
ppm	parts per million
ppt	parts per thousand
PSD	Prevention of Significant Deterioration
Psi	per square inch
PSO	Protected Species Observer
psu	practical salinity units
PTE	potential-to-emit
PTS	permanent threshold shifts
R/B	biomass ratio
RDD	Resource Development Districts

RFFA	reasonably foreseeable future actions
RMS	root-mean-square
ROD	Record of Decision
RSC	reduced sulfur compounds
RUSALCA	Russian-American Long-term Census of the Arctic
s	Second
SA	Subsistence Advisor
SAR	Search and Rescue
SBI	Shelf Basin Interactions
SBS	Southern Beaufort Sea stock
SCR	Selective catalytic control
SEL	sound exposure level
SEIS	Supplemental Environmental Impact Statement
SEMS	Safety and Environmental Management Systems
SFEIS	Supplemental Final EIS
SO	sulfur dioxide
SOPCs	Stressors of Potential Concern
SQRU	Scenic Quality Rating Unit
SSV	Sound Source Verification
SDC	Steel Drilling Caisson
SLRU	Sensitivity Level Rating Unit
SPLASH	Structure of Populations, Levels of Abundance, and Status of Humpbacks
SQRU	Scenic Quality Rating Unit
STI	Sexually transmitted infection
TA&R	Technology Assessment & Research
TAPS	Trans-Alaska Pipeline System
TB	Tuberculosis
TCH	Teshekpuk Caribou Herd
TCP	Traditional cultural properties
TK	Traditional Knowledge
TPY	tons per year

TTS	temporary threshold shifts
µPa	Micro Pascal
ULSD	ultra-low sulfur diesel
URI	Upper respiratory tract infection
U.S.	United States of America
USACE	U.S. Army Corps of Engineer
USCG	U.S. Coast Guard
USDOI	U.S. Department of the Interior
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey
USPS	U.S. Park Service
VLCC	Very Large Crude Carrier
VLOS	Very Large Oil Spill
VOC	volatile organic compounds
WAH	Western Arctic Caribou Herd
WCD	Worst Case Discharge

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8.0 GLOSSARY

Acute—Sudden, short term, severe, critical, crucial, intense, but usually of short duration.

Anadromous fish—Fish that migrate up river from the sea to breed in fresh water.

Annelid—Worm with a cylindrical body segmented both internally and externally.

Annular preventer—A component of the pressure control system in the Blowout Preventer that forms a seal in the annular space around any object in the wellbore or upon itself, enabling well control operations to commence.

Anthropogenic—Coming from human sources, relating to the effect of humankind on nature.

Aphotic zone—Zone where the levels of light entering through the surface are not sufficient for photosynthesis or for animal response.

Archaeological resource—Any material remains of human life or activities that are at least fifty years of age and that are of archaeological interest.

Aromatic—Class of organic compounds containing benzene rings or benzenoid structures.

Attainment area—An area that is shown by monitored data or by air-quality modeling calculations to be in compliance with primary and secondary ambient air quality standards established by the USEPA.

Barrel (bbl)—A volumetric unit used in the petroleum industry; equivalent to 42 U.S. gallons or 158.99 liters.

Benthic—Literally, living on the bottom. Refers to material, especially sediment, at the bottom of an aquatic ecosystem, or it can be used to describe the organisms that live on, or in, the bottom of a water body or the sea.

Benthos—A region that includes the bottom of the sea and the littoral zone; also refers to the benthic invertebrate community, which is a group of animals that lives on or in the bottom sediments.

Biological Opinion—The FWS or NMFS evaluation of the impact of a proposed action on endangered and threatened species, in response to formal consultation under Section 7 or the endangered Species Act.

Block—A geographical area portrayed on official BOEMRE protraction diagrams or leasing maps that contains approximately 2,331 ha (9 mi2).

Blowout—An uncontrolled flow of fluids below the mudline from appurtenances on a wellhead or from a wellbore.

Blowout preventer (BOP)—One of several valves installed at the wellhead to prevent the escape of pressure either in the annular space between the casing and drill pipe or in open hole (i.e., hole with no drill pipe) during drilling completion operations. Blowout preventers on jackup or platform rigs are located at the water's surface; on floating offshore rigs, BOP's are located on the seafloor.

Brackish—Slightly salty water.

Cetacean—Large aquatic carnivorous mammal with fin-like forelimbs, no hind limbs includes whales, dolphins, porpoises, and narwhals. Also of or relating to these animals.

Chemosynthetic—Organisms that obtain their energy from the oxidation of various inorganic compounds rather than from light (photosynthesis).

Critical habitat—Specific areas within the geographical area occupied by the species at the time of listing (under the ESA), if they contain physical or biological features essential to conservation, and those features may require special management considerations or protection; and specific areas outside the geographical area occupied by the species if the agency (USFWS or NMFS) determines that the area itself is essential for conservation.

Coastal waters—Waters within the geographical areas defined by each State's Coastal Zone Management Program.

Coastal wetlands—Forested and nonforested habitats, mangroves, and marsh islands exposed to tidal activity. These areas directly contribute to the high biological productivity of coastal waters by input of detritus and nutrients, by providing nursery and feeding areas for shellfish and finfish, and by serving as habitat for birds and other animals.

Coastal zone—The coastal waters (including the lands therein and thereunder) and the adjacent shore lands (including the waters therein and thereunder) strongly influenced by each other and in proximity to the shorelines of the several coastal states; the zone includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches and extends seaward to the outer limit of the United States territorial sea. The zone extends inland from the shorelines only to the extent necessary to control shore lands, the uses of which have a direct and significant impact on the coastal waters. Excluded from the coastal zone are lands the use of which is by law subject to the discretion of or which is held in trust by the Federal Government, its officers, or agents. (The State land and water area officially designated by the State as "coastal zone" in its State coastal zone program as approved by the U.S. Department of Commerce under the Coastal Zone Management Act.)

Condensate—Liquid hydrocarbons produced with natural gas; they are separated from the gas by cooling and various other means. Condensates generally have an API gravity of 50o-120o.

Continental margin—The ocean floor that lies between the shoreline and the abyssal ocean floor, includes the continental shelf, continental slope, and continental rise.

Continental shelf—The gently seaward-sloping surface that extends between the shoreline and the top of the continental slope at about 150 meters (345 feet) depth. The average gradient of the shelf is between 1:500 and 1:1000 and, although it varies greatly, the average width is approximately 70 kilometers (44 miles). This can also be a judicial term; for example, the outer limit of the legal continental shelf is determined by reference to be a distance of 200 nautical miles (370 kilometers, 230 miles) or to the outer edge of the geological continental margin, wherever the margin extends beyond 200 nautical miles (370 kilometers; 230 miles).

Contingency Plan—A plan for possible offshore emergencies prepared and submitted by the oil or gas operator as part of the plan of development and production, and which may be required for part of the plan of exploration.

Continental slope—That part of the continental margin that lies between the continental shelf and the bottom of the ocean. Sunlight does not penetrate this area, and mostly it is home to scavengers. It is characterized by a relatively steep slope of 3 to 6 degrees.

Critical habitat—a designated area that is essential to the conservation of an endangered or threatened species that may require special management considerations or protection.

Crude oil—Petroleum in its natural state as it emerges from a well, or after it passes through a gas-oil separator but before refining or distillation. An oily, flammable, bituminous liquid that is essentially a complex mixture of hydrocarbons of different types with small amounts of other substances.

Crustacean—Includes a diversity of marine, freshwater, and terrestrial animals. All crustaceans have a head and five pairs of appendages, two of which are antennae. Many microscopic crustaceans, like krill and brine shrimp, are marine plankton, an important food source for other animals in the sea. Shrimp, lobsters, crabs, crayfish, and barnacles are crustaceans.

Deferral—Action taken by the Secretary of the Interior at the time of the Area Identification to remove certain areas/blocks from the proposed sale.

Delineation well—A well that is drilled for the purpose of determining the size and/or volume of an oil or gas reservoir.

***Deepwater Horizon* (DWH) event**—All actions stemming from the April 20, 2010, explosion and subsequent sinking of the Transocean drillship *Deepwater Horizon*, up to and including the Macondo well kill declaration on September 19, 2010.

Depleted species—Defined by the MMPA as any case in which: (a) the Secretary of Commerce, after consultation with the Marine Mammal Commission and the Committee of Scientific Advisors on Marine Mammals, determines that a species or population stock is below its optimum sustainable population; (b) a State determines that such species or stock is below its optimum sustainable population; or (c) a species or population stock is listed as a threatened species or endangered species under the ESA.

Demersal—Living near, deposited on, or sinking to the bottom of the sea.

Development—Activities that take place following discovery of economically recoverable mineral resources, including geophysical surveying, drilling, platform construction, operation of onshore support facilities, and other activities that are for the purpose of ultimately producing the resources.

Development Operations Coordination Document (DOCD)—A document that must be prepared by the operator and submitted to BOEMRE for approval before any development or production activities are conducted on a lease in the Western Gulf.

Diapause—A state of rest, halted development, or arrested development or growth, accompanied by greatly decreased metabolism, often correlated with the seasons, usually applied only to insects.

Dilution—The reduction in the concentration of dissolved or suspended substrates by mixing with water.

Direct employment—Consists of those workers involved the primary industries of oil and gas exploration, development, and production operations (Standard Industrial Classification Code 13—Oil and Gas Extraction).

Discharge—Something that is emitted; flow rate of a fluid at a given instant expressed as volume per unit of time.

Dispersant—A suite of chemicals and solvents used to break up an oil slick into small droplets, which increases the surface area of the oil and hastens the processes of weathering and microbial degradation.

Dispersion—A suspension of finely divided particles in a medium.

Distinct Population Segment (DPS)—A vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. Distinct population segments may be listed as threatened or endangered under the ESA.

Drilling mud—A mixture of clay, water or refined oil, and chemical additives pumped continuously downhole through the drill pipe and drill bit, and back up the annulus between the pipe and the walls of the borehole to a surface pit or tank. The mud lubricates and cools the drill bit, lubricates the drill pipe as it turns in the wellbore, carries rock cuttings to the surface, serves to keep the hole from crumbling or collapsing, and provides the weight or hydrostatic head to prevent extraneous fluids from entering the well bore and to downhole pressures; also called drilling fluid.

Drillship—A self-propelled, self-contained vessel equipped with a derrick amidships for drilling wells in deep water.

Effluent—A waste product that is discharged to the environment, usually used to mean treated wastewater discharged from a wastewater treatment plant, sewer, or industrial outfall.

Effluent limitations—Any restriction established by a State or the USEPA on quantities, rates, and concentrations of chemical, physical, biological, and other constituents discharged from point sources into U.S. waters, including schedules of compliance.

Endangered species—Defined under the ESA as "any species which is in danger of extinction throughout all or a significant portion of its range."

Environmental Assessment—A concise public document required by the National Environmental Policy Act of 1969 (NEPA). In the document, a Federal agency proposing (or reviewing) and action provides evidence and analysis for determining whether it must prepare an Environmental Impact Statement (EIS) or whether it finds there is no significant impact (i.e., Finding of No Significant Impact [FONSI]).

Environmental effect—A measurable alteration or change in environmental conditions.

Environmental Impact Statement (EIS)—A statement required by the National Environmental Policy Act of 1969 (NEPA) or similar State law in relation to any major action significantly affecting the environment; a NEPA document.

Epifaunal—Animals living on the surface of hard substrate.

Essential Fish Habitat (EFH)—Defined under the Magnuson-Stevens Fishery Conservation and Management Act as waters and substrate that are necessary to the fish species for spawning, breeding, feeding, or growth to maturity.

Estuary—Coastal semienclosed body of water that has a free connection with the open sea and where freshwater meets and mixes with seawater.

Eutrophication—The process whereby an aquatic environment becomes rich in dissolved nutrients, causing excessive growth and decomposition of oxygen-depleting plant life and resulting in injury or death to other organisms.

Exclusive Economic Zone (EEZ)—The maritime region extending 200 nmi from the baseline of the territorial sea, in which the United States has exclusive rights and jurisdiction over living and nonliving natural resources.

Exploration—The process of searching for minerals. Exploration activities include: (1) geophysical surveys where magnetic, gravity, seismic, or other systems are used to detect or infer the presence of such minerals; and (2) any drilling, except development drilling, whether on or off known geological structures. Exploration also includes the drilling of a well in which a discovery of oil or natural gas in paying quantities is made, and the drilling, after such a discovery, of any additional well that is needed to delineate a reservoir and to enable the lessee to determine whether to proceed with development and production.

Exploration Plan (EP)—A plan that must be prepared by the operator and submitted to BOEMRE for approval before any exploration or delineation drilling is conducted on a lease.

Exploration well—A well drilled in unproven or semi-proven territory to determining whether economic quantities of oil or natural gas deposit are present; exploratory well.

Fault—A fracture in the earth's crust accompanied by a displacement of one side of the fracture with respect to the other.

Field—An accumulation, pool, or group of pools of hydrocarbons in the subsurface. A hydrocarbon field consists of a reservoir in a shape that will trap hydrocarbons and that is covered by an impermeable, sealing rock.

Fixed or bottom founded—Permanently or temporarily attached to the seafloor.

Flyway—An established air route of migratory birds.

Formation—A bed or deposit sufficiently homogeneous to be distinctive as a unit. Each different formation is given a name, frequently as a result of the study of the formation outcrop at the surface and sometimes based on fossils found in the formation.

Fugitive emissions—Emission into the atmosphere that could not reasonably pass through a stack, chimney, vent or other functionally equivalent opening.

Gathering lines—A pipeline system used to bring oil or gas production from a number of separate wells or production facilities to a central trunk pipeline, storage facility, or processing terminal.

Geochemical—Of or relating to the science dealing with the chemical composition of and the actual or possible chemical changes in the crust of the earth.

Geologic hazard—A feature or condition that, if unmitigated, may seriously jeopardize offshore oil and gas exploration and development activities. Mitigation may necessitate special engineering procedures or relocation of a well.

Geophysical—Of or relating to the physics of the earth, especially the measurement and interpretation of geophysical properties of the rocks in an area.

Geophysical data—Facts, statistics, or samples that have not been analyzed or processed, pertaining to gravity, magnetic, seismic, or other surveys/systems.

Geophysical survey—A method of exploration in which geophysical properties and relationships are measured remotely by one or more geophysical methods.

Habitat—A specific type of environment that is occupied by an organism, a population, or a community.

Halophytic—A plant that can tolerate or thrive in alkaline soil rich in sodium or calcium salts; tolerant of saline (salty) conditions.

Harassment—Under the 1994 amendments to the MMPA, harassment is statutorily defined as any act of pursuit, torment, or annoyance which: has the potential to injure a marine mammal or marine mammal stock in the wild (Level A Harassment); or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild (Level B Harassment).

Haulout area—Specific locations where pinnipeds come ashore and concentrate in numbers to rest, breed, and/or bear young.

Holocene Epoch—A geologic time segment of the Quaternary Period, dating from the end of the Pleistocene Epoch, approximately 8,000 years ago until the present.

Hydrocarbons—Any of a large class of organic compounds containing primarily carbon and hydrogen. Hydrocarbon compounds are divided into two broad classes: aromatic and aliphatics. They occur primarily in petroleum, natural gas, coal, and bitumens.

Hypothermia—Condition in which body temperature drops below the level required for normal metabolism and/or bodily function to take place.

Hypoxia—Depressed levels of dissolved oxygen in water, usually resulting in decreased metabolism.

Incidental take—Takings that result from, but are not the purpose of, carrying out an otherwise lawful activity (e.g., fishing) conducted by a Federal agency or applicant (see Taking).

Indigenous—Originating where it is found. Refers to species or peoples found locally and from the local area.

Indirect effects—Effects caused by activities that are stimulated by an action but not directly related to it.

Industry infrastructure—The facilities associated with oil and gas development, e.g., refineries, gas processing plants, etc.

Indirect employment—Secondary or supporting oil- and gas-related industries, such as the processing of crude oil and gas in refineries, natural gas plants, and petrochemical plants.

Intertidal—The zone between the high and low water marks.

Invertebrate—An animal without a backbone or spinal column, such as an insect.

Isobath—Line connecting points of equal water depth on a nautical chart; a seabed contour.

Jackup rig—A barge-like, floating platform with legs at each corner that can be lowered to the sea bottom to raise the platform above the water.

Lagoon—A water body often separated from ocean water exchange, with enclosure as a defining characteristic.

Lease—Authorization that is issued under and that authorizes exploration for, and development and production of, minerals. Lease means an agreement that is issued under Section 8 or maintained under Section 6 of the Outer Continental Shelf Lands Act and that authorizes exploration for, and development and production of, minerals. The term also means the area covered by that authorization, whichever the context requires.

Lease sale—The competitive auction of leases granting companies or individuals the right to explore for and develop certain minerals under specified conditions and periods of time.

Lease term—The initial period for oil and gas leases, usually a period of 5, 8, or 10 years depending on water depth or potentially adverse conditions.

Lessee—A party who has entered into a lease with the United States to explore for, develop, and produce the leased minerals.

Lightering—Smaller boats supplying larger boats with supplies and/or carrying fuel; lightering operations include transfers within the vessel, to lightering barges, or if necessary, into the sea.

Lithic—Of or pertaining to stone.

Macondo Oil Spill—The name given to the oil spill that resulted from the explosion and sinking of the *Deepwater Horizon* rig from the period between April 24, 2010, when search and recovery vessels on site reported oil at the sea surface until uncontrolled flow from the Macondo well was capped.

Marshes—Persistent, emergent, nonforested wetlands characterized by predominantly cordgrasses, rushes, and cattails.

Migratory bird—Any mutation or hybrid of a listed species, as well as any part, egg, or nest of such bird. Protected under the Migratory Bird Treaty Act.

Minerals—As used in this document, minerals include oil, gas, sulphur, and associated resources, and all other minerals authorized by an Act of Congress to be produced from public lands as defined in Section 103 of the Federal Land Policy and Management Act of 1976.

Mollusk—An invertebrate having a soft unsegmented body, usually enclosed in a shell. Also a group of freshwater and saltwater animals, including oysters, clams, mussels, snails, conches, scallops, squid, and octopus.

Mysticete—A whale that has baleen (plates of keratinized tissue that hang from the upper jaw) instead of teeth (suborder Mysticeti). Examples include the humpback whale (*Megaptera novaeangliae*), gray whale (*Eschrichtius robustus*), and minke whale (*Balaenoptera acutorostrata*).

Nautical mile—A distance measurement equivalent to 1.15 statutory miles, or 1.8 kilometers.

Nearshore waters—Offshore open waters that extend from the shoreline out to the limit of the territorial seas (twelve nautical miles).

Nonattainment area—An area that is shown by monitoring data or by air-quality modeling calculations to exceed primary or secondary ambient air quality standards established by the USEPA.

Odontocete—Toothed marine mammals (suborder Odontoceti). Examples include the sperm whale (*Physeter macrocephalus*), beluga whale (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), and bottlenose dolphin (*Tursiops truncatus*).

Offloading—Unloading liquid cargo, crude oil, or refined petroleum products.

Offshore—In beach terminology, the comparatively flat zone of variable width, extending from the shore to the edge of the continental shelf. It is continually submerged. Also the breaker zone directly seaward of the low tide line.

Oil spill contingency plan—A plan submitted by the lease or unit operator along with or prior to a submission of a plan of exploration or a development/production plan that details provisions for fully defined specific actions to be taken following discovery and notification of an oil spill occurrence.

Operational discharge—Any incidental pumping, pouring, emitting, emptying, or dumping of wastes generated during routine offshore drilling and production activities.

Operator—An individual, partnership, firm, or corporation having control or management of operations on a leased area or portion thereof. The operator may be a lessee, designated agent of the lessee, or holder of operating rights under an approved operating agreement.

Organic matter—Material derived from living plants or animals.

Outer Continental Shelf (OCS)—All submerged lands that comprise the continental margin adjacent to the United States and seaward of State offshore lands.

Pelagic—Of or pertaining to the open sea; associated with open water beyond the direct influence of coastal systems.

Perturbation—A secondary influence on a system that causes it to deviate.

Plankton—Passively floating or weakly motile aquatic plants (phytoplankton) and animals (zooplankton).

Pathology—The scientific study of the nature of disease and its causes, processes, development, and consequences.

Phocid—True or earless seals (family Phocidae). Examples include the bearded seal (*Erignathus barbatus*) and ringed seal (*Phoca hispida*).

Phytoplankton—Microscopic floating aquatic plants that produce their own nutrients through photosynthesis.

Pinniped—Aquatic carnivorous mammals having a streamlined body specialized for swimming with limbs modified as flippers, for example, seals.

Platform—A steel or concrete structure from which offshore development wells are drilled.

Plankton—Very small, free-floating organisms of the ocean or other aquatic systems, including phytoplankton and zooplankton, which get their nutrients from organisms.

Play—A prospective subsurface area for hydrocarbon accumulation that is characterized by a particular structural style or depositional relationship.

Plume—A narrow thermal feature, which can be either hot or cold, that rises or sinks because of its anomalous temperature compared to the surrounding fluid.

Polychaete—A class of mainly marine annelids, characterized by parapodia bearing numerous hairs; for example, bristle worm.

Polychlorinated Biphenyls (PCBs)—A group of toxic, carcinogenic organic compounds previously used for industrial purposes.

Polycyclic Aromatic Hydrocarbon (PAH)—Chemical compounds that consist of fused aromatic rings; many are known or suspected carcinogens.

Potential impact (effect)—The range of alterations or changes to environmental conditions that could be caused by an action.

Primary production—Organic material produced by photosynthetic or chemosynthetic organisms.

Produced water—Total water discharged from the oil and gas extraction process; production water or production brine.

Production—Activities that take place after the successful completion of any means for the extraction of resources, including bringing the resource to the surface, transferring the produced resource to shore, monitoring operations, and drilling additional wells or workovers.

Promulgated—Formally made public; published accounts.

Prospect—An untested geologic feature having the potential for trapping and accumulating hydrocarbons.

Province—A spatial entity with common geologic attributes. A province may include a single dominant structural element such as a basin or a fold belt, or a number of contiguous related elements.

Refining—Fractional distillation of petroleum, usually followed by other processing (for example, cracking).

Relief—The difference in elevation between the high and low points of a surface.

Reserves—Proved oil or gas resources.

Reservoir—A subsurface, porous, permeable rock boy in which hydrocarbons have accumulated.

Rig—A structure used for drilling an oil or gas well.

Right-of-way—A legal right of passage, an easement; the specific area or route for which permission has been granted to place a pipeline, (and) ancillary facilities, and for normal maintenance thereafter.

Rookery—The nesting or breeding grounds of gregarious (i.e., social) birds or mammals; also a colony of such birds or mammals.

Royalty—A share of the minerals produced from a lease paid in either money or "in-kind" to the landowner by the lessee.

Sale area—The geographic area of the Outer Continental Shelf (OCS) being offered for lease for the exploration, development, and production of mineral resources.

Scoping—The process prior to Environmental Impact Statement (EIS) preparation to determine the range and significance of issues to be addressed in the EIS for each proposed major federal action.

Seagrass beds—More or less continuous mats of submerged, rooted marine flowering vascular plants occurring in shallow tropical and temperate waters. Seagrass beds provide habitat, including breeding and feeding grounds, for adults and/or juveniles of many of the economically important shellfish and finfish.

Seismic—Pertaining to, characteristic of, or produced by water, earthquakes or earth vibration; having to do with elastic waves in the earth; also geophysical when applied to surveys.

Sediment—Material that has been transported and deposited by water, wind, glacier, precipitation, or gravity; a mass of deposited material.

Seeps (hydrocarbon)—Gas or oil that reaches the surface along bedding planes, fractures, unconformities, or fault planes.

Sensitive area—An area containing species, populations, communities, or assemblages of living resources, that is susceptible to damage from normal OCS-related activities. Damage includes interference with established ecological relationships.

Stranding—Defined under the MMPA as "an event in the wild in which (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance."

Stipulations—Specific measures imposed upon a lessee that apply to a lease. Stipulations are attached as a provision of a lease; they may apply to some or all tracts in a sale. For example, a stipulation might limit drilling to a certain time period of the year or certain areas.

Subarea—A discrete analysis area.

Subsistence uses—The customary and traditional uses by rural residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for making and selling of handcraft articles out of nonedible byproducts of fish and wildlife resources take for personal or family consumption; for barter, or sharing for personal or family consumption; and for customary trade.

Substrate—Any stratum lying underneath another.

Supply vessel—A boat that ferries food, water, fuel, and drilling supplies and equipment to an offshore rig or platform and returns to land with refuse that cannot be disposed of at sea.

Take—In the Marine Mammal Protection Act, meaning "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." In the Endangered Species Act, the definition includes to harass, harm, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. A notable component of this definition is "harm," which means an act that actually kills or injures protected wildlife. Such acts may include significant habitat modification or degradation that actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering.

Tertiary—A geologic period dating from 63 million to 2 million years ago.

Threatened species—Defined under the Endangered Species Act as “any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.”

Total suspended solids—The total amount of suspended solids in water.

Turbidity—Reduced water clarity due to the presence of suspended matter.

Trawling—The operation of towing a net (trawl) to catch fish and/or shellfish. Trawls are towed either with bottom contact or in midwater. The towing speed varies, according to such factors as the type of trawl and trawling and the target species.

Trophic—Trophic levels refer to the hierarchy of organisms form photosynthetic plants to carnivores, such as man; feeding trophic levels refer to the hierarchy of organisms from photosynthetic plants to carnivores in which organisms at one level are fed upon by those at the next higher level (e.g., phytoplankton eaten by zooplankton eaten by fish).

Turbidity—Reduced water clarity resulting from the presence of suspended matter.

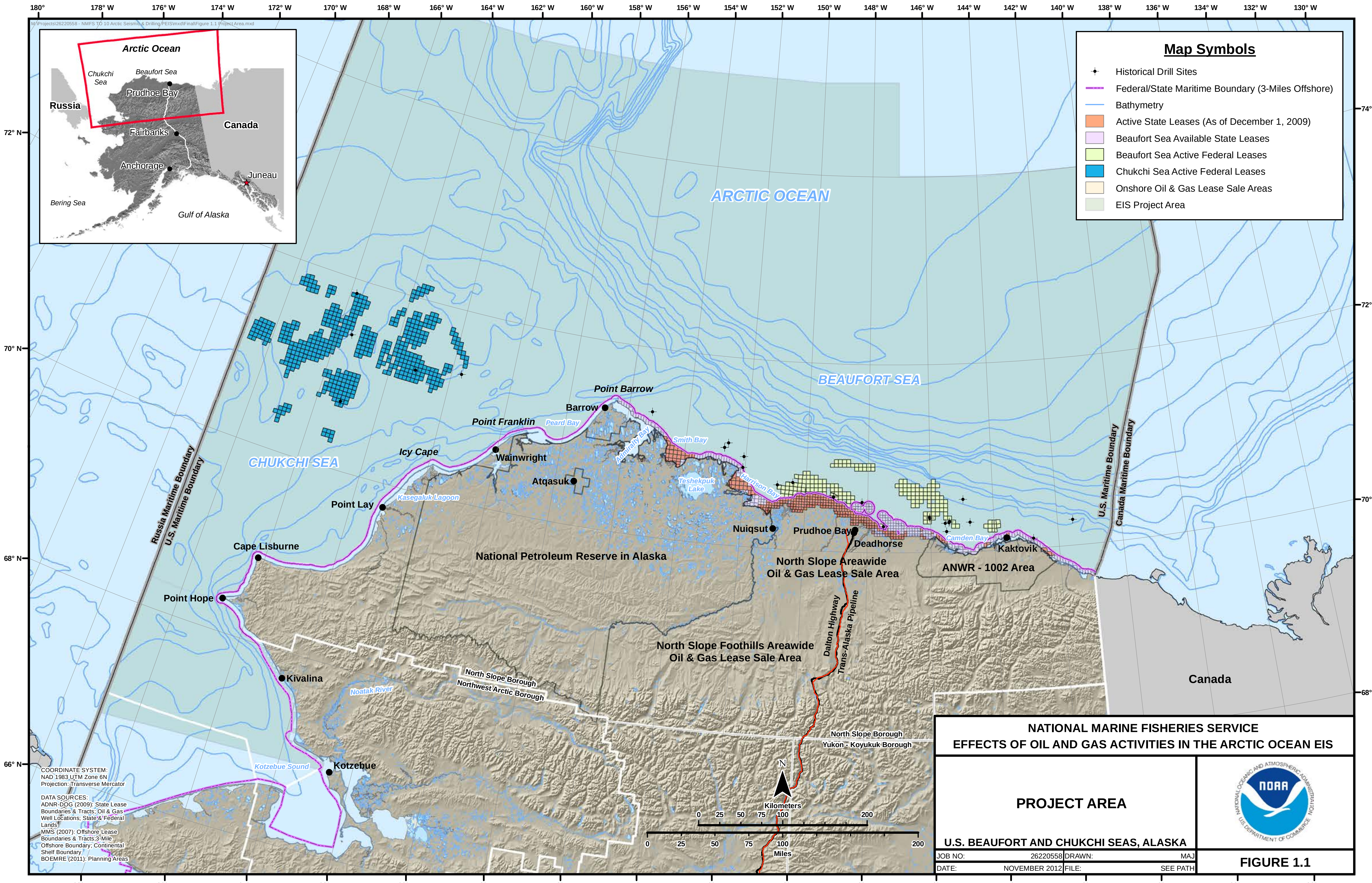
Upwelling—Divergence of water currents or the movement of surface water away from land, leading to upward movement of cold nutrient-rich water from the ocean depths; often associated with great production of fish and fisheries.

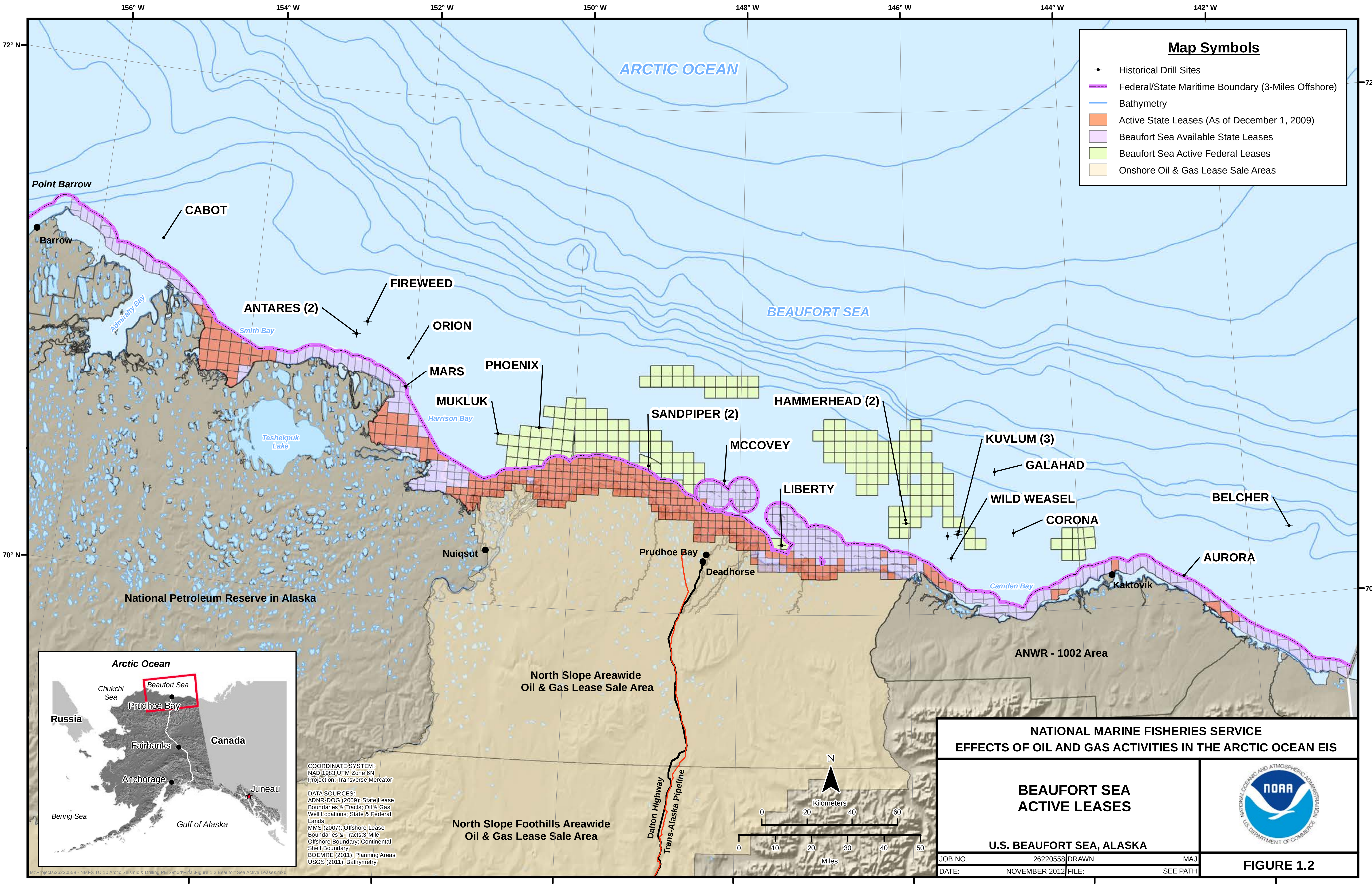
Volatile organic compound (VOC)—Any reactive organic compound that is emitted to the atmosphere as a vapor. The definition does not include methane.

Weathering (of oil)—The aging of oil due to its exposure to the atmosphere, causing marked alterations in its physical and chemical makeup.

FIGURES

CHAPTER 1 FIGURES


Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Chukchi Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
EIS Project Area
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
ARCTIC OCEAN
CHUKCHI SEA
BEAUFORT SEA
Point Barrow
Barrow
Point Franklin
Peard Bay
Icy Cape
Wainwright
Atqasuk
Admiralty Bay
Smith Bay
Teshekpuk Lake
Harrison Bay
Point Lay
Kasegaluk Lagoon
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
Point Hope
Kivalina
Noatak River
Kotzebue Sound
Kotzebue
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
North Slope Borough
Northwest Arctic Borough
North Slope Borough
Yukon - Koyukuk Borough
Russia Maritime Boundary
U.S. Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Canada
N
Kilometers
0 25 50 75 100 200
0 25 50 75 100 200
Miles
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
PROJECT AREA
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 1.1



ARCTIC OCEAN
BEAUFORT SEA
Map Symbols
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Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
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Point Barrow
Barrow
CABOT
FIREWEED
ANTARES (2)
ORION
MARS
PHOENIX
MUKLUK
SANDPIPER (2)
MCCOVEY
HAMMERHEAD (2)
KUVLUM (3)
GALAHAD
LIBERTY
WILD WEASEL
CORONA
BELCHER
AURORA
Admiralty Bay
Smith Bay
Harrison Bay
Teshekpuk Lake
Camden Bay
Nuiqsut
Prudhoe Bay
Deadhorse
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Dalton Highway
Trans-Alaska Pipeline
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
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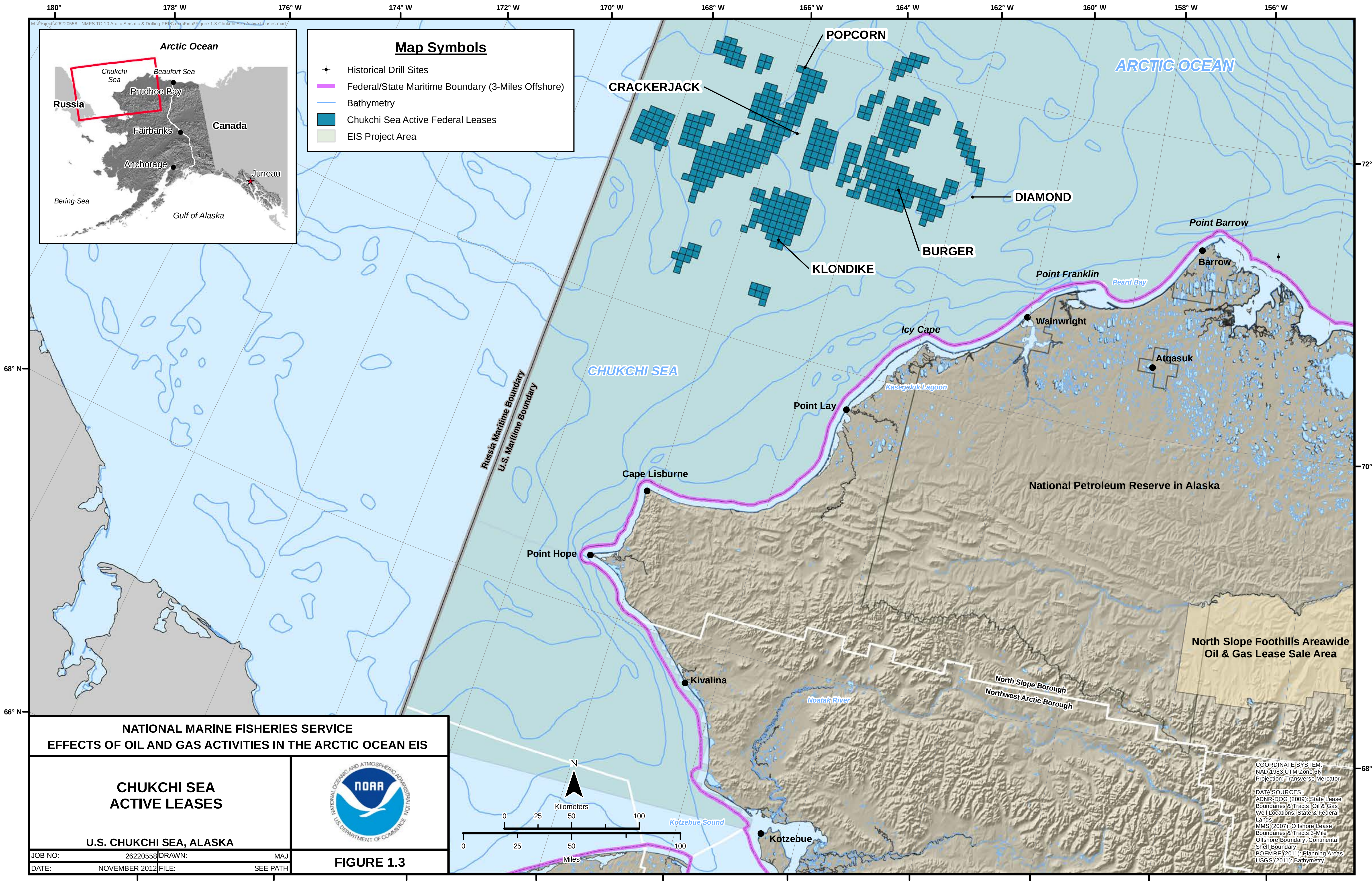
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
N
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W
72° N 70° N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
BEAUFORT SEA
ACTIVE LEASES
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558 DRAWN: MAJ
DATE: NOVEMBER 2012 FILE: SEE PATH

FIGURE 1.2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Gulf of Alaska
POPCORN
CRACKERJACK
DIAMOND
BURGER
KLONDIKE
ARCTIC OCEAN
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Wainwright
Icy Cape
Atqasuk
Kasegaluk Lagoon
Point Lay
Cape Lisburne
Point Hope
National Petroleum Reserve in Alaska
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Kivalina
North Slope Borough
Northwest Arctic Borough
Noatak River
Kotzebue Sound
Kotzebue
Kilometers
0 25 50 100
Miles
0 25 50 100
180°
178° W
176° W
174° W
172° W
170° W
168° W
166° W
164° W
162° W
160° W
158° W
156° W
154° W
72° N
70° N
68° N
66° N
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
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CHUKCHI SEA ACTIVE LEASES
U.S. CHUKCHI SEA, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 1.3

CHAPTER 2 FIGURES

Figure 2.1 Simple Illustration of a Marine Seismic Survey Operation using Streamers.
Source: USDOI, MMS 2006a

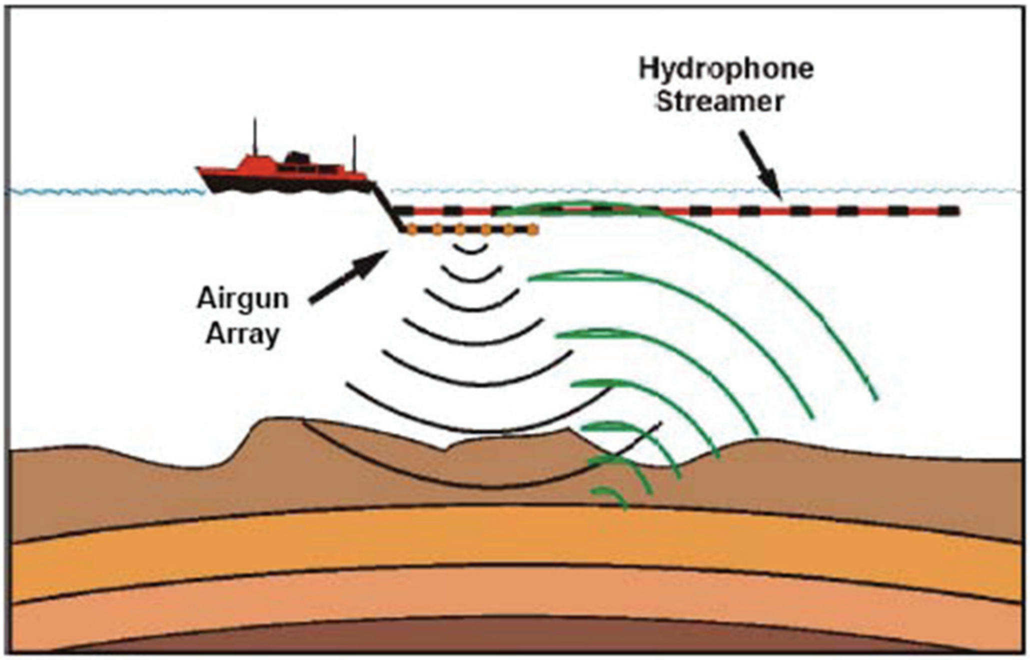

Figure 2.2 Illustration of Ocean Bottom Cable survey.
Source: Schlumberger 2011

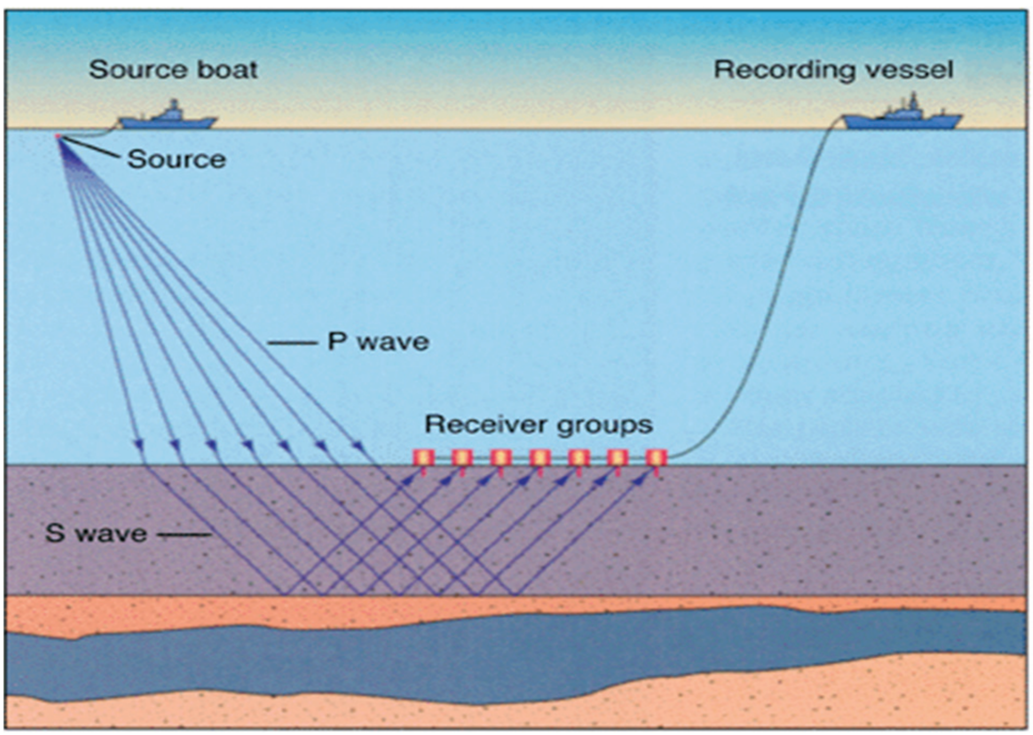

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Figure 2.3 Schematic view of a Controlled Source Electromagnetic (CSEM) survey.
A horizontal electric dipole is towed above receivers that are deployed on the seafloor.

Source: 2010 Electromagnetic Geoservices ASA

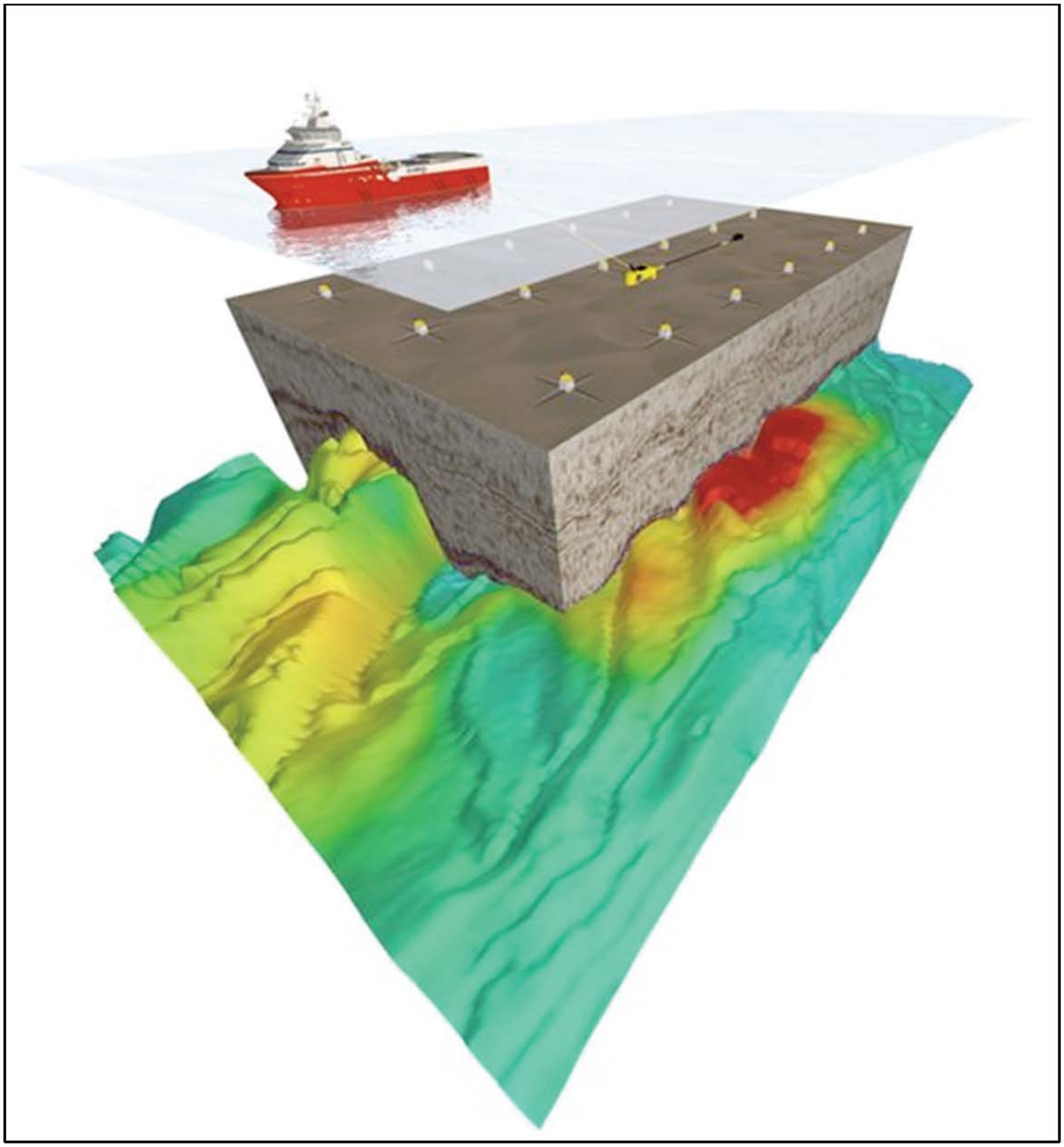
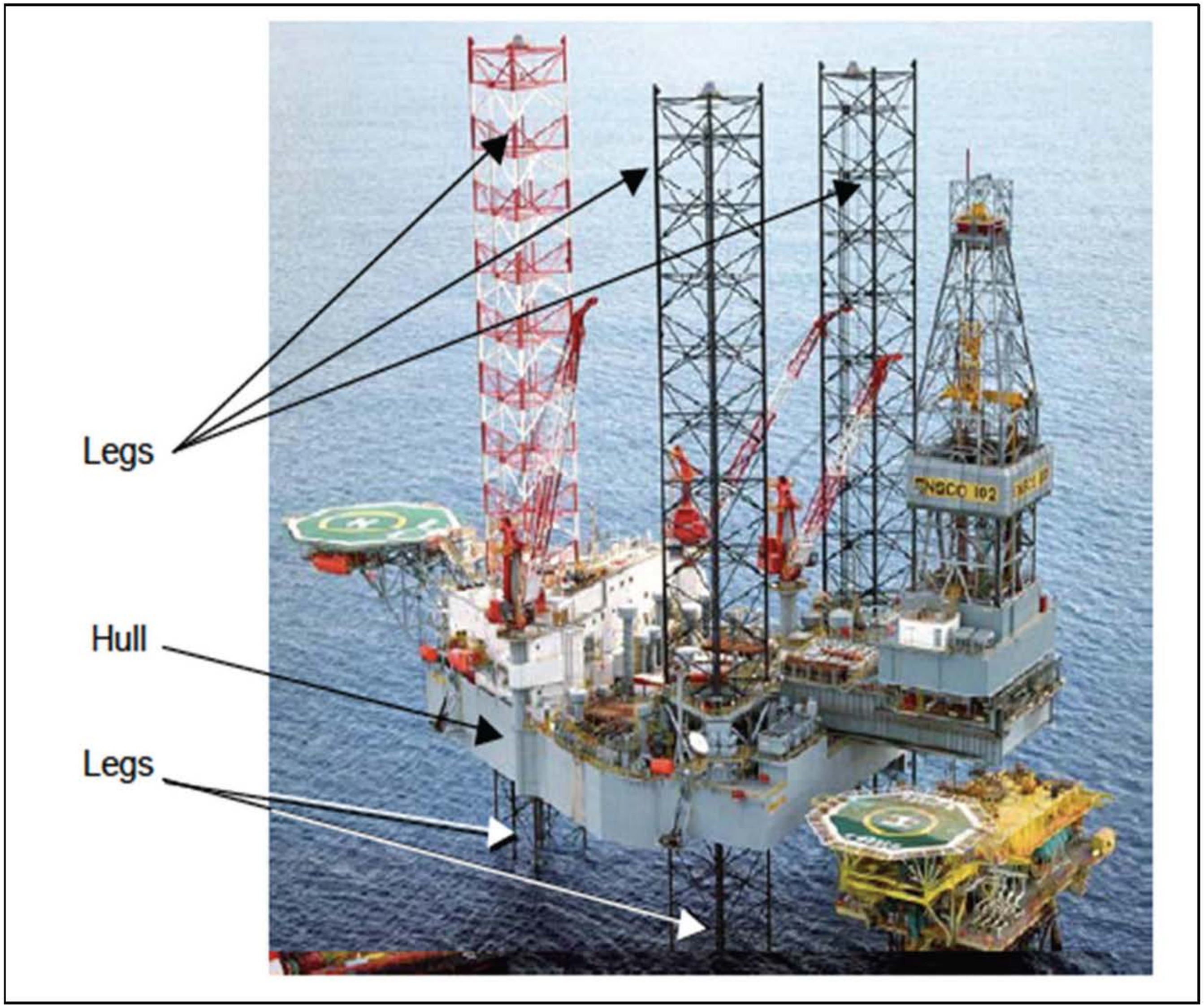


Figure 2.4 SDC operating in the Beaufort Sea.
Source: ICETECH 2010 Conference

Figure 2.5 M/V Noble Discoverer.
Source: Shell Inc. 2010a

Figure 2.6 ***Jackup Rig.***

Source: Bennet & Associates LLC and Offshore Technology Development Inc. 2011



CHAPTER 3 FIGURES

Figure 3.1-1 General circulation map of the Beaufort and Chukchi seas.
Source: Weingartner and Danielson 2010

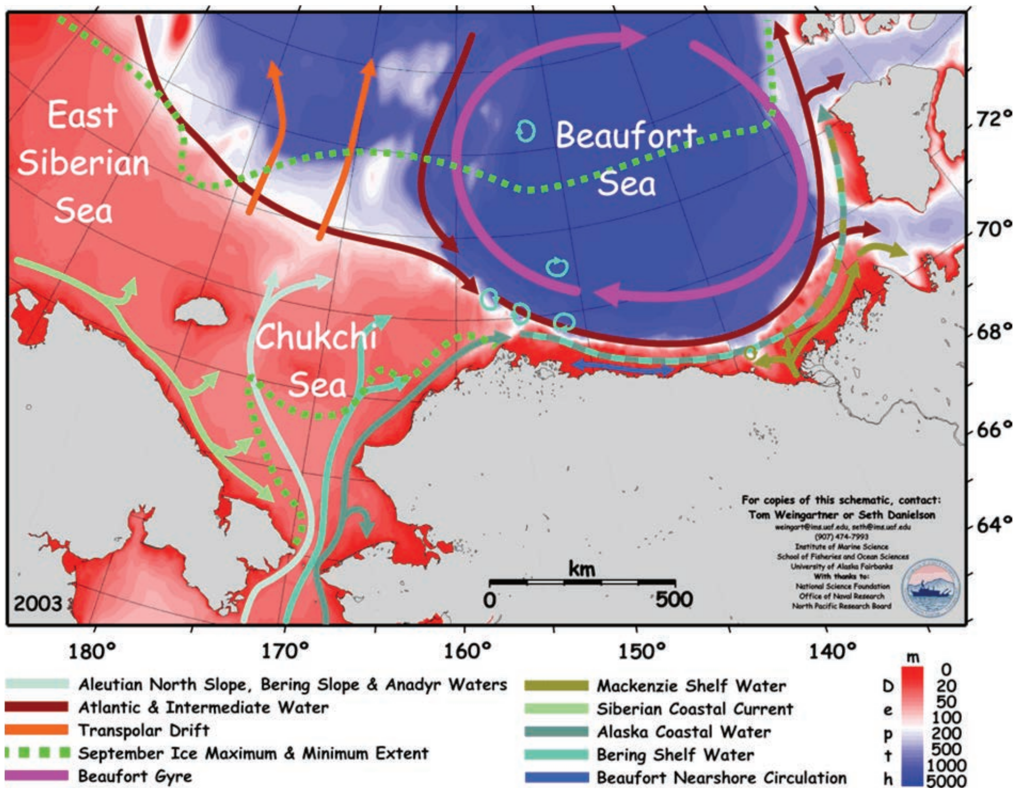


Figure 3.1-2 Bathymetry of the Beaufort Sea, with place names indicated.
Source: Weingartner 2008

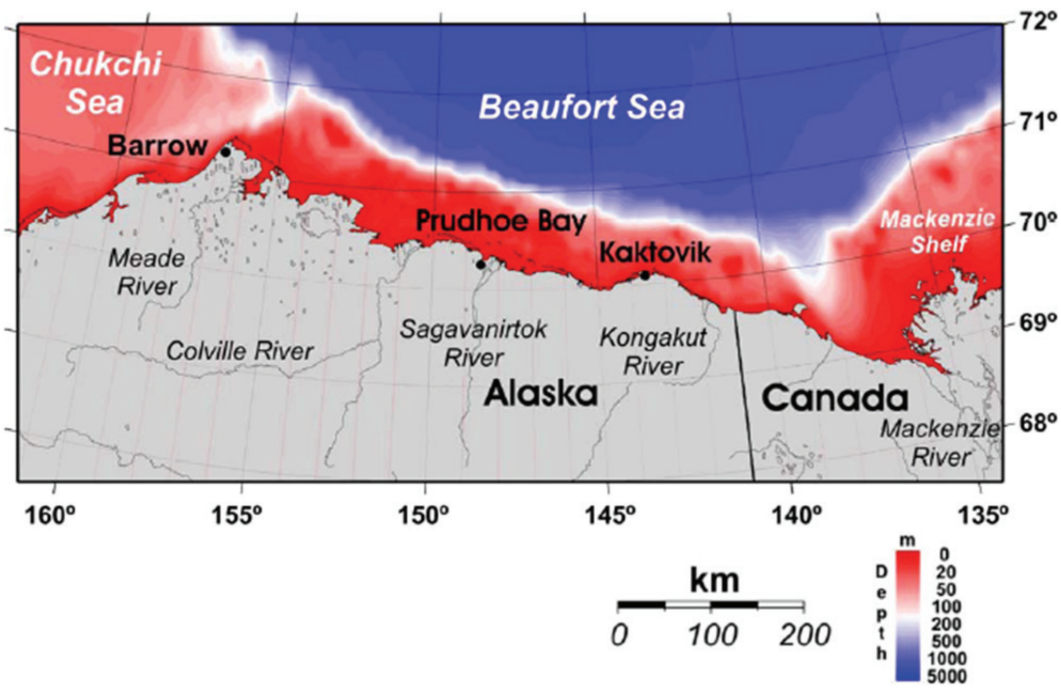


Figure 3.1-3 Schematic circulation map of the Beaufort and Chukchi shelves showing the flow of Bering Strait water through the Chukchi Sea along three principal pathways that are associated with distinct bathymetric features: the Herald Valley, the Central Channel, and Barrow Canyon.

Source: Weingartner and Danielson 2010

Three branches of the inflowing Pacific water are color-coded with navy blue (Anadyr Water) being the most nutrient-rich water and light blue (Alaska Coastal Water) being the least nutrient-rich. The Siberian Coastal Current (green) is present in summer and fall, but absent or weak in winter and spring. On the continental slope, the Pacific-origin water encounters Atlantic-origin Water (red) which is flowing counter-clockwise around the Arctic basin. Offshore of the slope, in the interior of the Canada Basin, is the clockwise wind-driven flow of the Beaufort Gyre (purple)

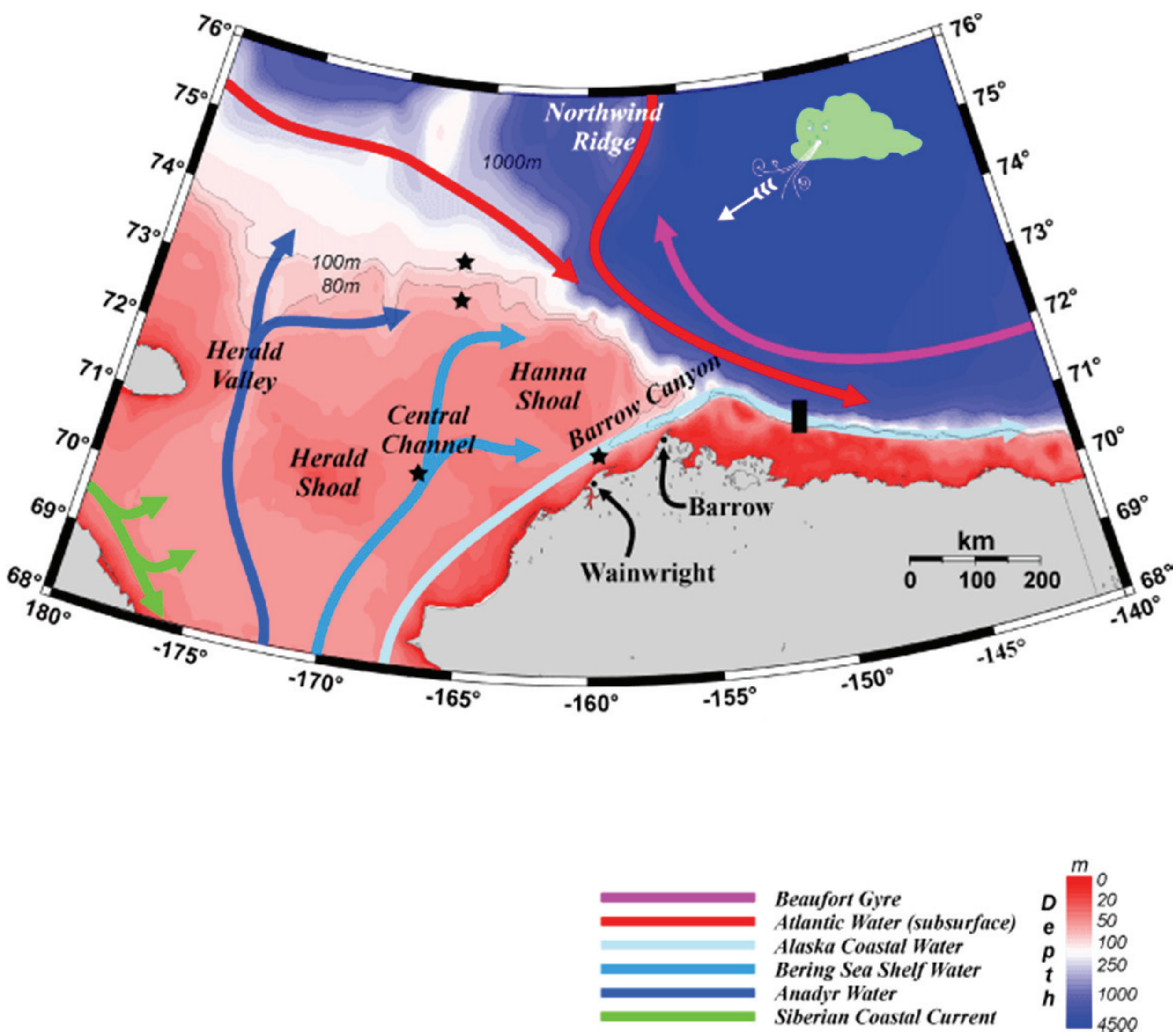
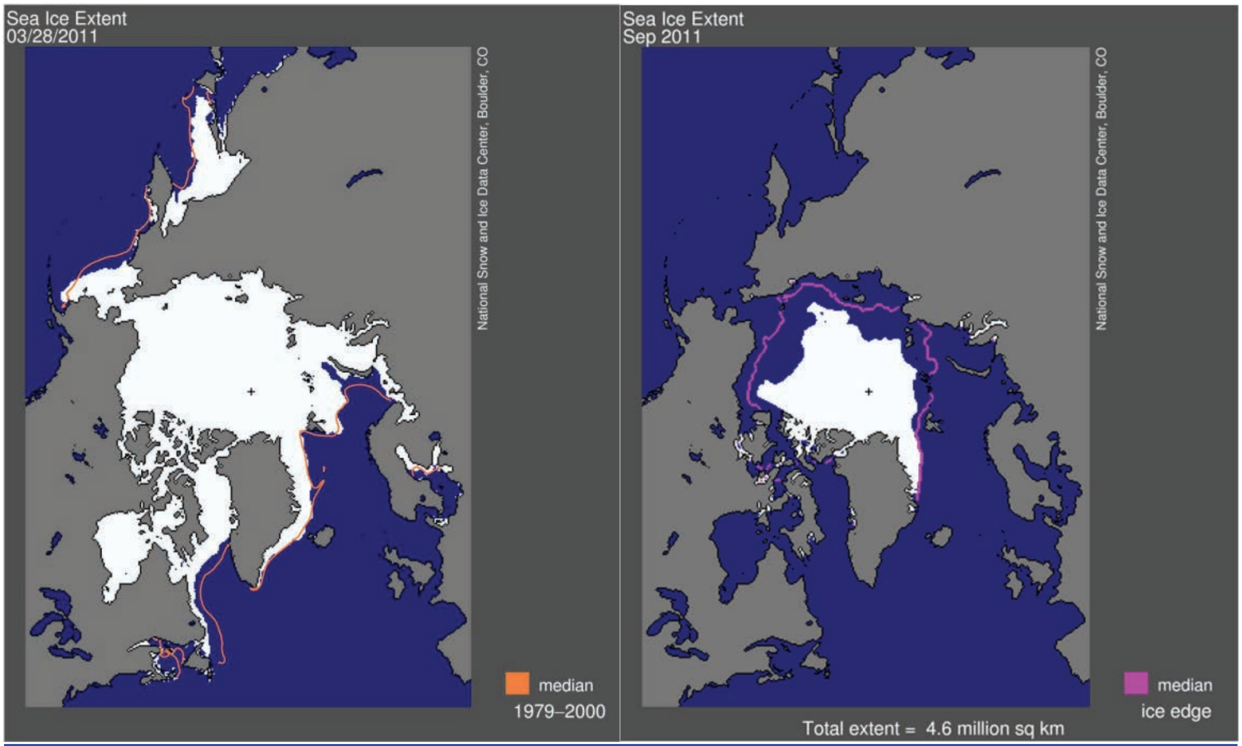


Figure 3.1-4 a) Sea Ice Extent March 2011 and September 2011. b) Average Monthly Arctic Sea Ice Extent March 1979 – 2011 and September 1979 – 2011.

Sources: NSIDC, 2011a,b

a) Map shows the maximum sea ice extent (in white) for March 2011, and also the median sea ice extent (red line) for the period 1979–2000. Graph shows the average monthly sea ice extent over the period 1979–2011.



b) Map shows the minimum sea ice extent (in white) for September 2011, and the median sea ice extent (red line) for the period 1979–2000. Graph shows the average monthly sea ice extent over the period 1979–2011.

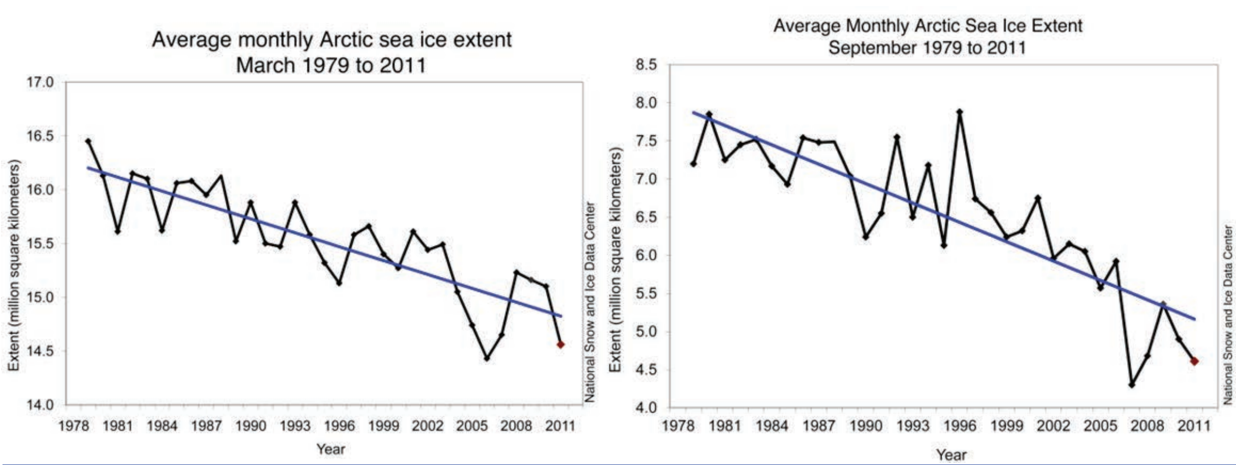


Figure 3.1-5 Sound Level Metrics.

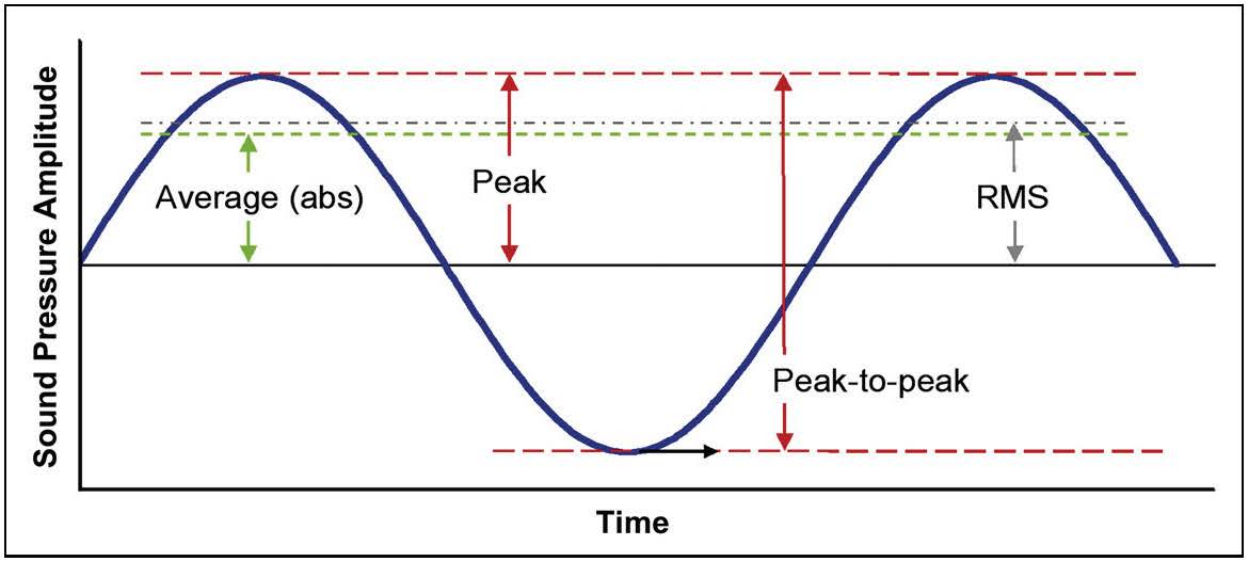


Figure 3.1-6a An audiogram of human hearing.
Source: Discovery of Sound in the Sea 2011

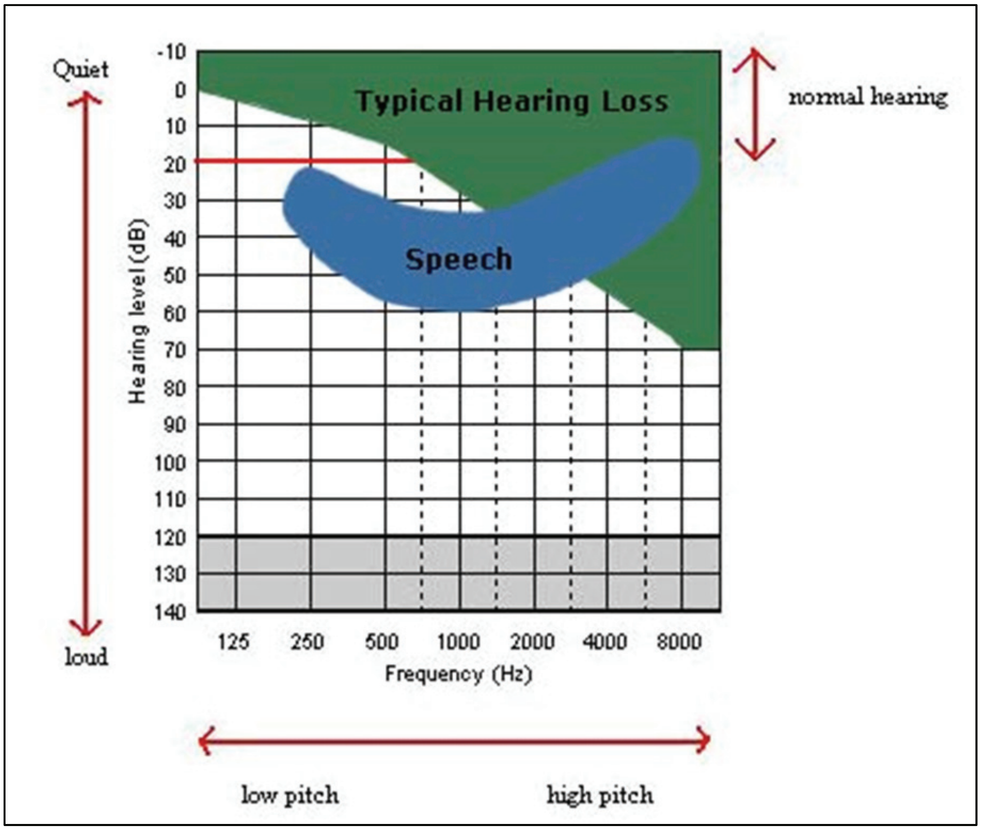


Figure 3.1-6b Graphic showing A-weighting function for human hearing.
Source: Harris 1998

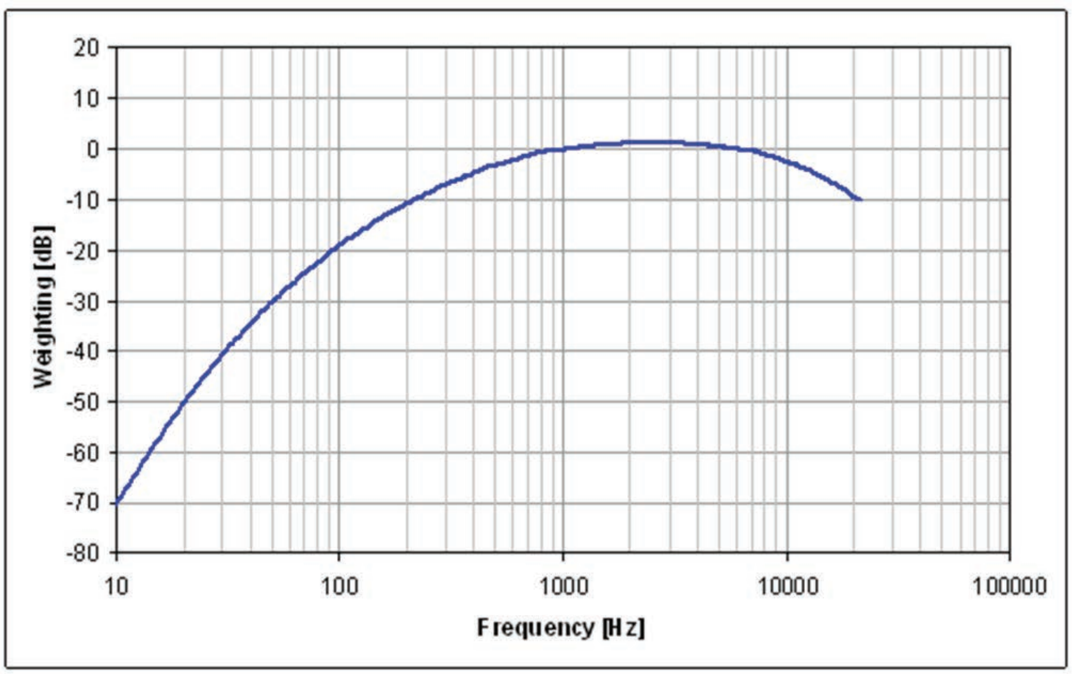


Figure 3.1-7 Hearing curves for some marine mammals in water and a typical human in air.

Source: Discovery of Sound in the Sea 2011

There are two sets of y-axes (vertical) because different reference pressures are used to measure sound in water (re 1 µPa; left axis) vs in air (re 20 µPa; right axis). Notice that the decibel values differ by 61.5 dB for the same value of intensity (watts/ m 2). The x-axis (horizontal) is the frequency of a sound on a logarithmic scale.

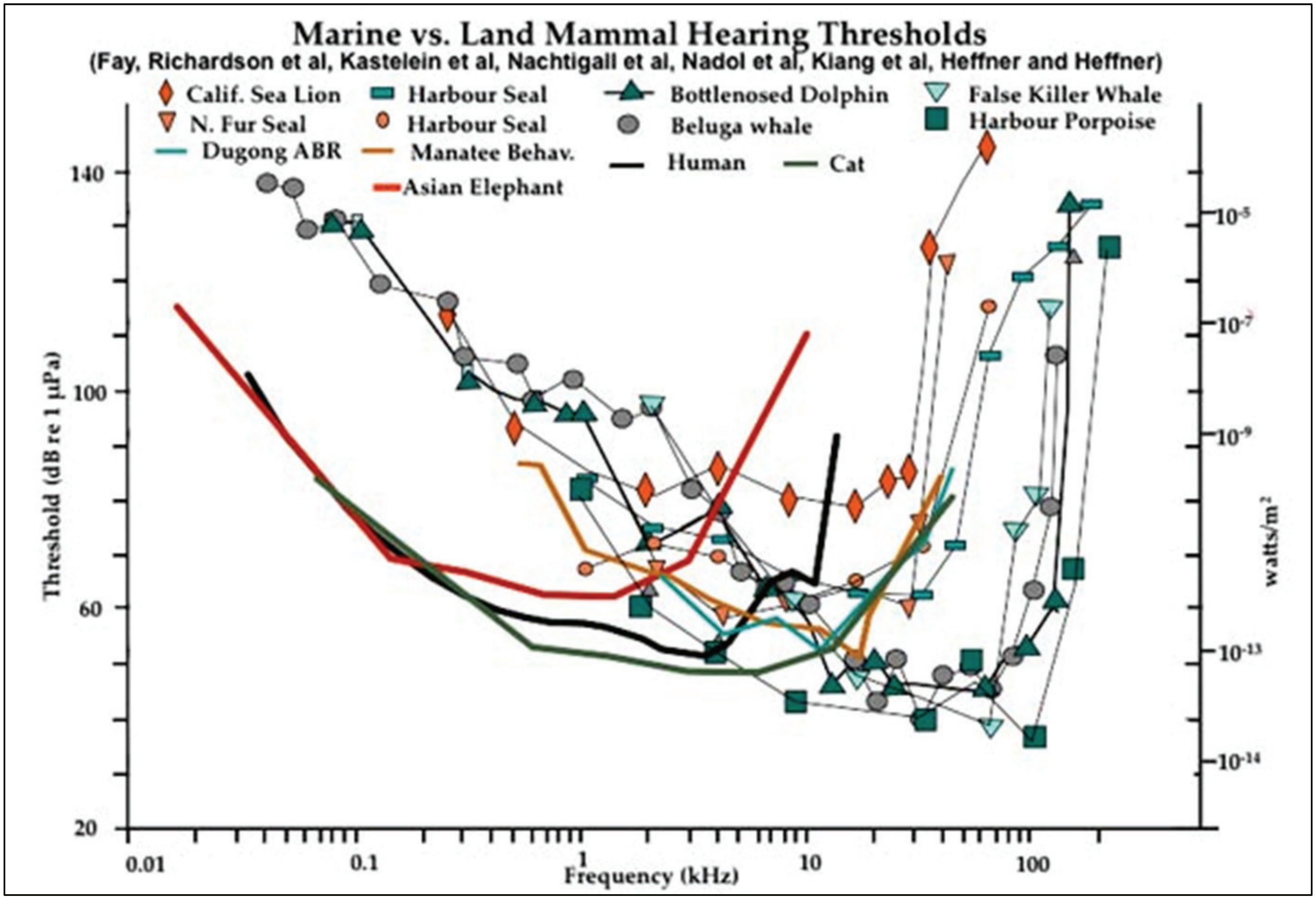


Figure 3.1-8 Graphic showing M-weighting functions for marine mammal hearing for (A) low, mid, and high frequency cetaceans, and (B) for pinnipeds in water and air.

Source: Southall et al. (2007)

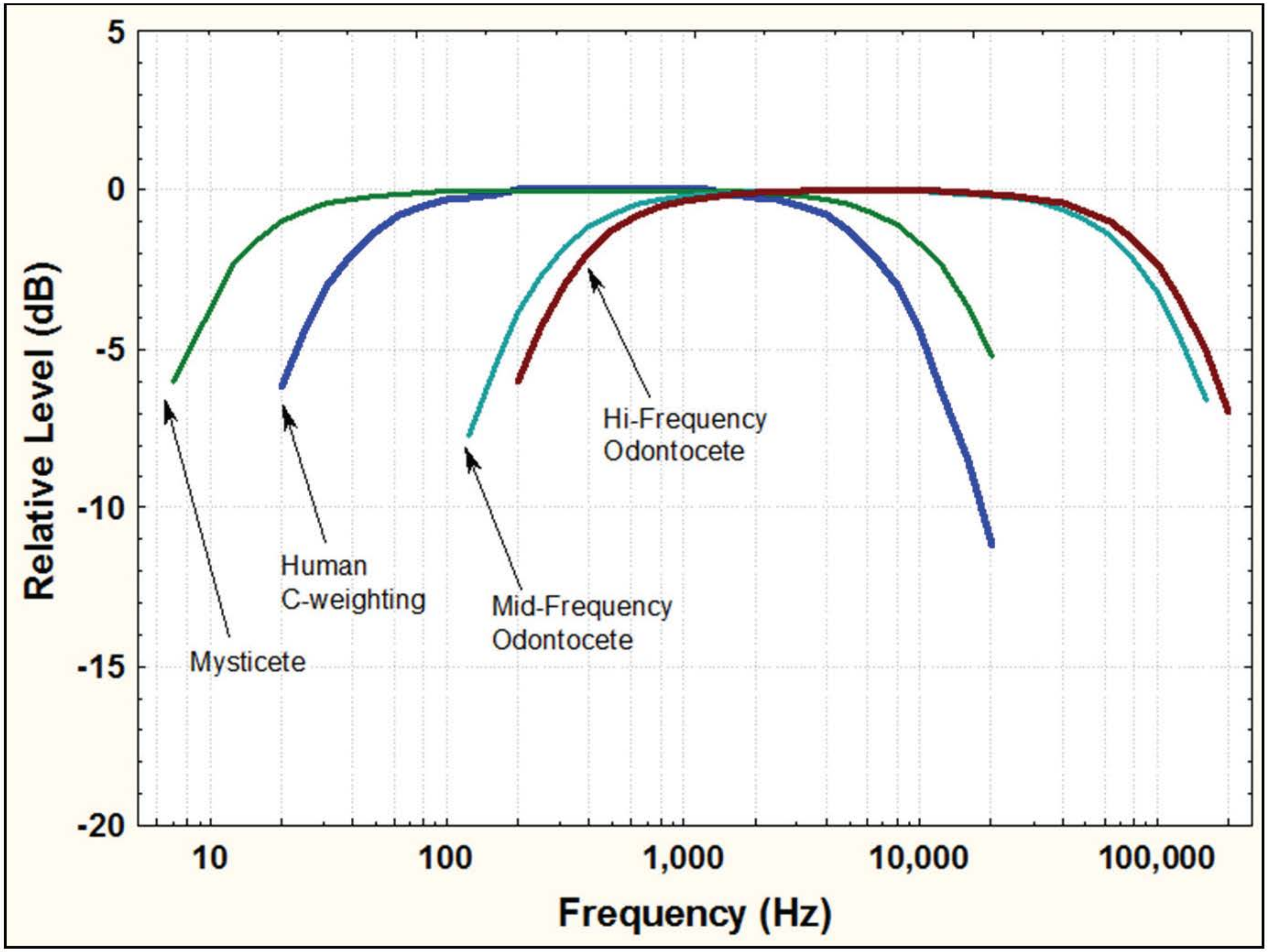


Figure 3.1-9 Prevailing underwater sound levels.

Source: NRC 2003a

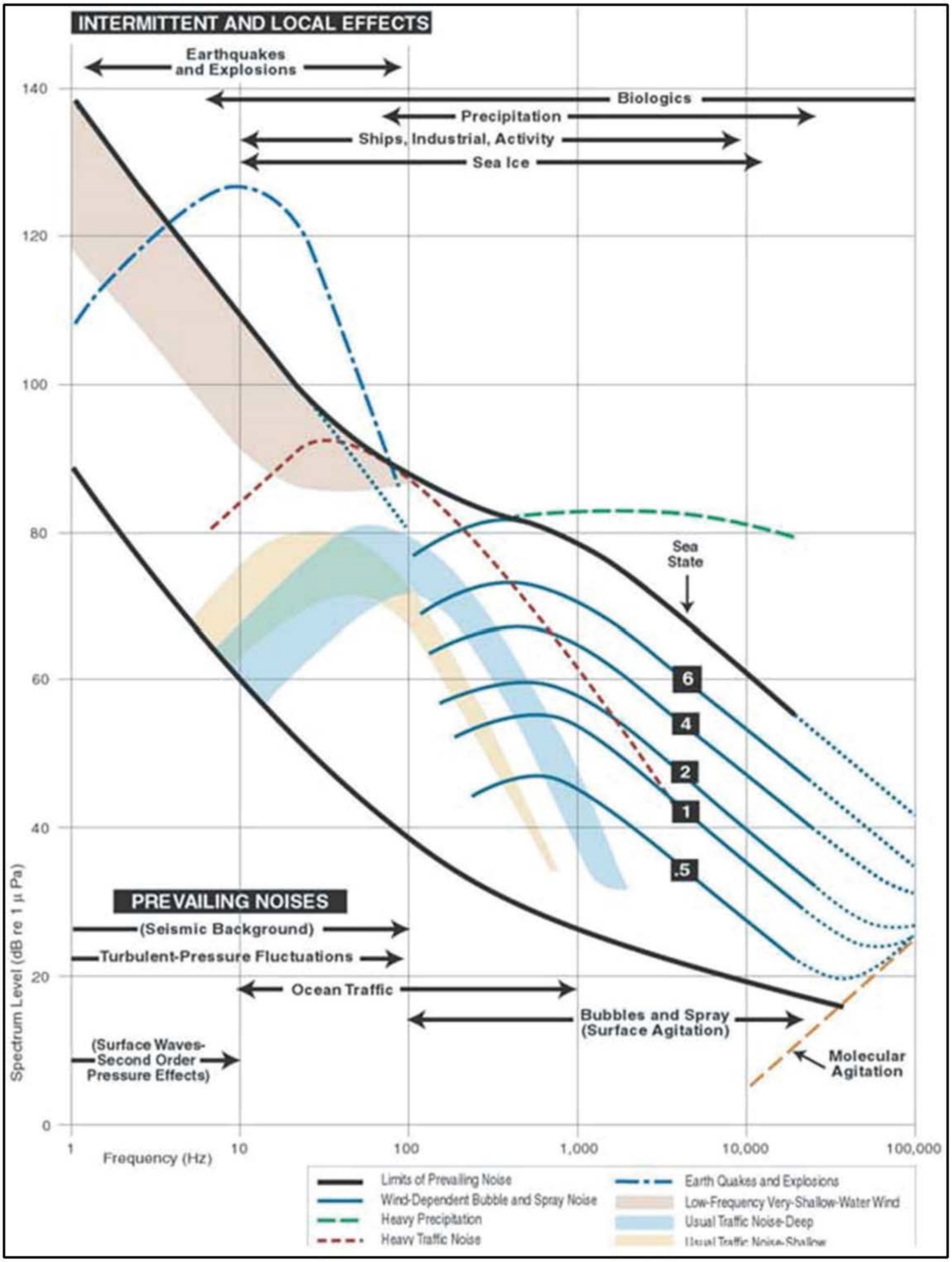
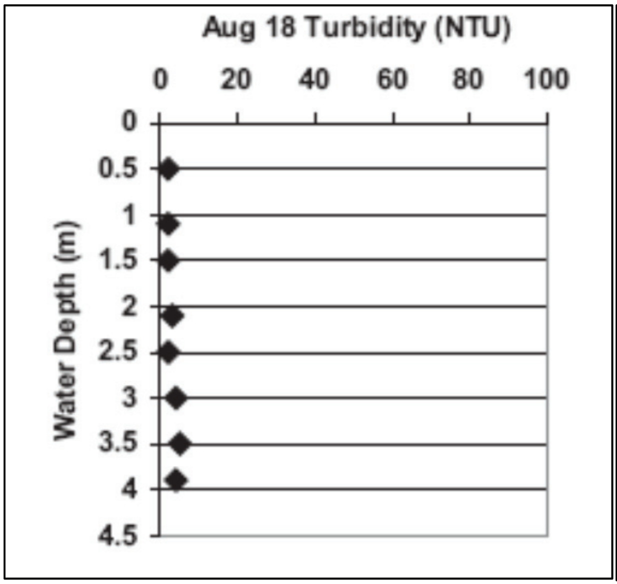


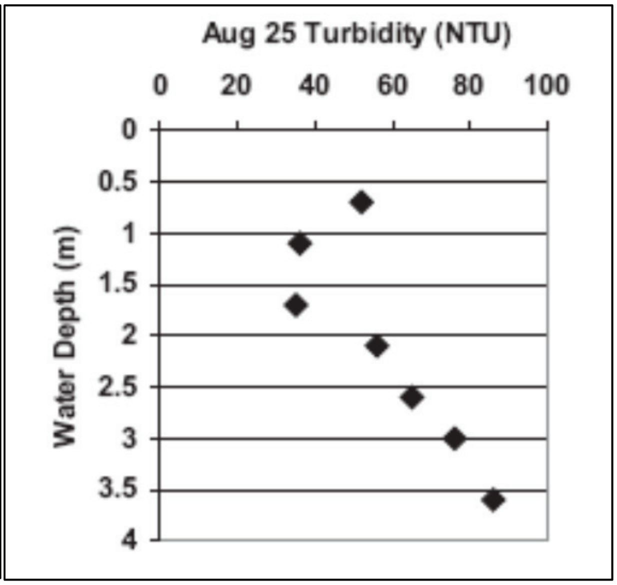
Figure 3.1-10 Depth profiles of natural turbidity levels measured in the nearshore Alaskan Beaufort Sea in 1999.

Source: Boehm 2001

Profile (a) shows turbidity levels before a storm event; profile (b) shows turbidity levels immediately following a storm event



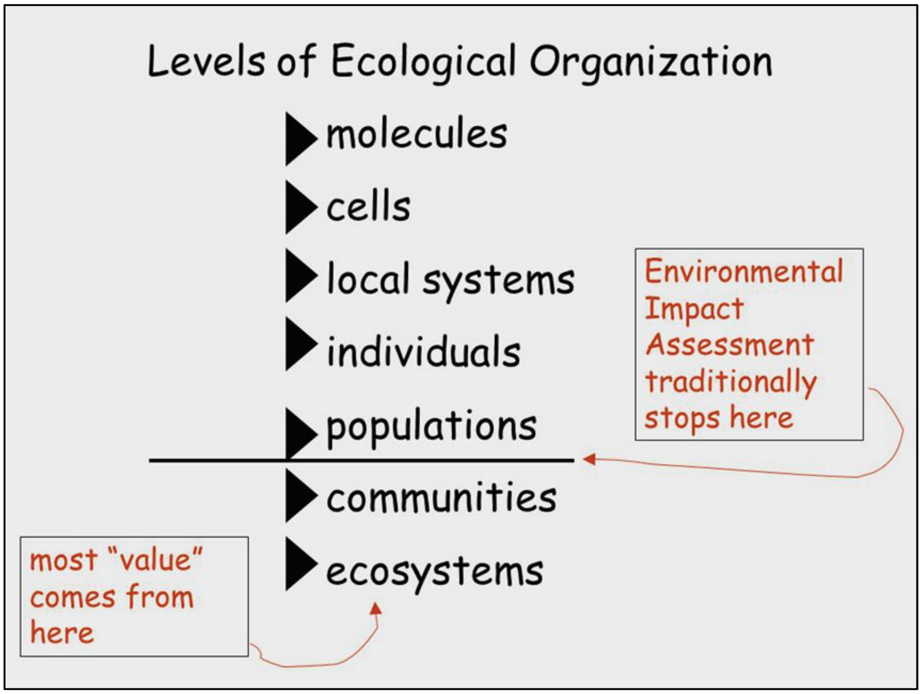
(a)

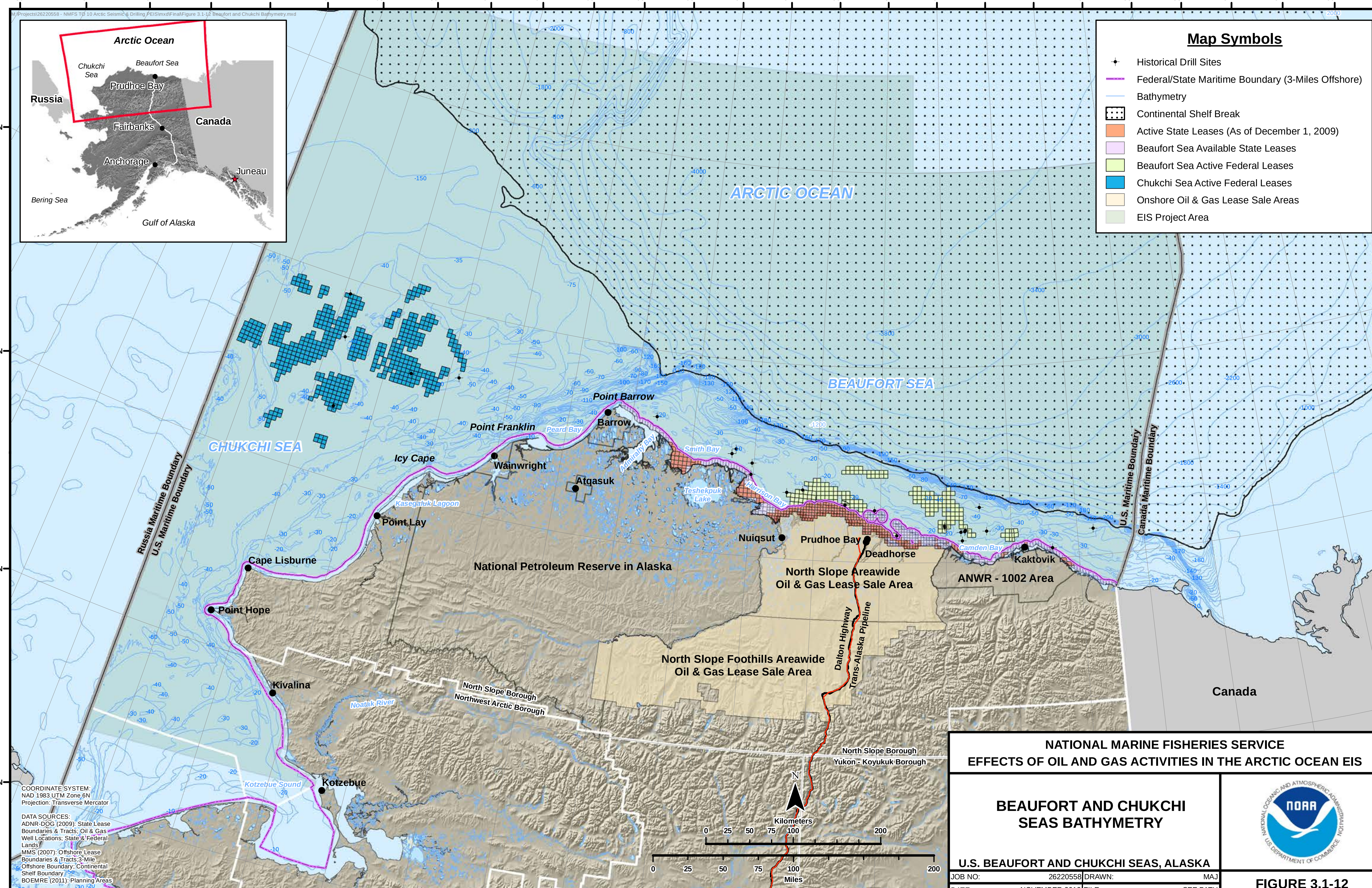


(b)

Figure 3.1-11 Levels of Ecological Organization.

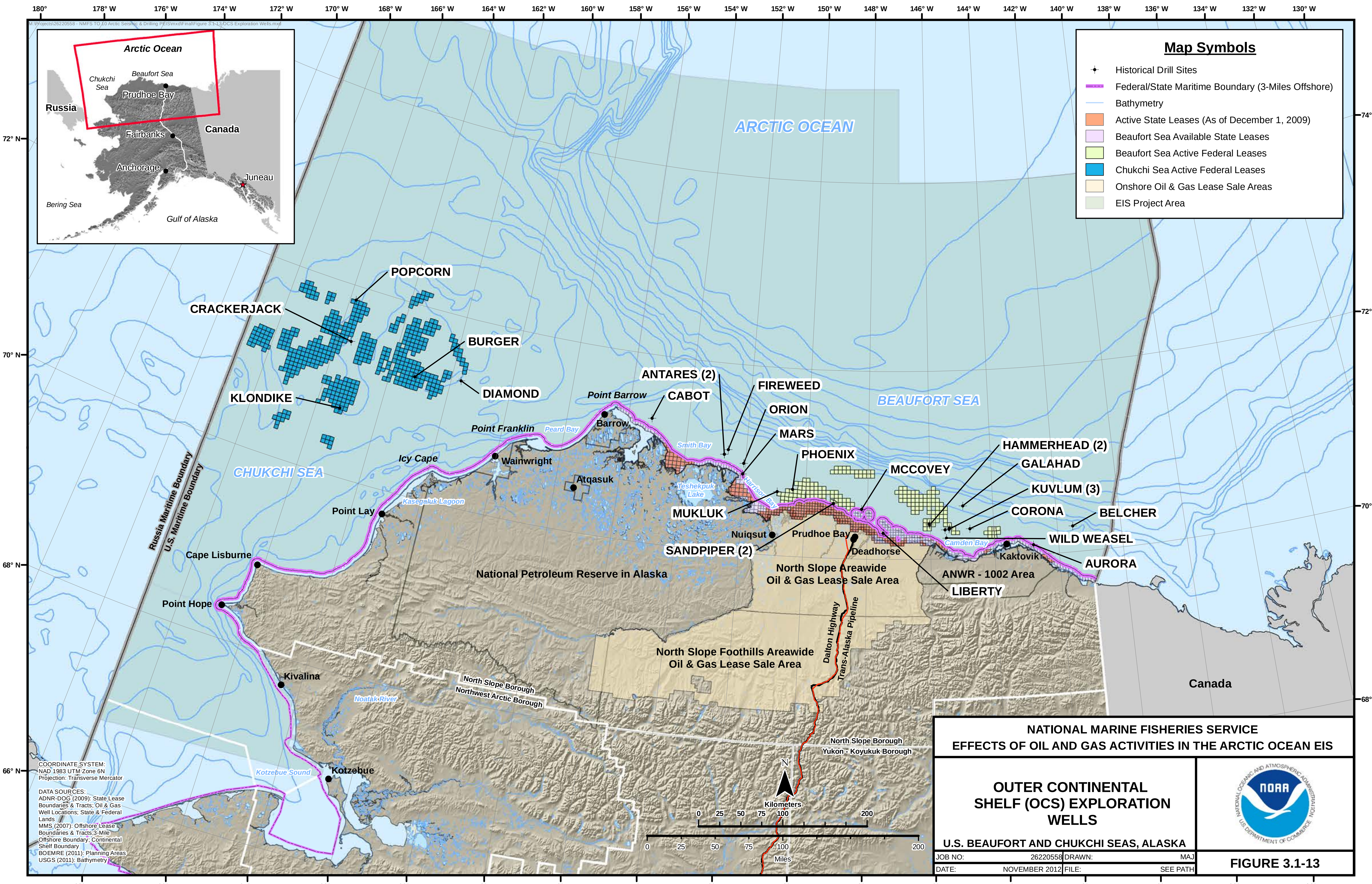
The dose-response model traditionally used in environmental impact assessment only considers the effects of stressors on individuals or populations. However, the value of ecosystem goods and services is usually derived from interactions among physical, chemical, and biological ecosystem components.





BEAUFORT AND CHUKCHI SEAS BATHYMETRY

FIGURE 3.1-12



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OUTER CONTINENTAL SHELF (OCS) EXPLORATION WELLS

U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA

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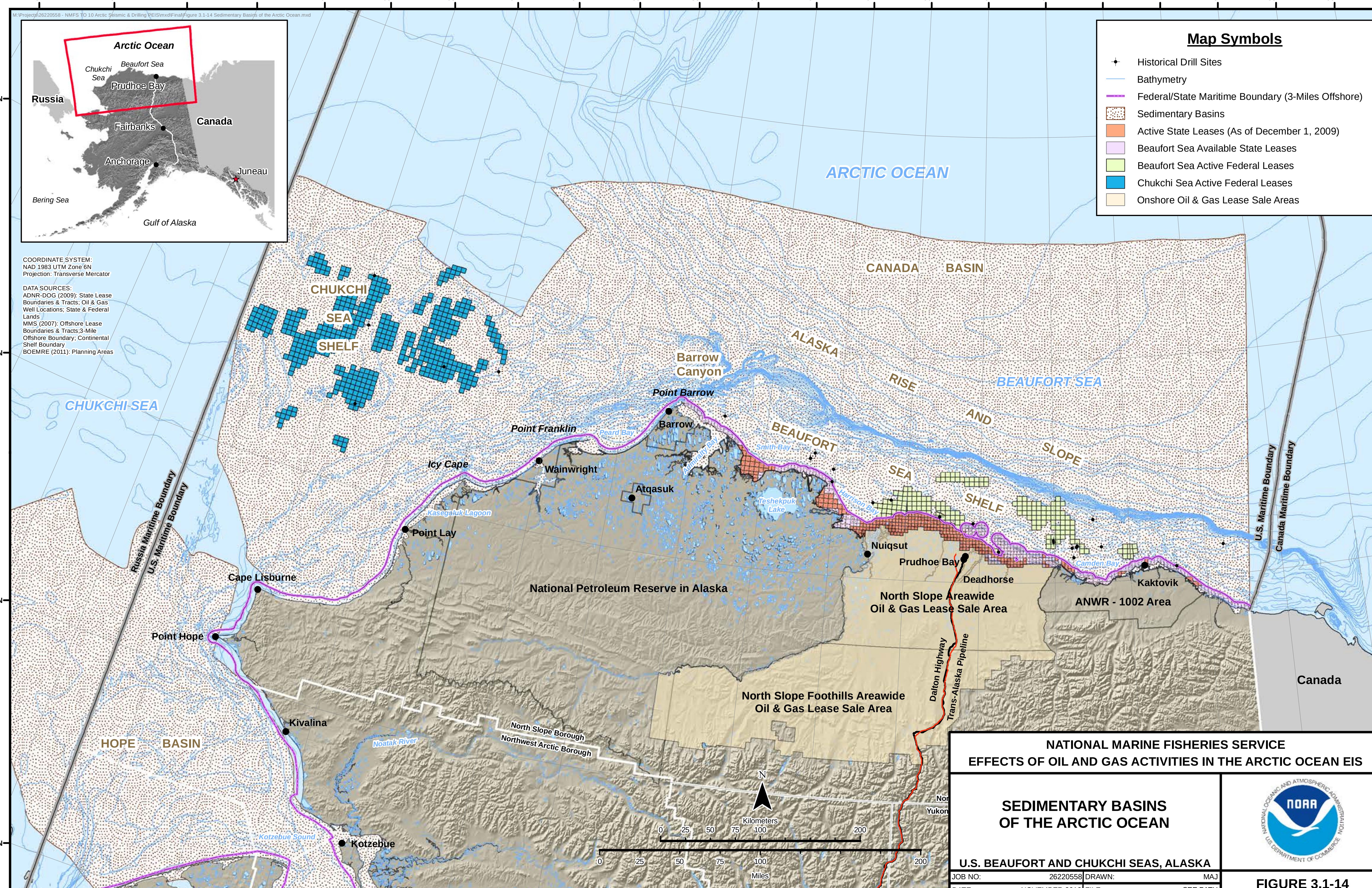
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.1-13



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EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

SEDIMENTARY BASINS OF THE ARCTIC OCEAN

U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA

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FIGURE 3.1-14

Figure 3.2-1 Simplified Food Web of the Arctic Ocean Ecosystem.

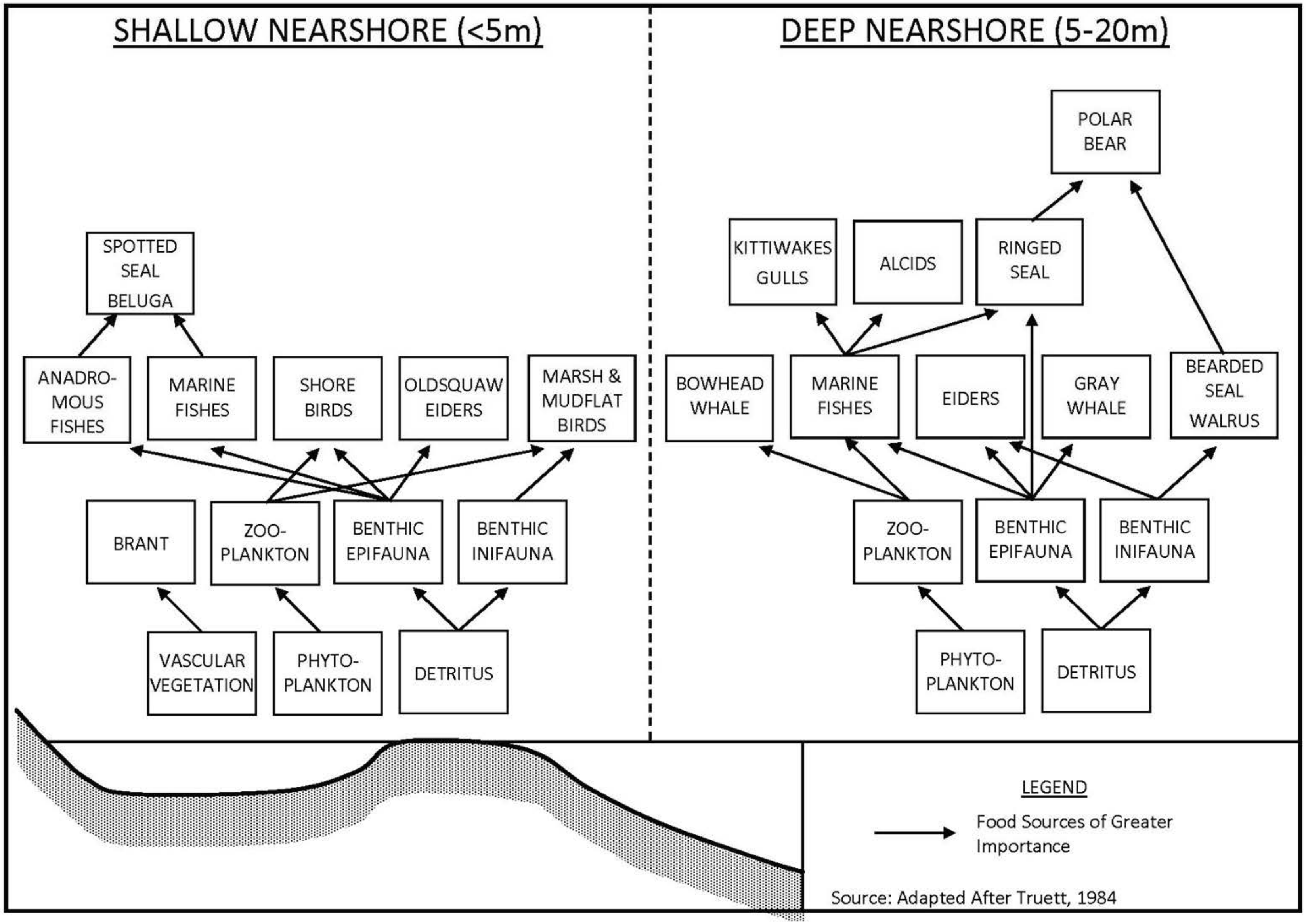


Figure 3.2-2 Seasonal ranges of the Western Arctic caribou herd with locations of satellite-collared caribou collected during the 2006-2007 regulatory year.

Source: ADF&G 2003

Data excludes first year caribou was collared; all collars standardized to one location every six days.

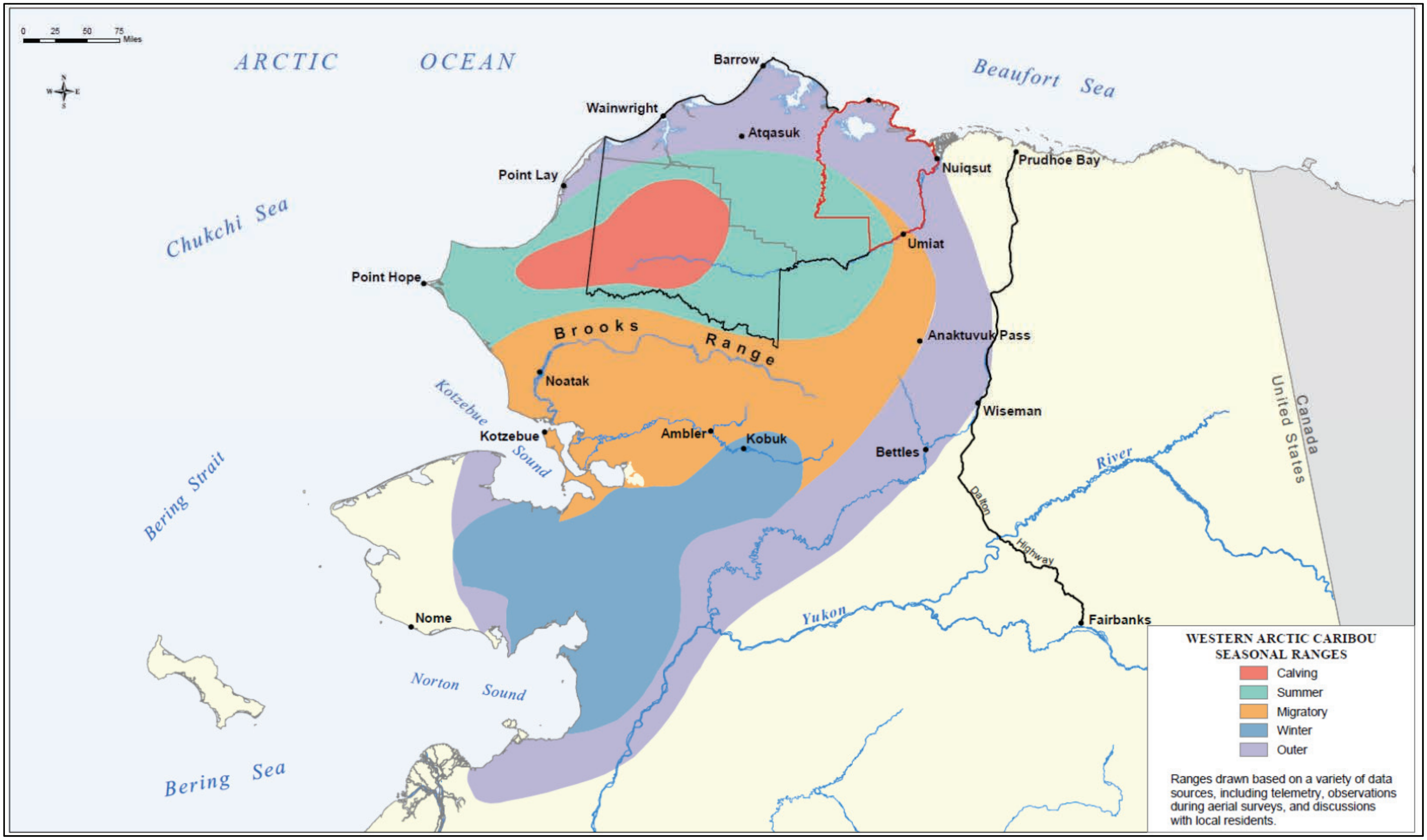


Figure 3.2-3 Central Arctic Caribou Herd Seasonal Ranges in Northern Alaska.

Source: BLM 2005

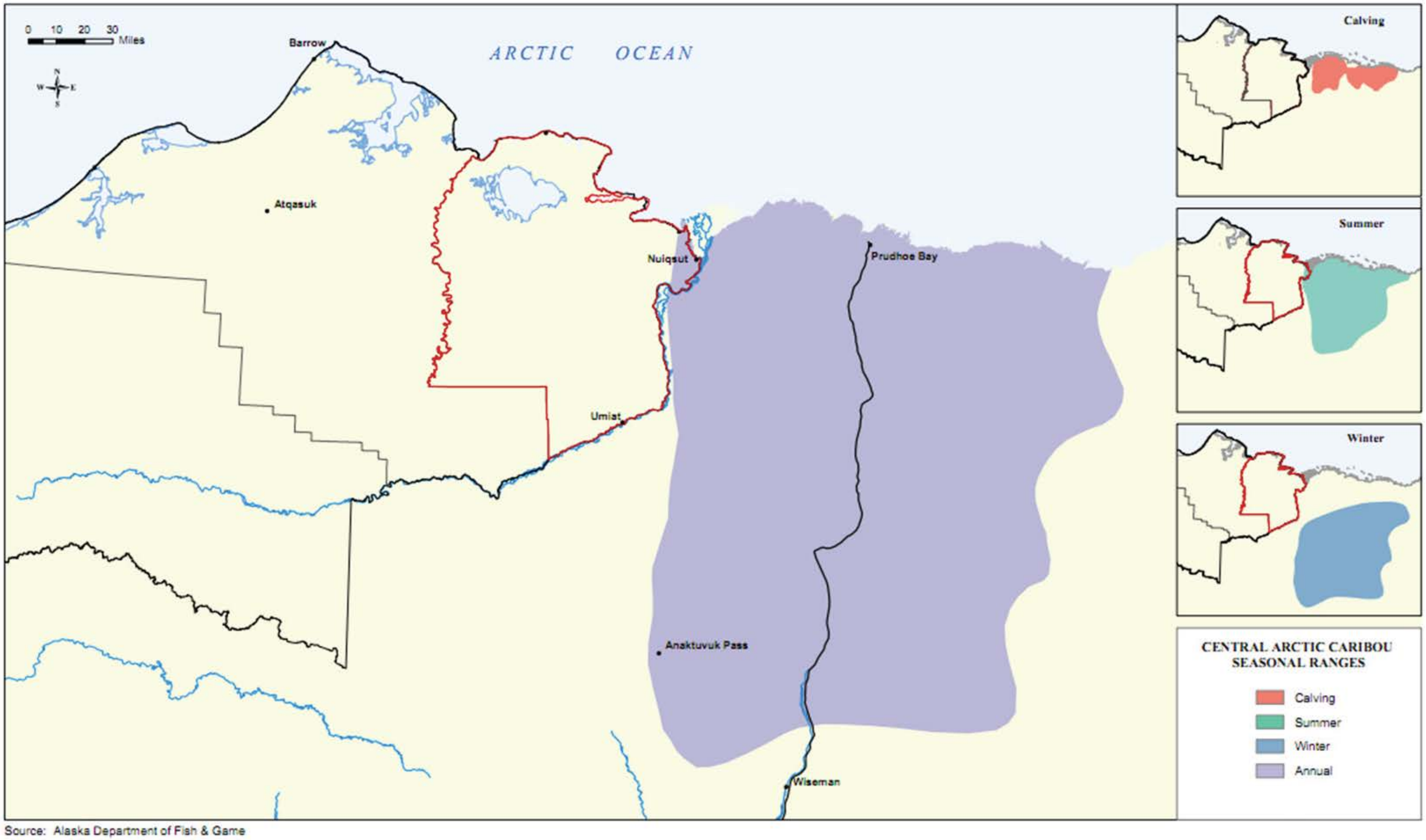


Figure 3.2-4 Caribou calving areas within the Arctic National Wildlife Refuge.
Source: USFWS 2008 The Teshekpuk Caribou Herd

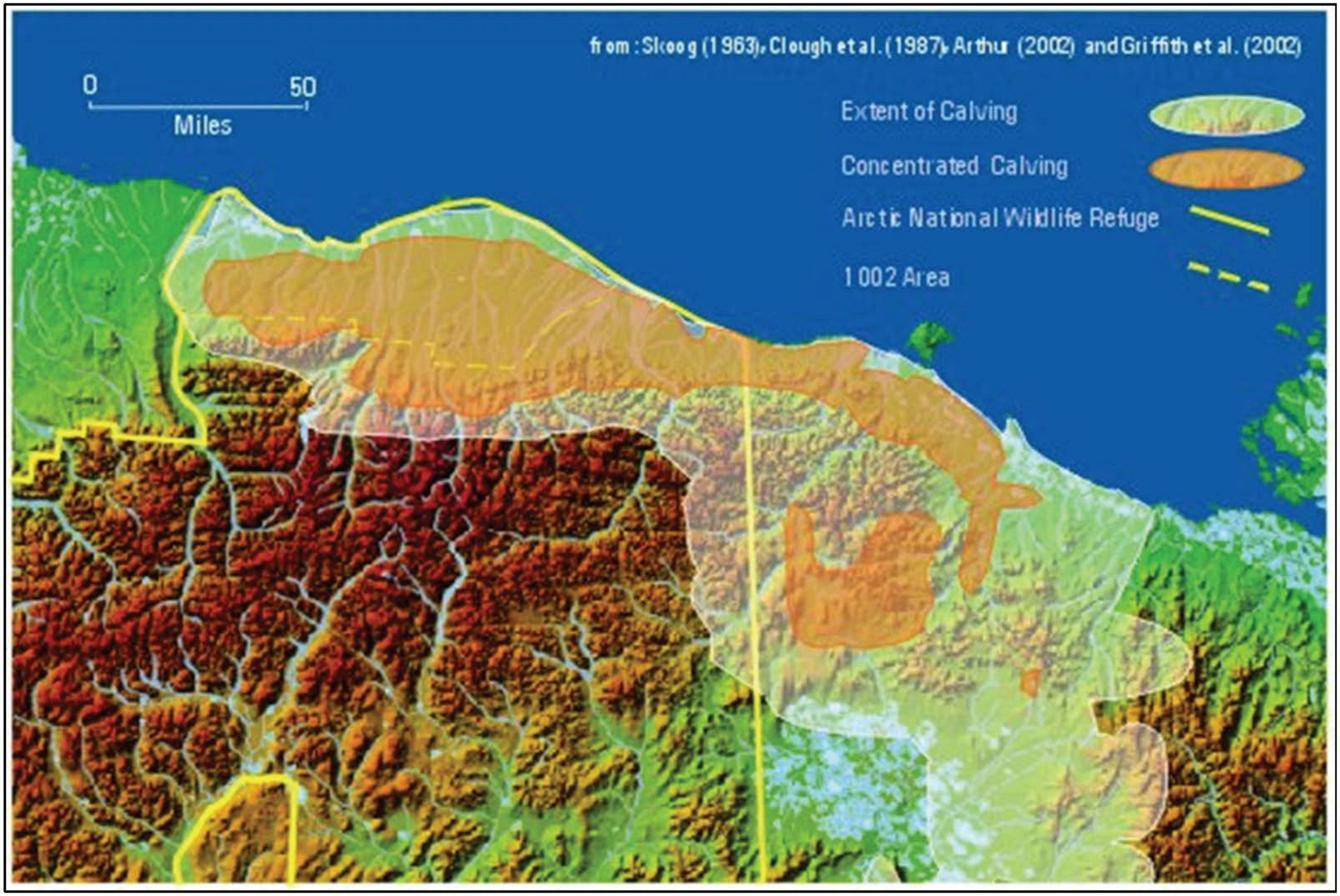
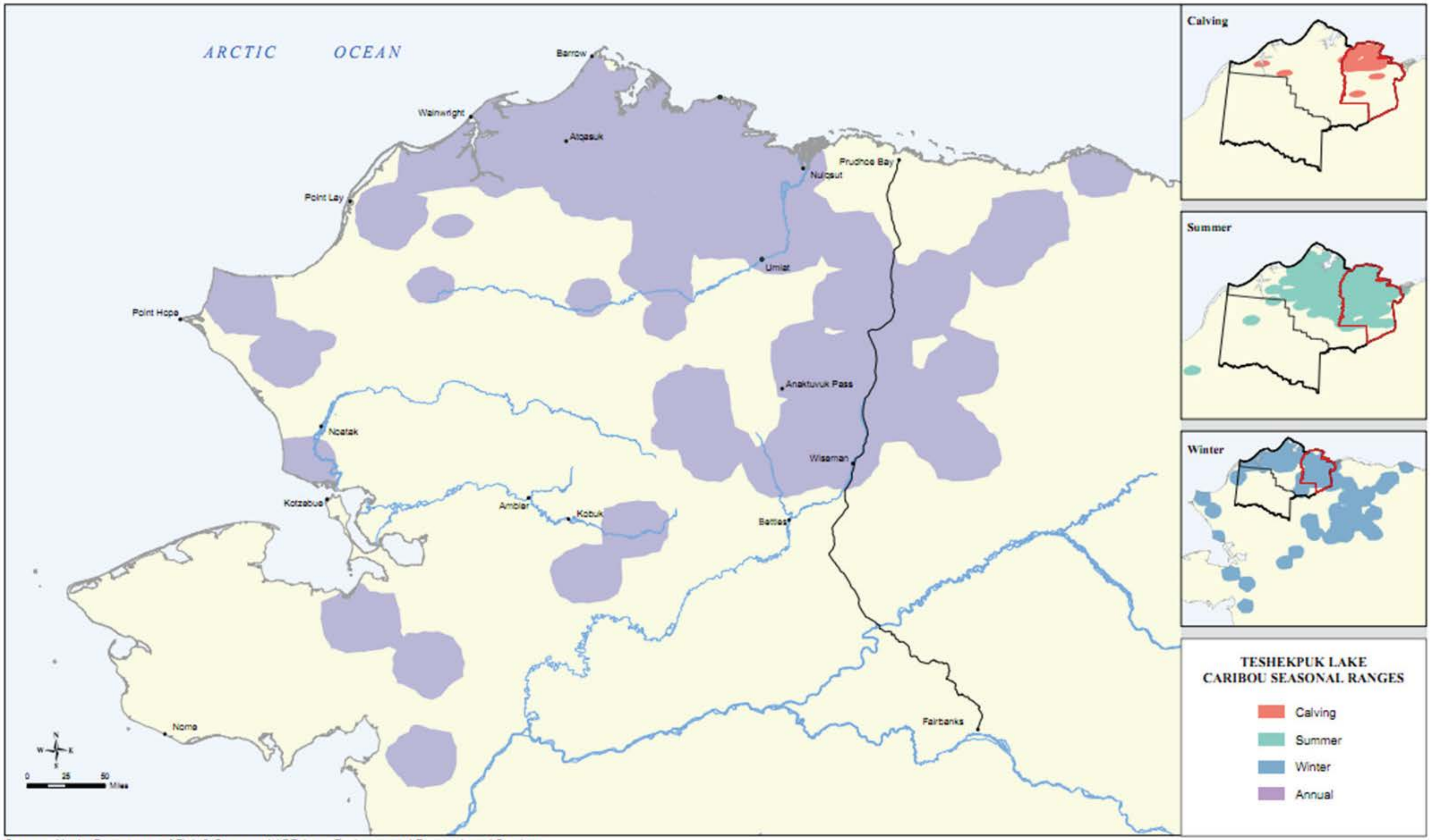


Figure 3.2-5 Teshekpuk Lake Caribou Herd Seasonal Ranges in Northern Alaska (1990 – 2005 Satellite Telemetry Data).
Source: BLM 2005

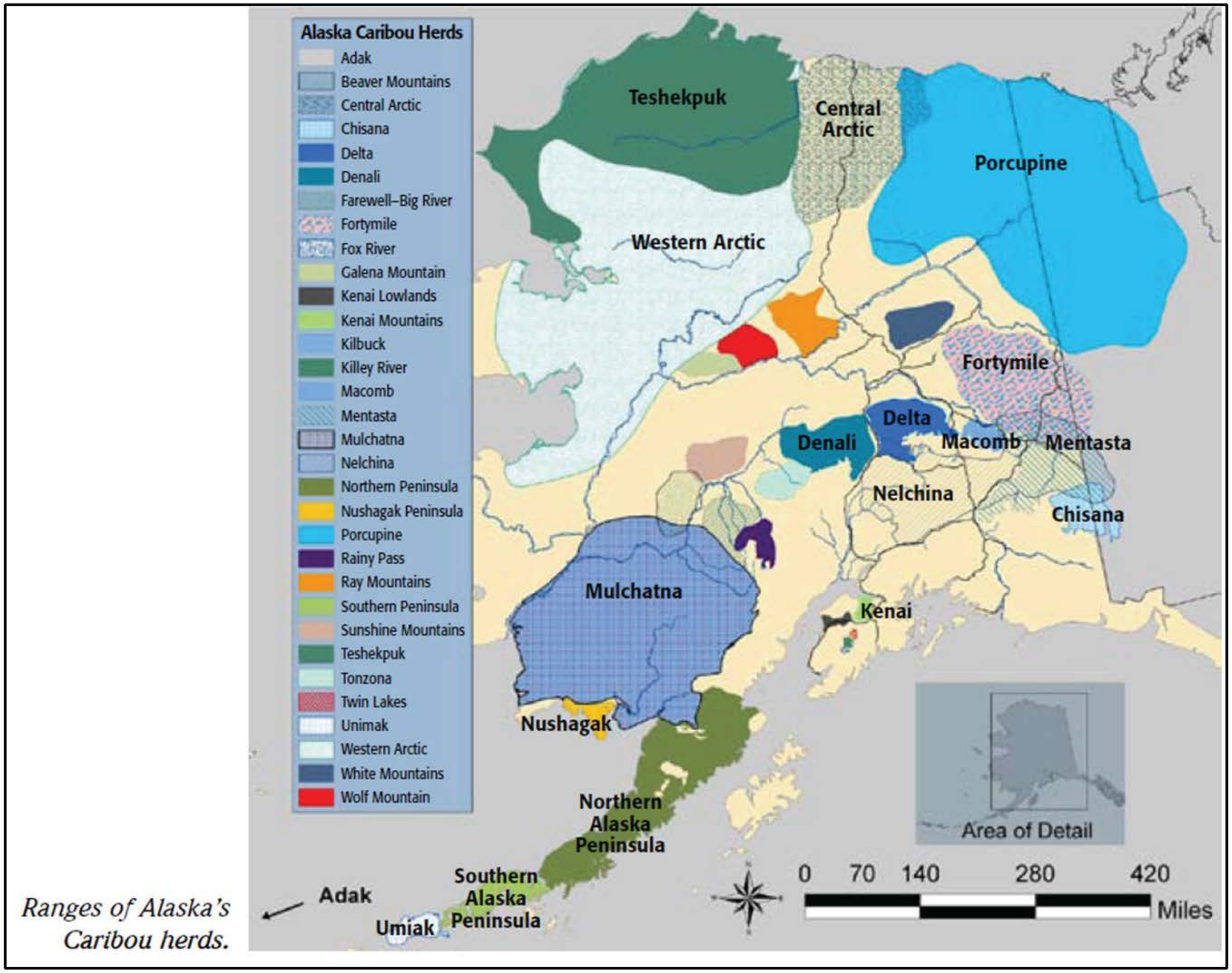


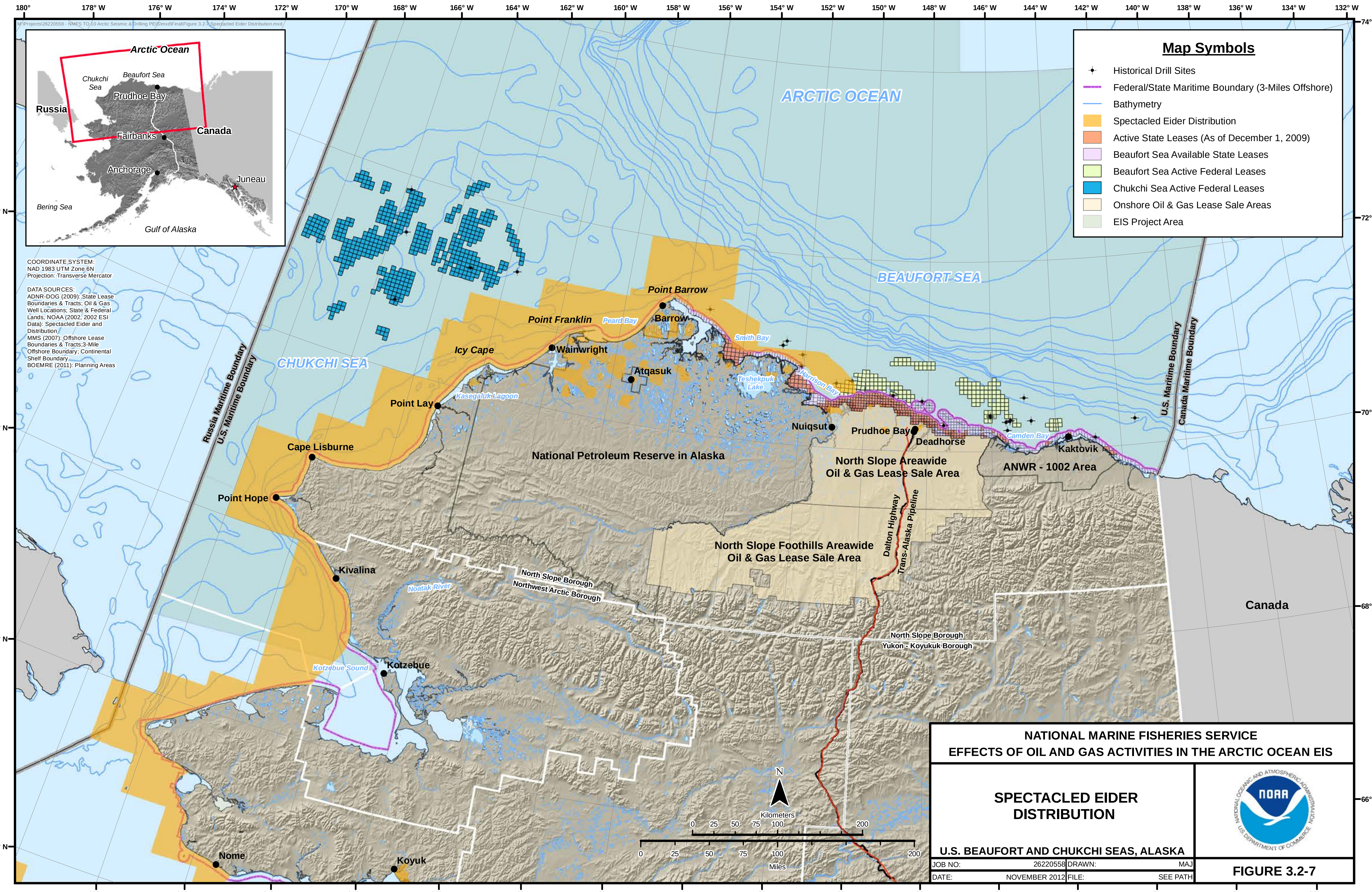
Source: Alaska Department of Fish & Game and ABR Inc. - Environmental Research and Services

Map 3-20. Teshekpuk Lake Caribou Herd Seasonal Ranges in Northern Alaska (1990 - 2005 Satellite Telemetry Data)

Figure 3.2-6 Ranges of Alaska's Caribou herds.

Source: ADFG 2010a





Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Spectacled Eider Distribution
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Chukchi Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
EIS Project Area
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands, NOAA (2002, 2002 ESI Data): Spectacled Eider and Distribution
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
Arctic Ocean
Chukchi Sea
Beaufort Sea
Russia
Prudhoe Bay
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Smith Bay
Icy Cape
Wainwright
Atqasuk
Teshekpuk Lake
Harrison Bay
Point Lay
Kasegaluk Lagoon
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Point Hope
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Kivalina
Noatak River
North Slope Borough
Northwest Arctic Borough
Yukon - Koyukuk Borough
Canada
Kotzebue Sound
Kotzebue
Nome
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Kilometers
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EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
SPECTACLED EIDER DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
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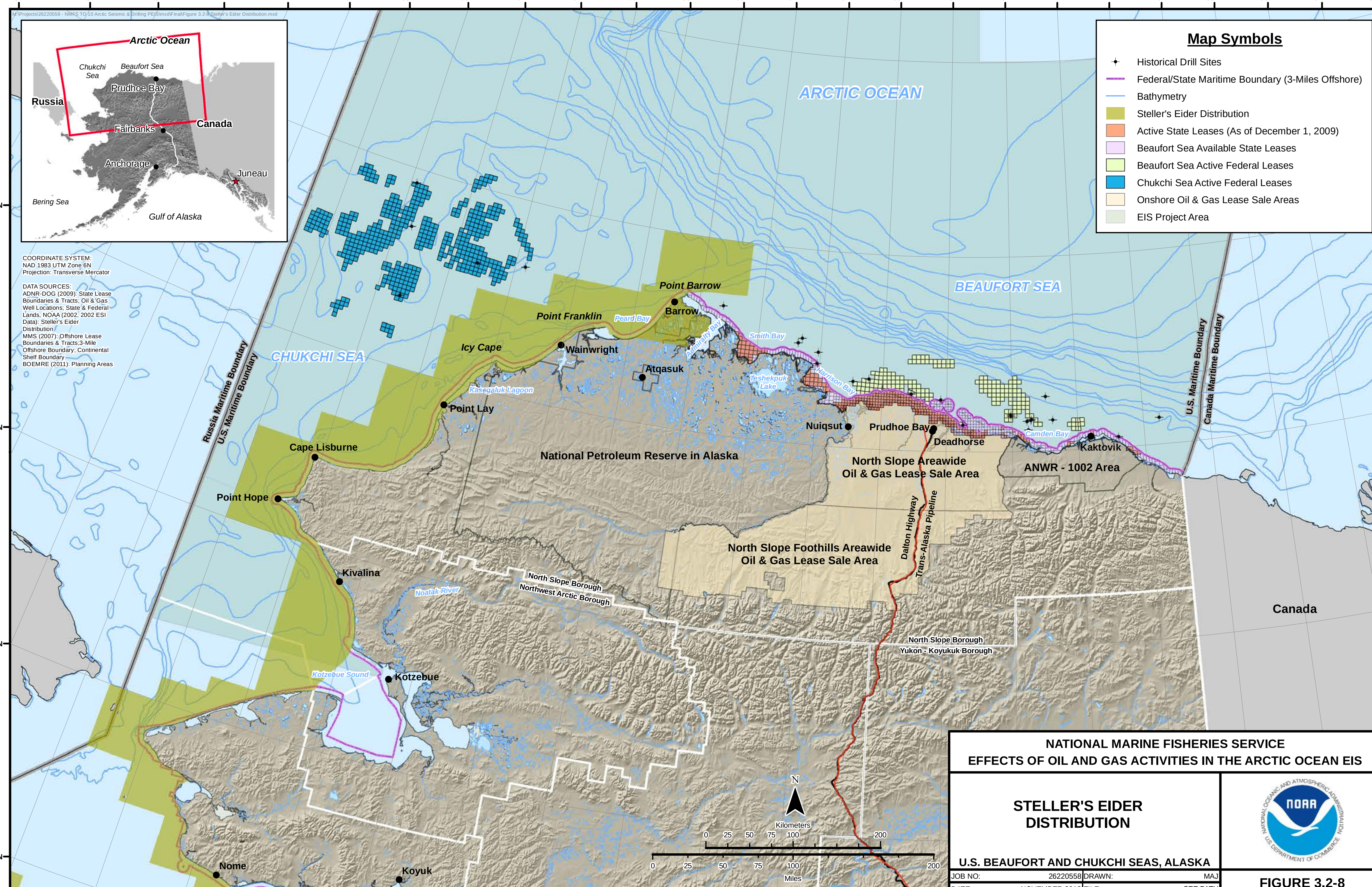
FIGURE 3.2-7



Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands, NOAA (2002, 2002 ESI Data): Steller's Eider Distribution
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
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Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Steller's Eider Distribution
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Chukchi Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
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CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
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Peard Bay
Icy Cape
Wainwright
Atqasuk
Admiralty Bay
Smith Bay
Harrison Bay
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Kasegaluk Lagoon
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ANWR - 1002 Area
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Canada
Kotzebue Sound
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NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
STELLER'S EIDER DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
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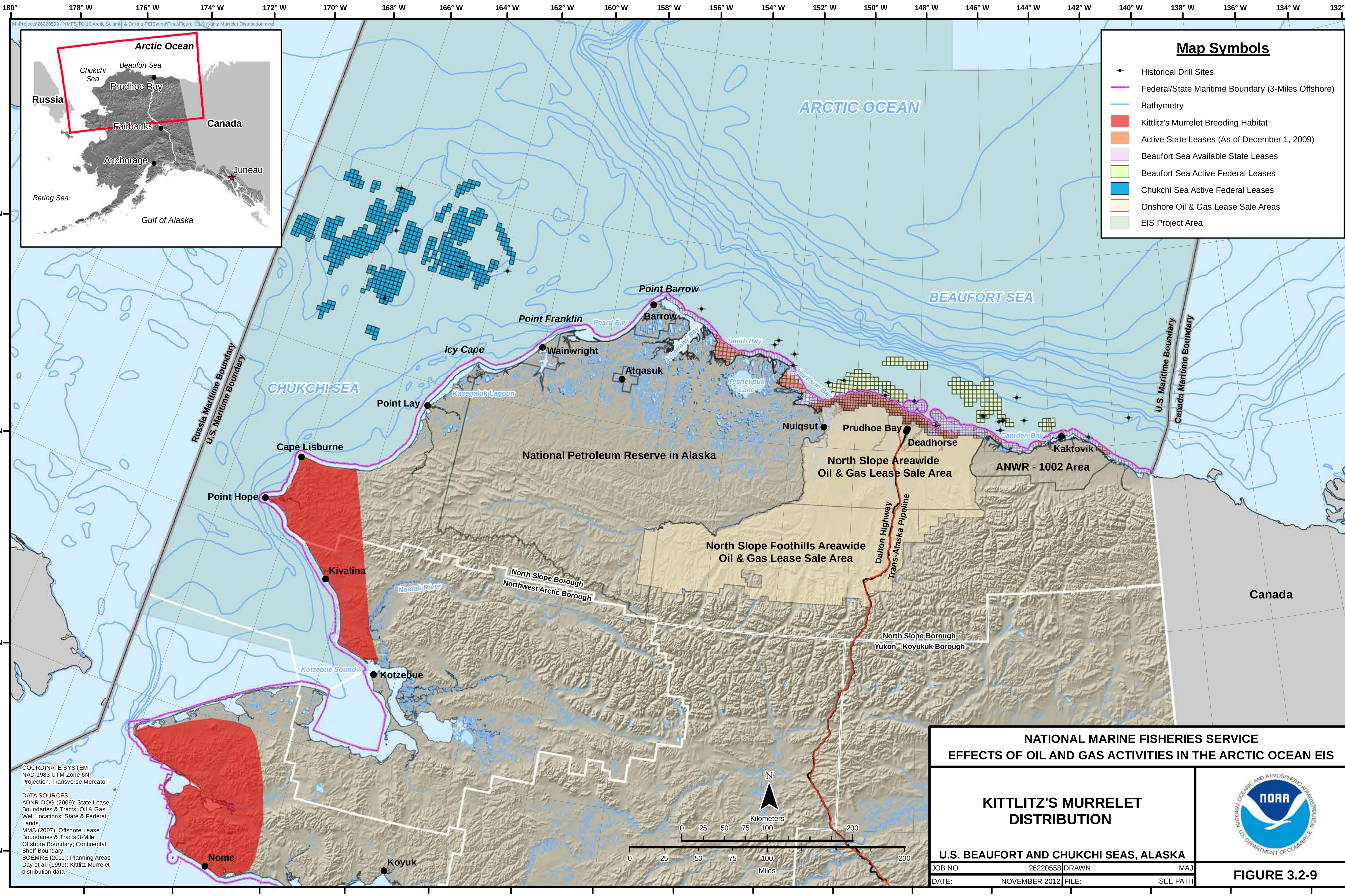
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
FIGURE 3.2-8


Arctic Ocean
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Chukchi Sea
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Juneau
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Gulf of Alaska
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Kittlitz's Murrelet Breeding Habitat
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Onshore Oil & Gas Lease Sale Areas
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Admiralty Bay
Smith Bay
Harrison Bay
Teshekpuk Lake
Kasegaluk Lagoon
Point Lay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Russia Maritime Boundary
U.S. Maritime Boundary
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North Slope Borough
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North Slope Borough
Yukon - Koyukuk Borough
Canada
Kotzebue Sound
Kotzebue
Nome
Koyuk
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Projection: Transverse Mercator
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MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
Day et al. (1999): Kittlitz Murrelet distribution data
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Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
KITTLITZ'S MURRELET DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558 DRAWN: MAJ
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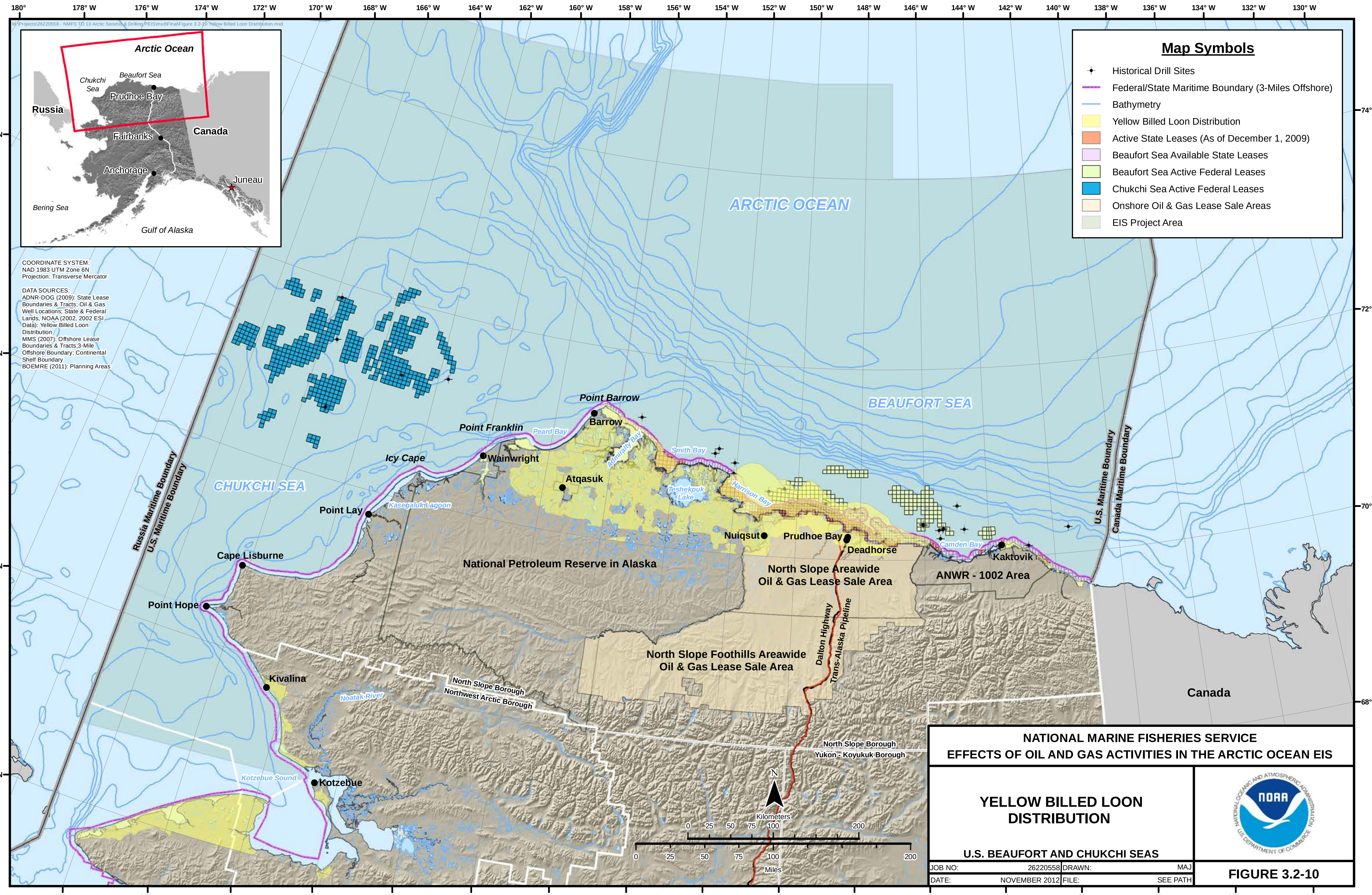
FIGURE 3.2-9



Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Yellow Billed Loon Distribution
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Chukchi Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
EIS Project Area
Arctic Ocean
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Beaufort Sea
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Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands, NOAA (2002, 2002 ESI Data): Yellow Billed Loon Distribution
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
ARCTIC OCEAN
BEAUFORT SEA
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Kotzebue Sound
Kotzebue
Canada
Kilometers
Miles
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YELLOW BILLED LOON DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS
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DRAWN: MAJ
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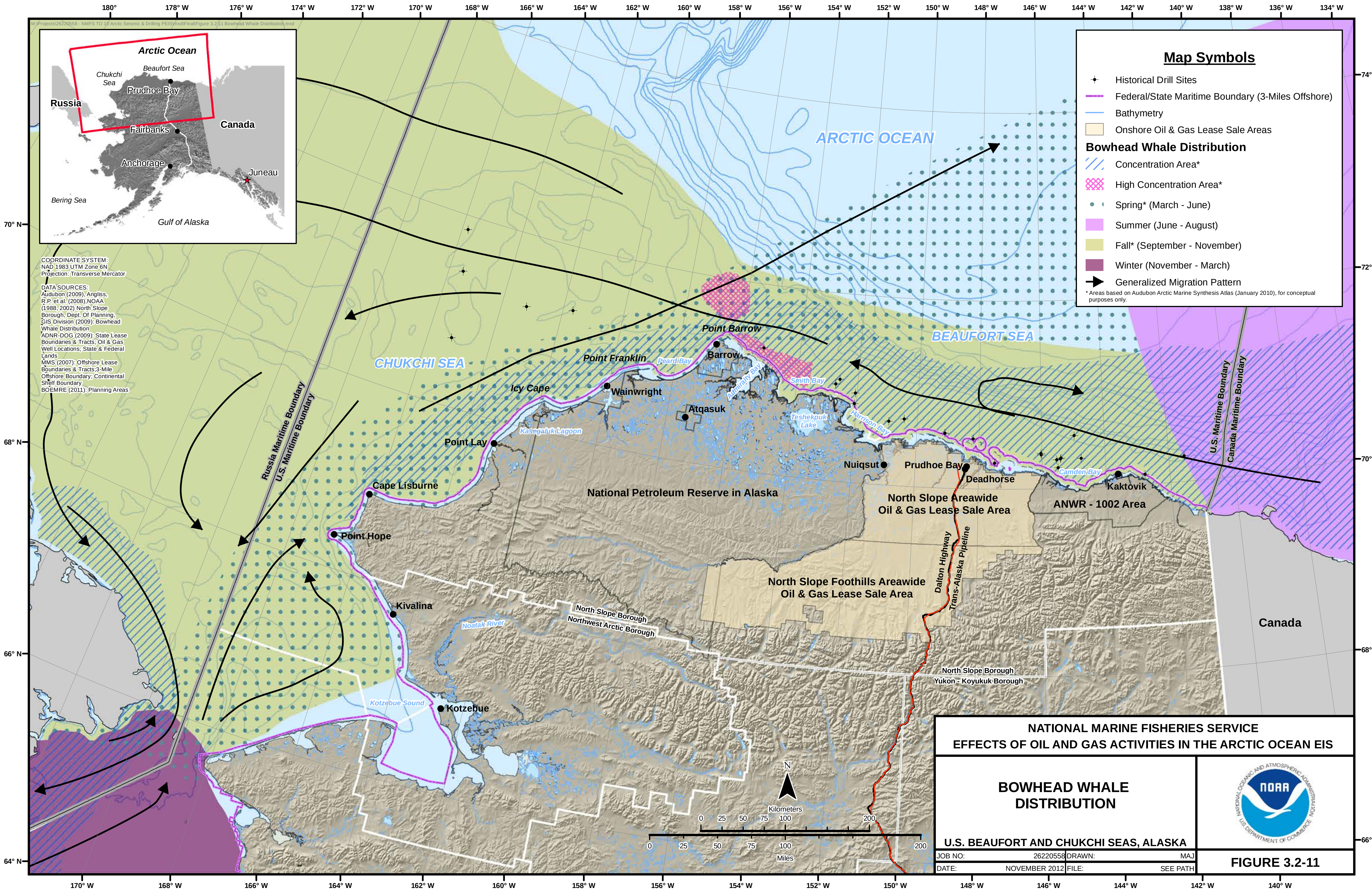
FIGURE 3.2-10


Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Bowhead Whale Distribution
Concentration Area*
High Concentration Area*
Spring* (March - June)
Summer (June - August)
Fall* (September - November)
Winter (November - March)
Generalized Migration Pattern
* Areas based on Audubon Arctic Marine Synthesis Atlas (January 2010), for conceptual purposes only.
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
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Audubon (2009), Angliss, R.P. et al. (2008),NOAA (1988, 2002) North Slope Borough, Dept. Of Planning, GIS Division (2009): Bowhead Whale Distribution
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
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Kilometers
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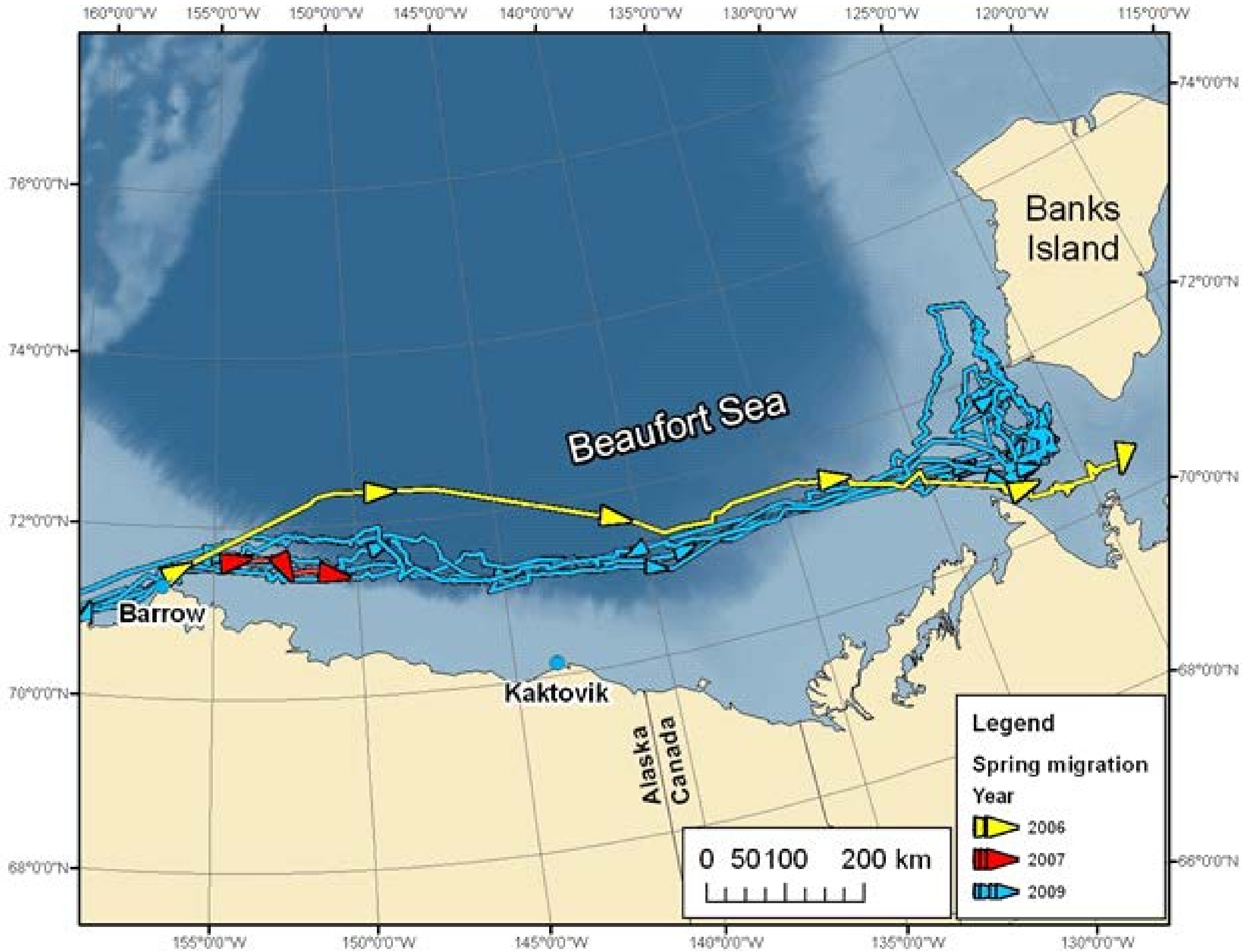
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
BOWHEAD WHALE DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558 DRAWN: MAJ
DATE: NOVEMBER 2012 FILE: SEE PATH
FIGURE 3.2-11

M:\Projects\26220558 - NMFS TO 10 Arctic Seismic & Drilling PEIS\mxd\Final\Figure 3.2-12 Tracks of Satellite Tagged Bowhead Whales.mxd



DATA SOURCE:
Quakenbush et al. 2010b

NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

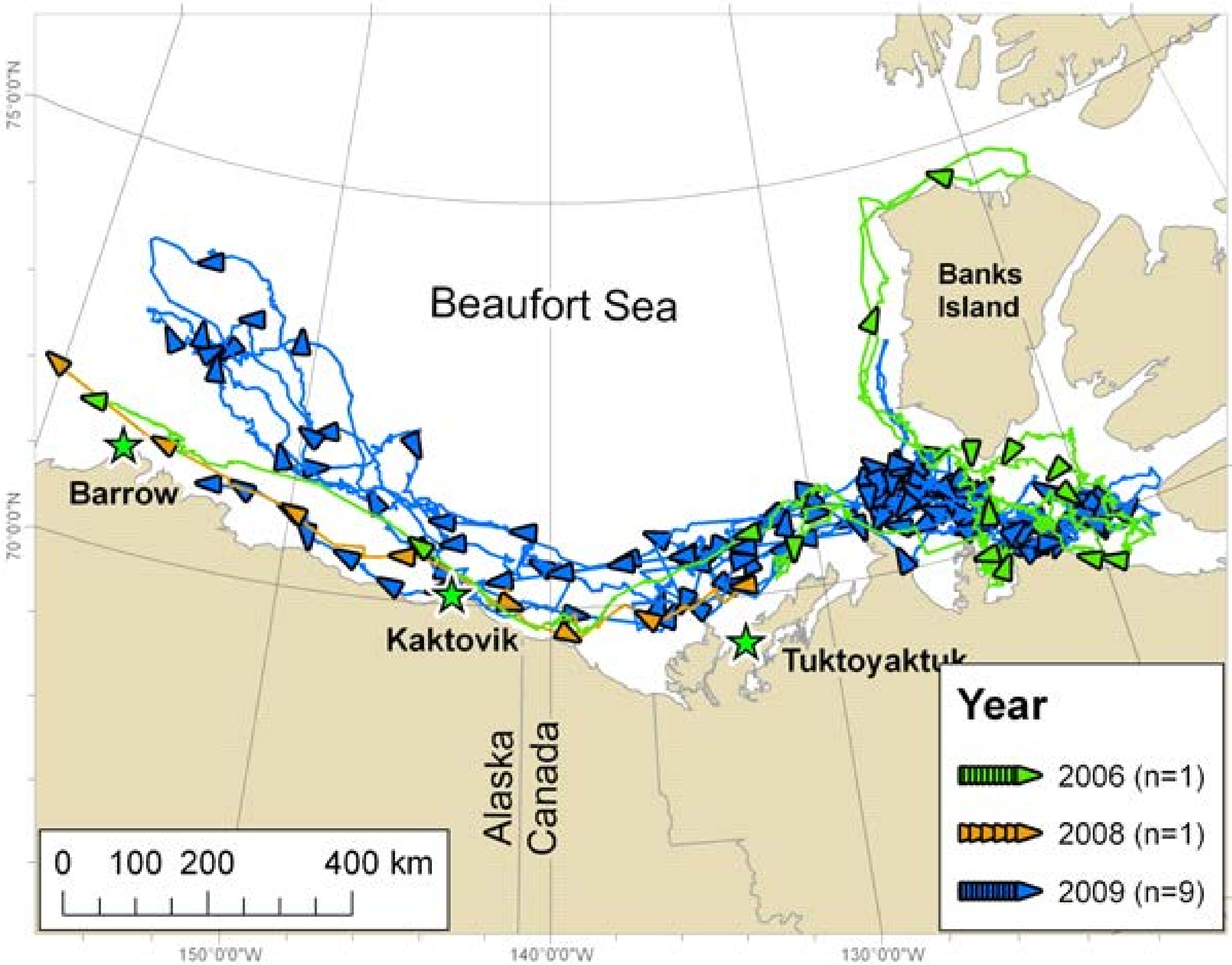
TRACKS OF SATELLITE-TAGGED BOWHEAD WHALES DURING SPRING MIGRATION IN THE BEAUFORT SEA IN 2006, 2007, AND 2009

U.S. BEAUFORT SEA, ALASKA

JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.2-12

M:\Projects\26220558 - NMFS TO 10 Arctic Seismic & Drilling PEIS\mxd\Final\Figure 3.2-13 Tracks of Satellite Tagged Bowhead Whales.mxd



DATA SOURCE:
Quakenbush et al. 2010b

NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

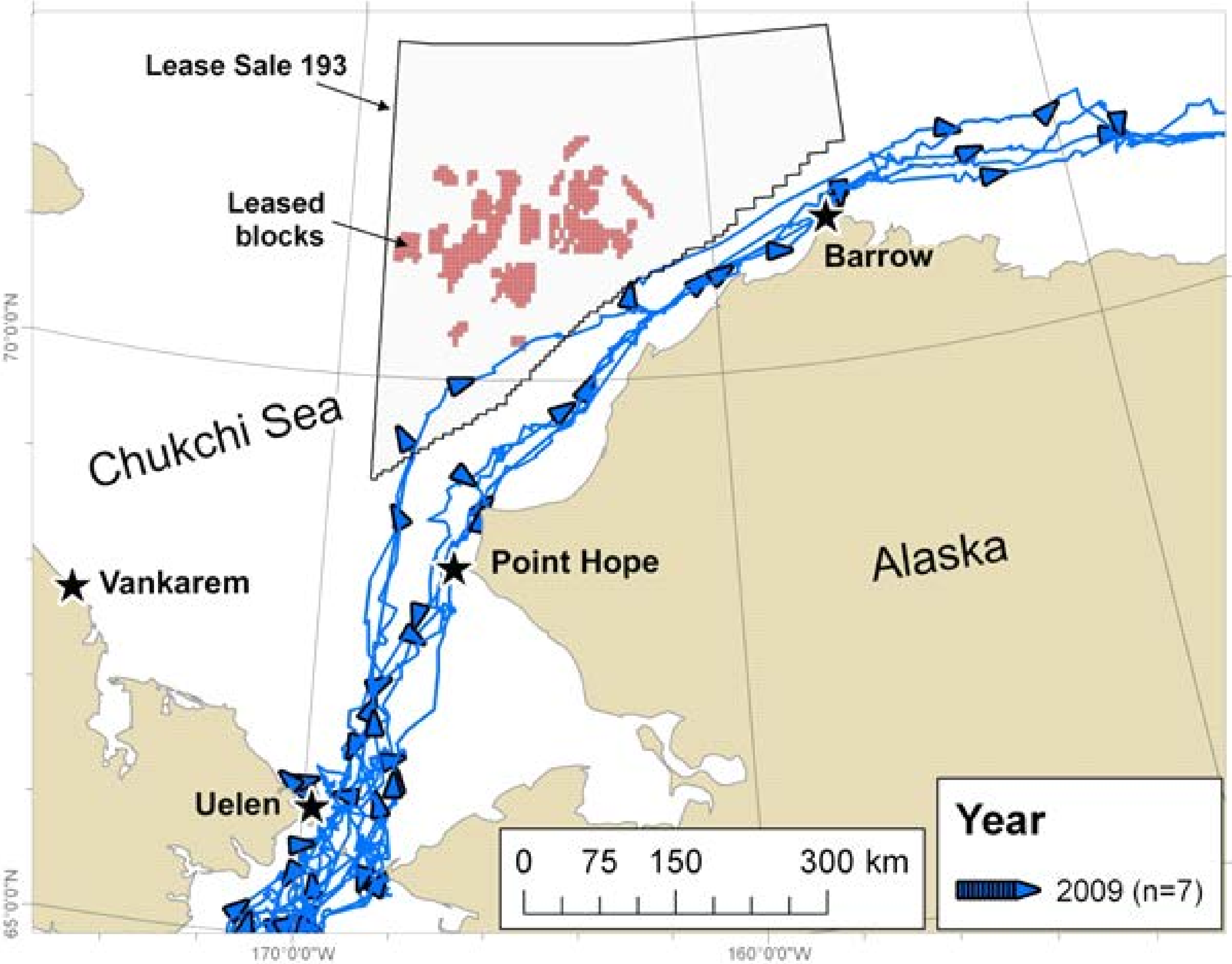
TRACKS OF ELEVEN SATELLITE-TAGGED BOWHEAD WHALES IN THE BEAUFORT SEA IN SUMMER/FALL 2006-2009

U.S. BEAUFORT SEA, ALASKA

JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.2-13

M:\Projects\26220558 - NMFS TO 10 Arctic Seismic & Drilling PEIS\mxd\Final\Figure 3.2-14 Tracks of Satellite Tagged Bowhead Whales.mxd



NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

TRACKS OF SATELLITE-TAGGED BOWHEAD WHALES MIGRATING THROUGH THE CHUKCHI SEA AND PAST POINT BARROW IN SPRING 2009

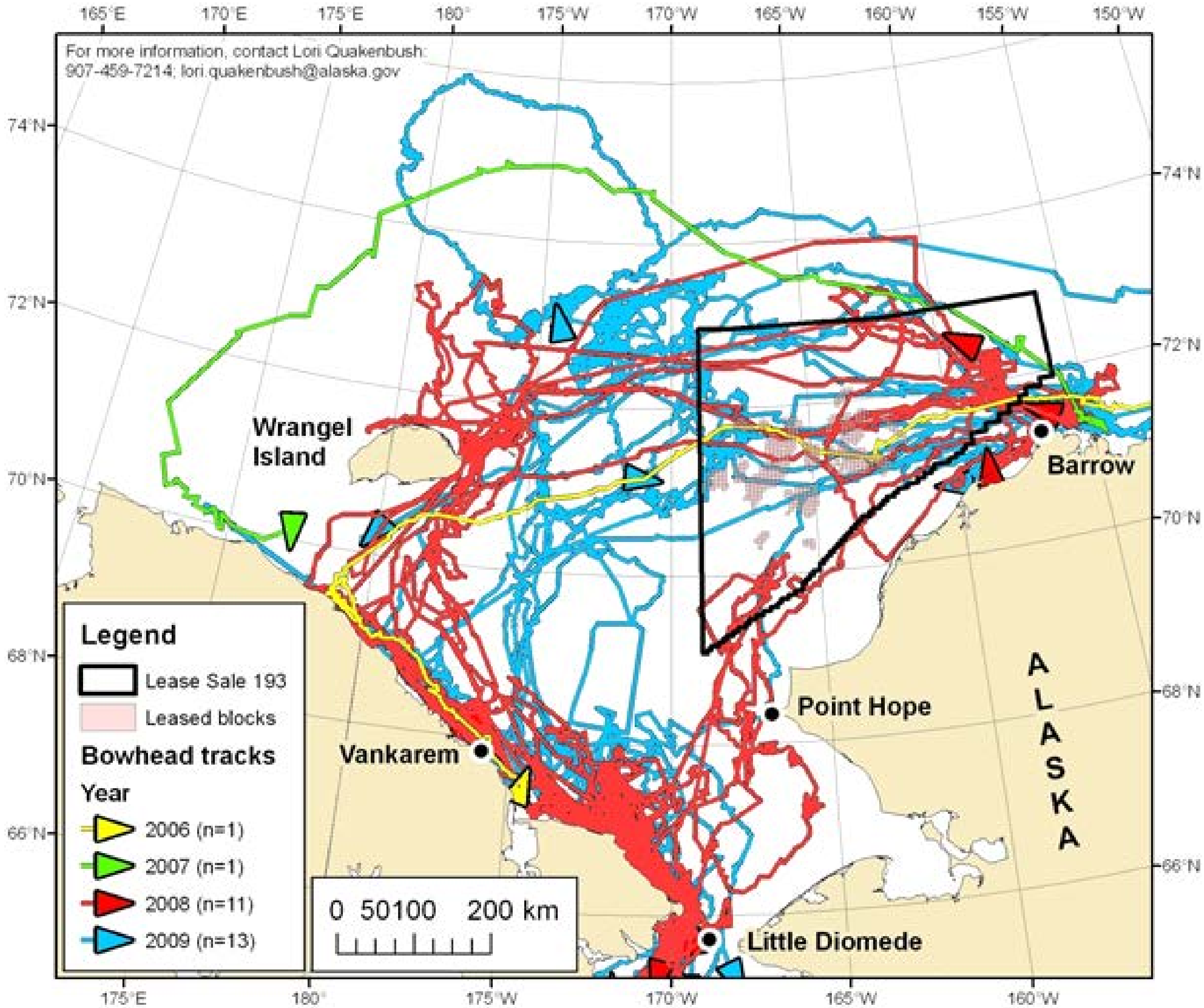
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA

JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.2-14

DATA SOURCE:
Quakenbush et al. 2010b

M:\Projects\26220558 - NMFS TO 10 Arctic Seismic & Drilling PEIS\mxd\Final\Figure 3.2-15 Tracks of Twenty Six Satellite Tagged Bowheads.mxd



NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

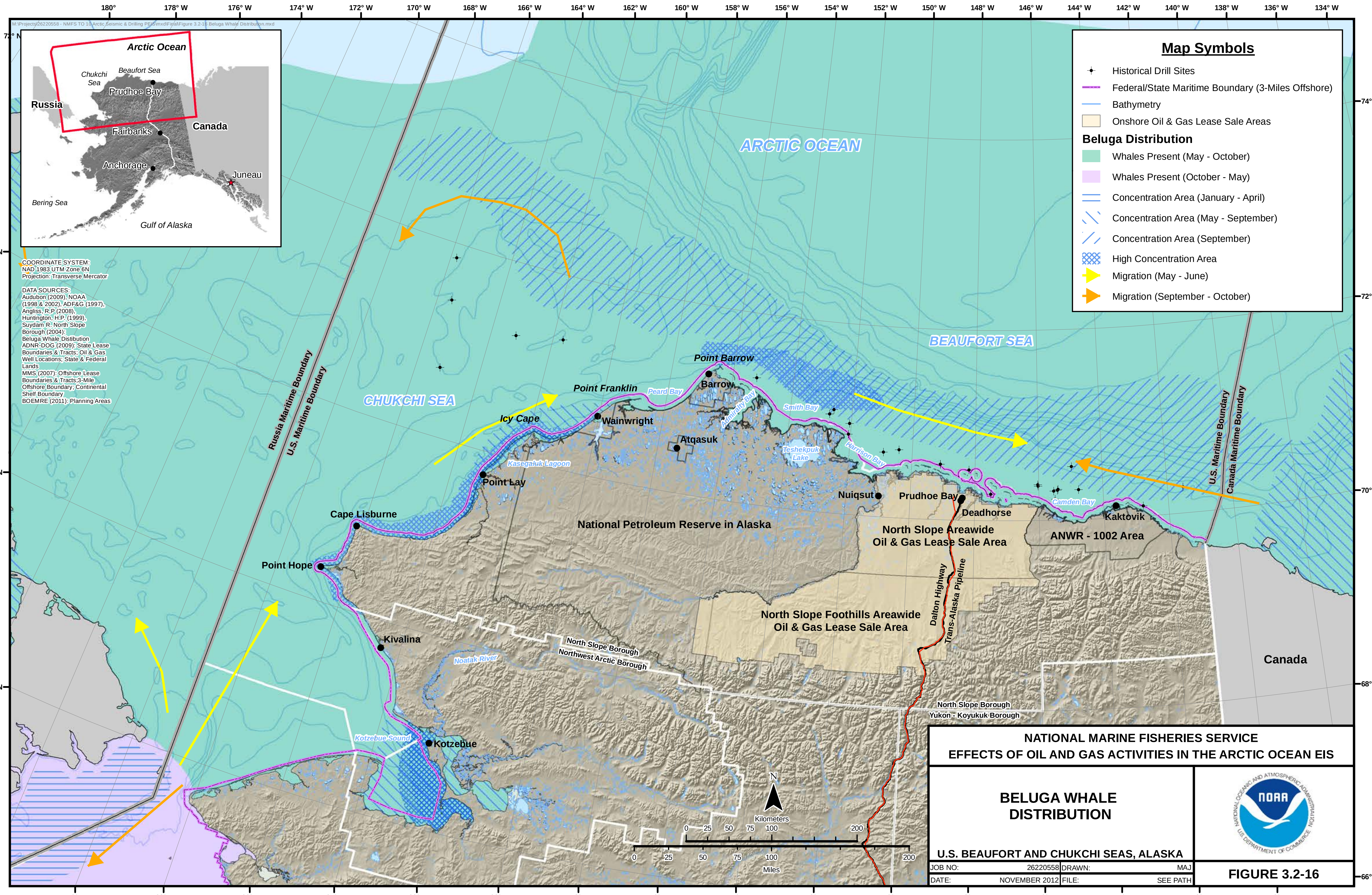
TRACKS OF TWENTY-SIX SATELLITE-TAGGED BOWHEAD WHALES IN THE CHUKCHI SEA DURING FALL 2006-2009

U.S. CHUKCHI SEA, ALASKA

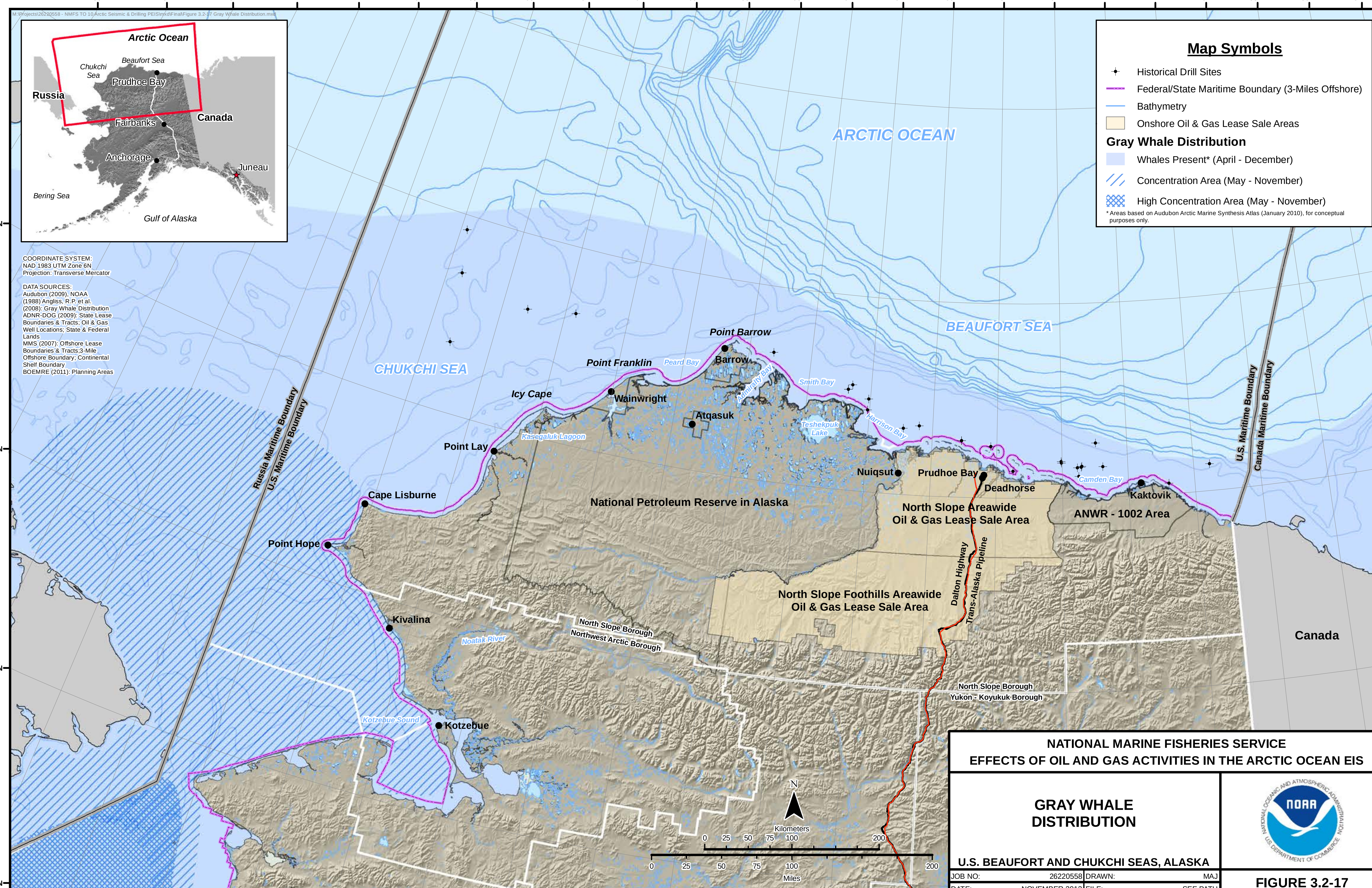
JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.2-15

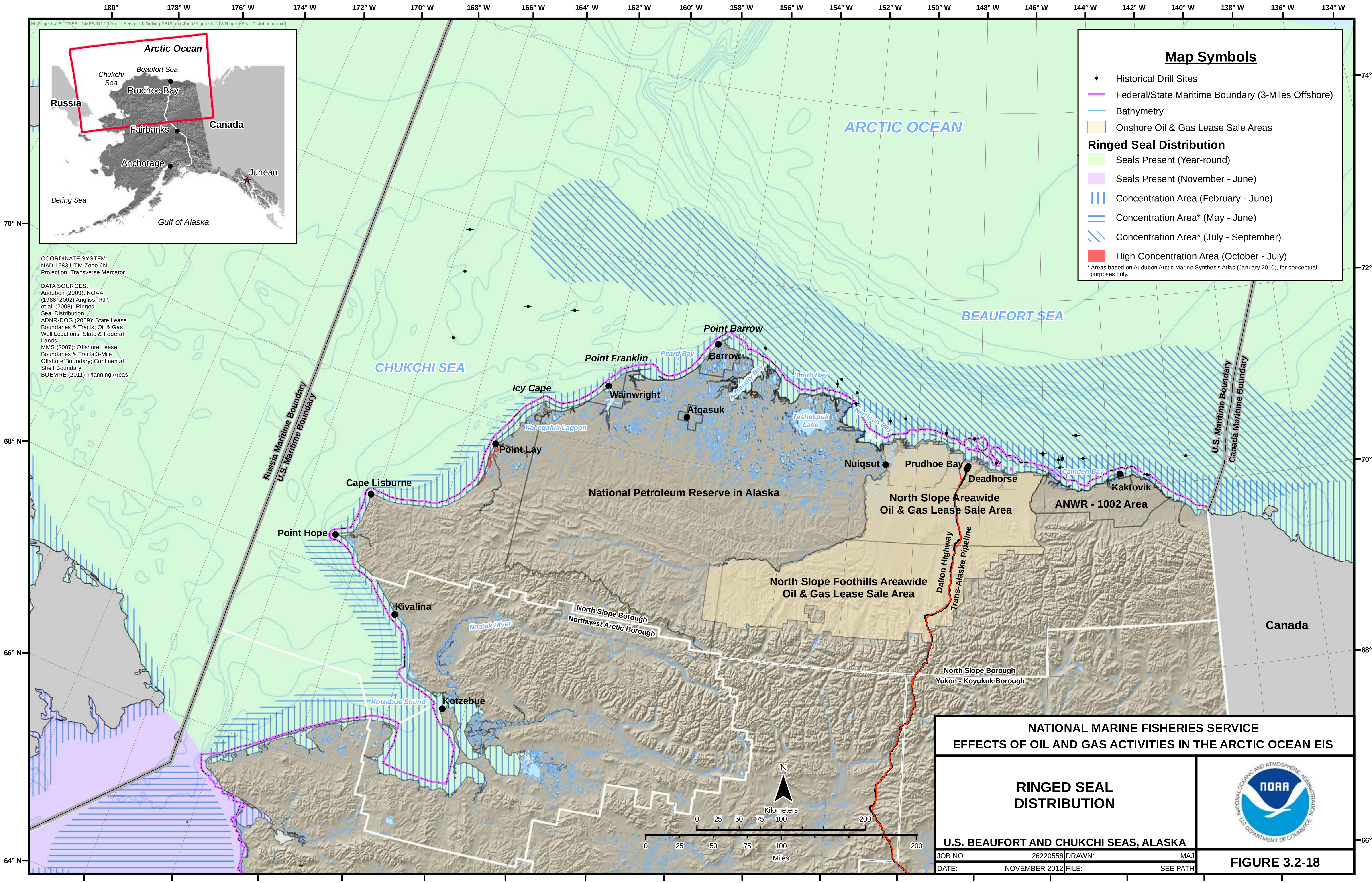
DATA SOURCE:
Quakenbush et al. 2010b



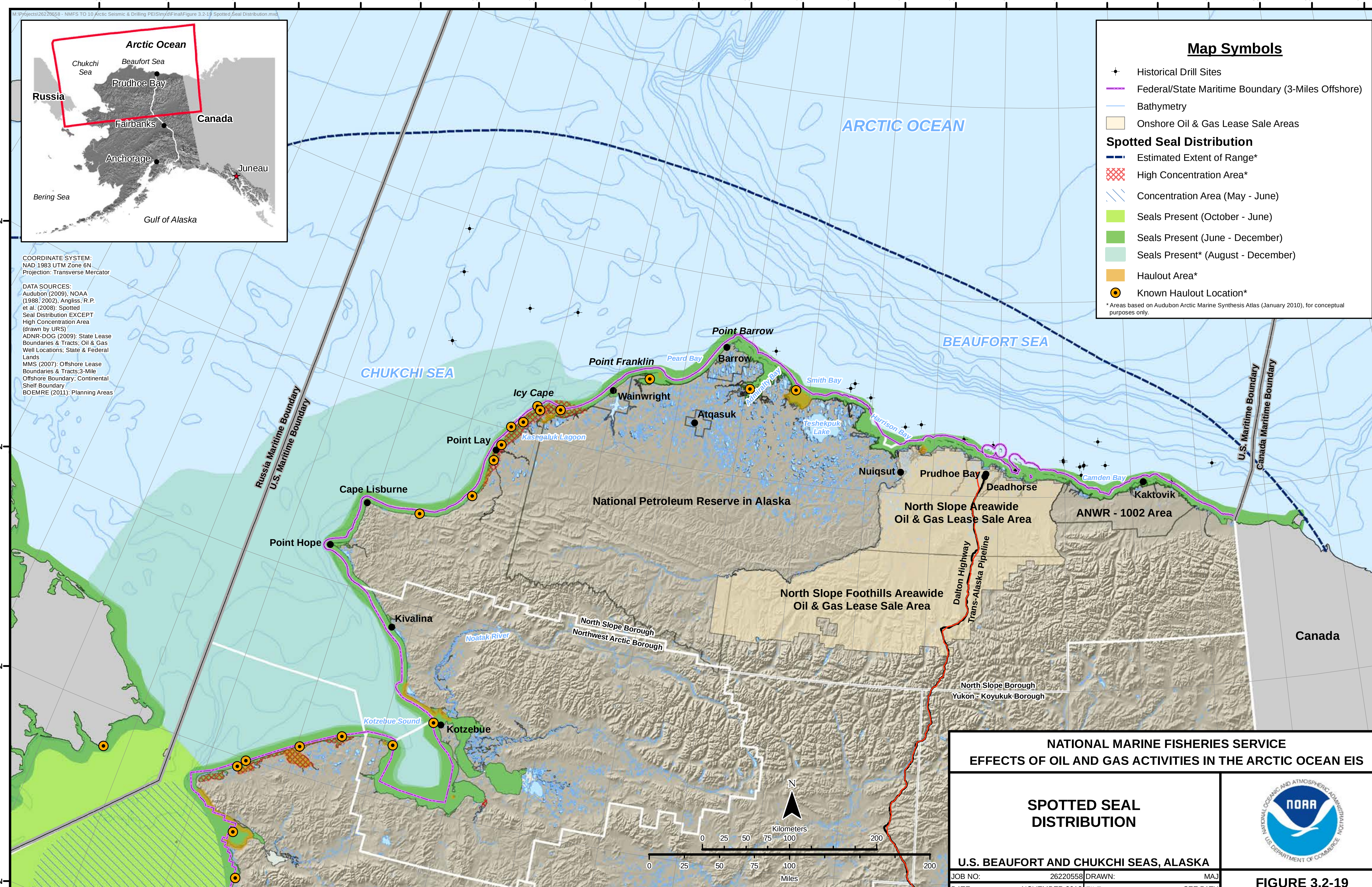
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Beluga Distribution
Whales Present (May - October)
Whales Present (October - May)
Concentration Area (January - April)
Concentration Area (May - September)
Concentration Area (September)
High Concentration Area
Migration (May - June)
Migration (September - October)
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Fairbanks
Canada
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
Audubon (2009), NOAA (1998 & 2002), ADF&G (1997), Angliss, R,P (2008), Huntington, H.P. (1999), Suydam R. North Slope Borough (2004): Beluga Whale Distibution
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Admiralty Bay
Smith Bay
Wainwright
Icy Cape
Atqasuk
Teshekpuk Lake
Harrison Bay
Kasegaluk Lagoon
Point Lay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Point Hope
Dalton Highway
Trans-Alaska Pipeline
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Kivalina
North Slope Borough
Northwest Arctic Borough
Noatak River
Yukon - Koyukuk Borough
Kotzebue Sound
Kotzebue
Canada
N
Kilometers
0 25 50 75 100 200
Miles
0 25 50 75 100 200
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
BELUGA WHALE DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-16

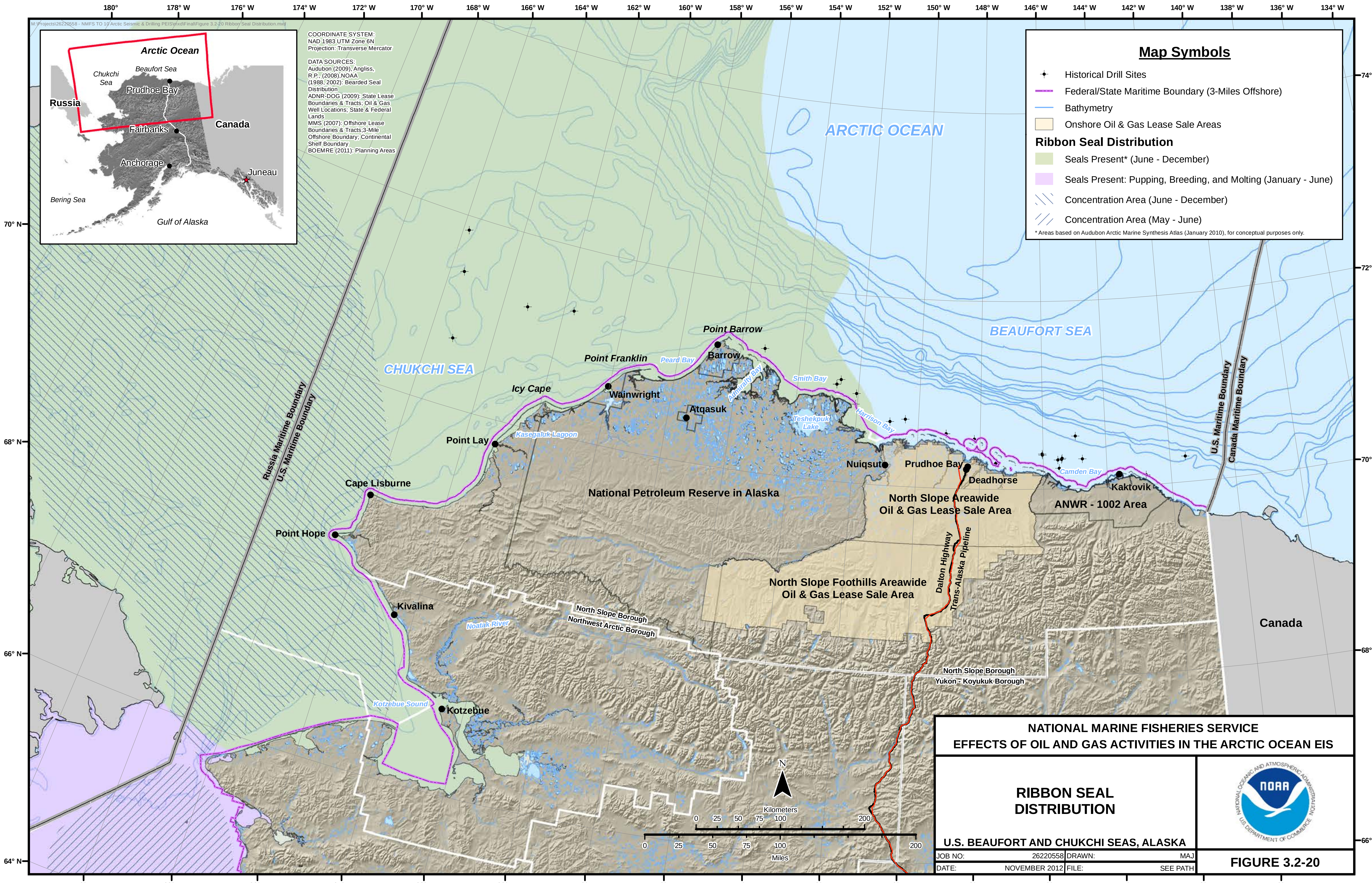


Arctic Ocean
Beaufort Sea
Chukchi Sea
Prudhoe Bay
Russia
Fairbanks
Canada
Anchorage
Juneau
Bering Sea
Gulf of Alaska
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Gray Whale Distribution
Whales Present* (April - December)
Concentration Area (May - November)
High Concentration Area (May - November)
* Areas based on Audubon Arctic Marine Synthesis Atlas (January 2010), for conceptual purposes only.
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
Audubon (2009), NOAA (1988) Angliss, R.P. et al. (2008): Gray Whale Distribution
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Point Barrow
Barrow
Point Franklin
Peard Bay
Icy Cape
Wainwright
Atqasuk
Admiralty Bay
Smith Bay
Teshekpuk Lake
Harrison Bay
Kasegaluk Lagoon
Point Lay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
Point Hope
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Kivalina
Noatak River
North Slope Borough
Northwest Arctic Borough
Yukon - Koyukuk Borough
Kotzebue Sound
Kotzebue
Russia Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Canada
Kilometers
Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
GRAY WHALE DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-17



Arctic Ocean
Beaufort Sea
Chukchi Sea
Prudhoe Bay
Russia
Fairbanks
Canada
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
Audubon (2009), NOAA (1988, 2002) Angliss, R.P. et al. (2008): Ringed Seal Distribution
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Ringed Seal Distribution
Seals Present (Year-round)
Seals Present (November - June)
Concentration Area (February - June)
Concentration Area* (May - June)
Concentration Area* (July - September)
High Concentration Area (October - July)
* Areas based on Audubon Arctic Marine Synthesis Atlas (January 2010), for conceptual purposes only.
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
Barrow
Peard Bay
Point Franklin
Wainwright
Icy Cape
Atqasuk
Admiralty Bay
Smith Bay
Teshekpuk Lake
Harrison Bay
Kasegaluk Lagoon
Point Lay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Point Hope
Dalton Highway
Trans-Alaska Pipeline
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Kivalina
North Slope Borough
Northwest Arctic Borough
Noatak River
Canada
North Slope Borough
Yukon - Koyukuk Borough
Kotzebue Sound
Kotzebue
Kilometers
0 25 50 75 100 200
Miles
0 25 50 75 100 200
180° 178° W 176° W 174° W 172° W 170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W 140° W 138° W 136° W 134° W
170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W 140° W
64° N 66° N 68° N 70° N 72° N 74° N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
RINGED SEAL DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-18


Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Spotted Seal Distribution
Estimated Extent of Range*
High Concentration Area*
Concentration Area (May - June)
Seals Present (October - June)
Seals Present (June - December)
Seals Present* (August - December)
Haulout Area*
Known Haulout Location*
* Areas based on Audubon Arctic Marine Synthesis Atlas (January 2010), for conceptual purposes only.
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
Audubon (2009), NOAA (1988, 2002), Angliss, R.P. et al. (2008): Spotted Seal Distribution EXCEPT High Concentration Area (drawn by URS)
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
Barrow
Peard Bay
Point Franklin
Wainwright
Icy Cape
Atqasuk
Admiralty Bay
Smith Bay
Teshekpuk Lake
Harrison Bay
Point Lay
Kasegaluk Lagoon
Cape Lisburne
Point Hope
National Petroleum Reserve in Alaska
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
ANWR - 1002 Area
North Slope Areawide Oil & Gas Lease Sale Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Kivalina
Noatak River
North Slope Borough
Northwest Arctic Borough
North Slope Borough
Yukon - Koyukuk Borough
Kotzebue Sound
Kotzebue
Canada
Kilometers
0 25 50 75 100 200
Miles
0 25 50 75 100 200
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
SPOTTED SEAL DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-19



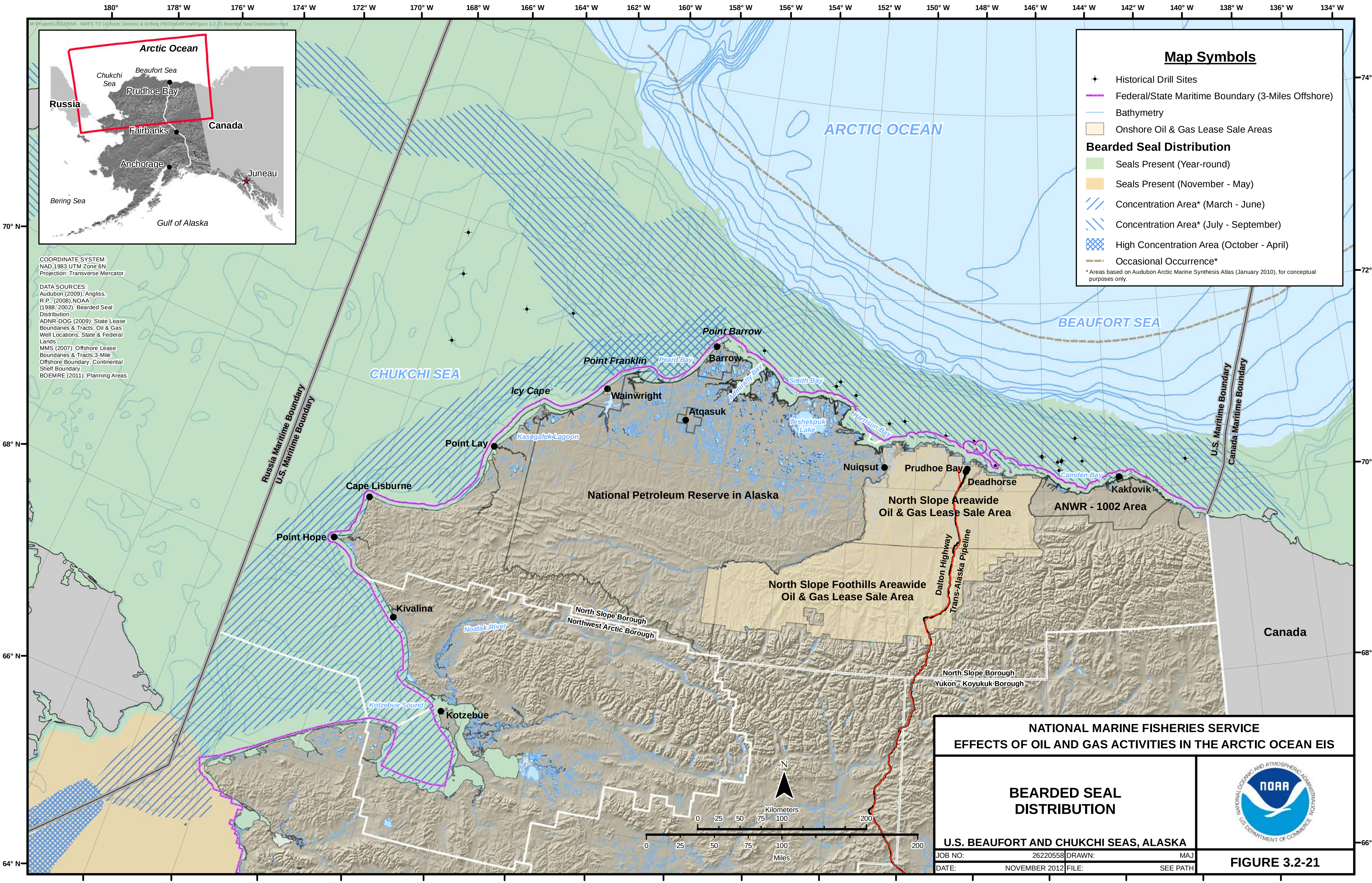
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

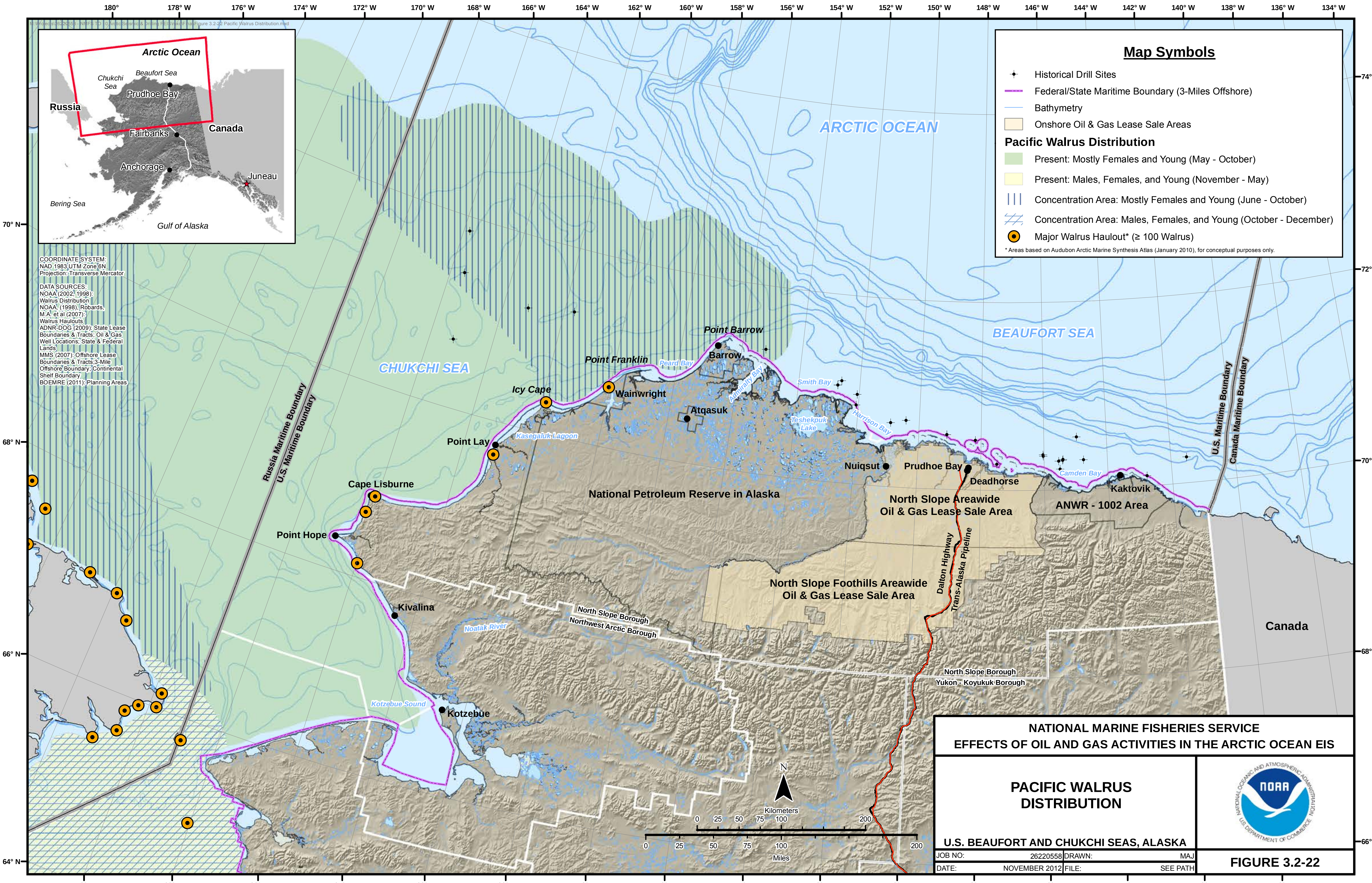
RIBBON SEAL DISTRIBUTION

U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA

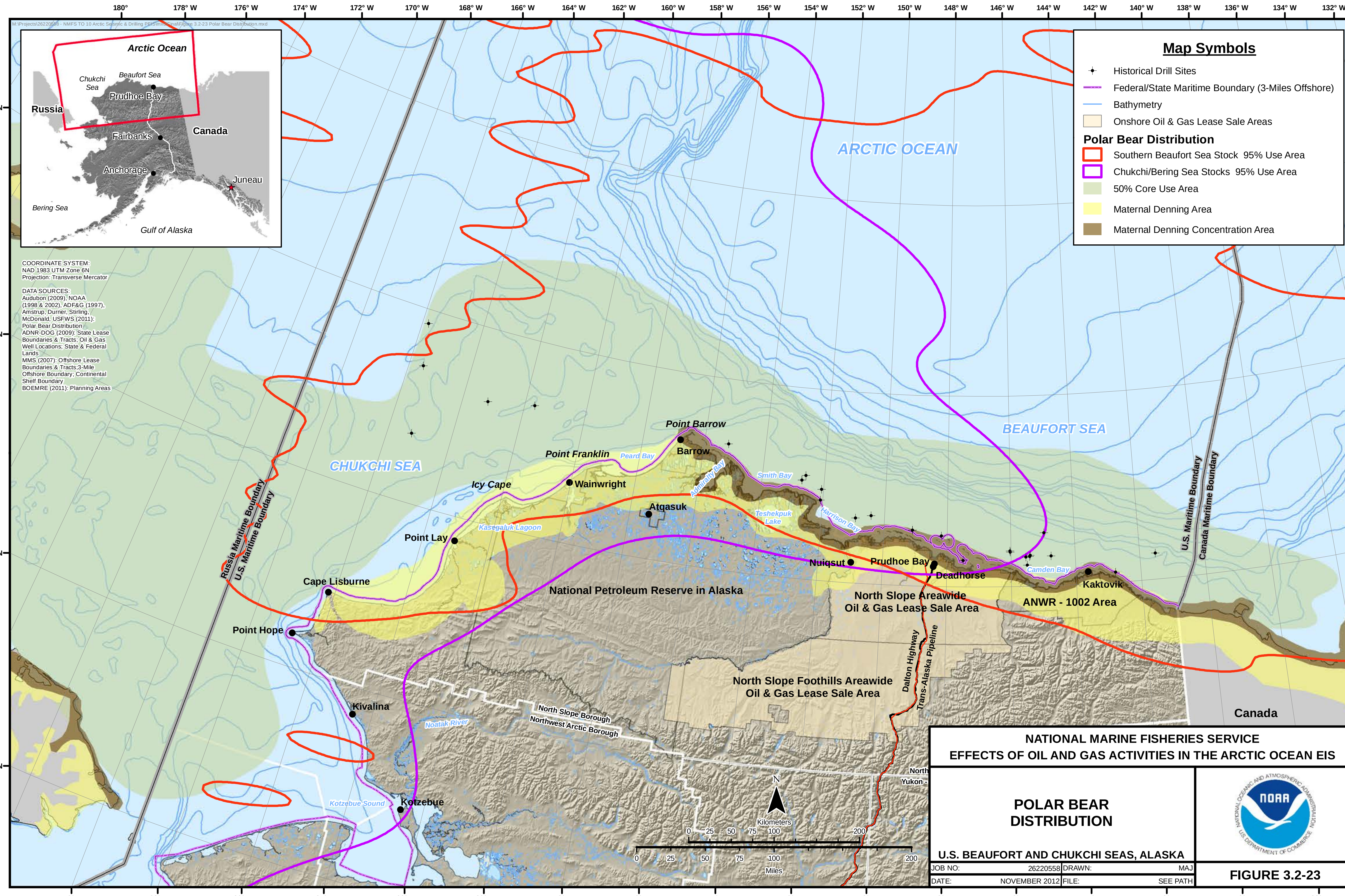
JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

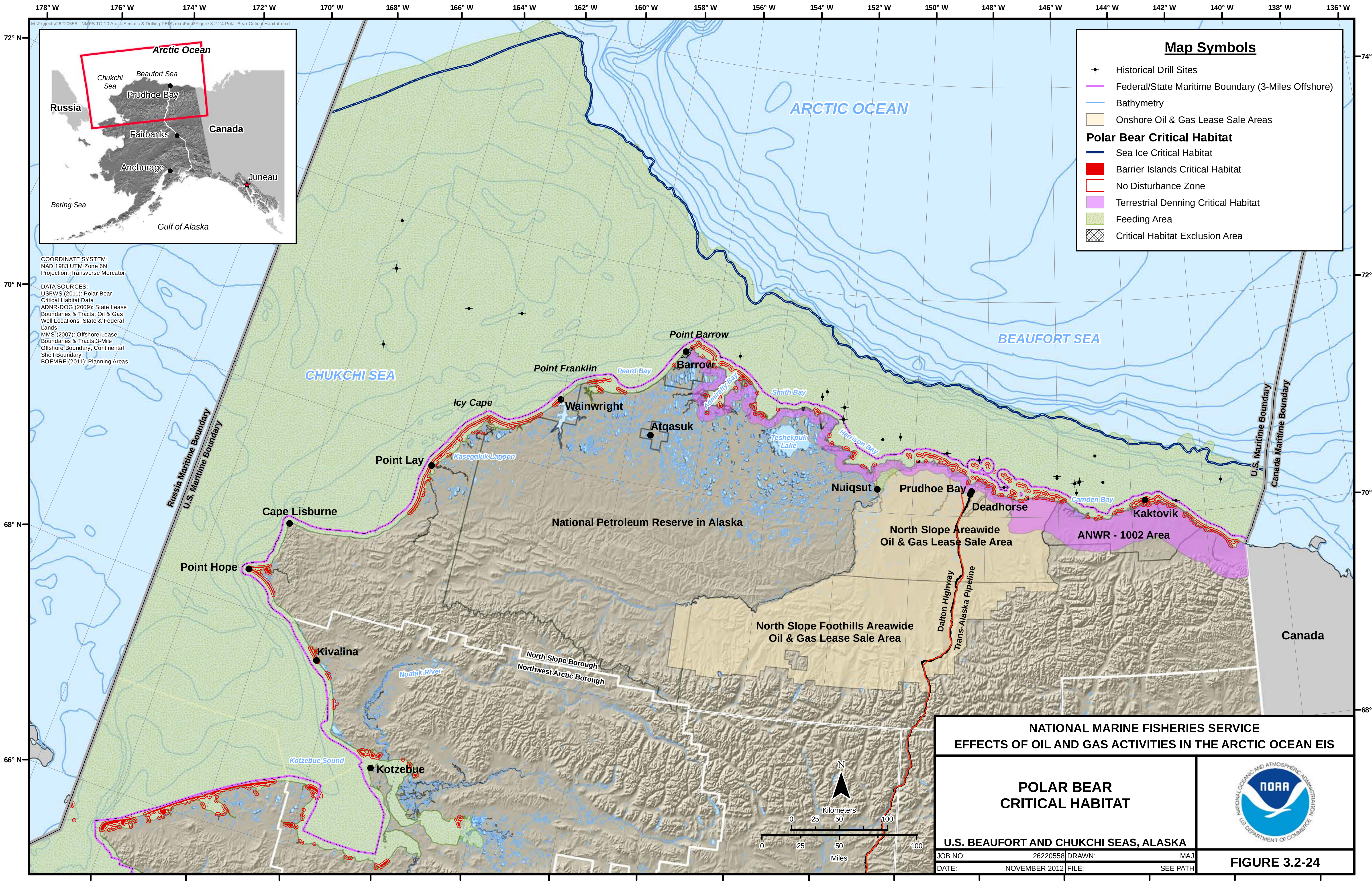
FIGURE 3.2-20

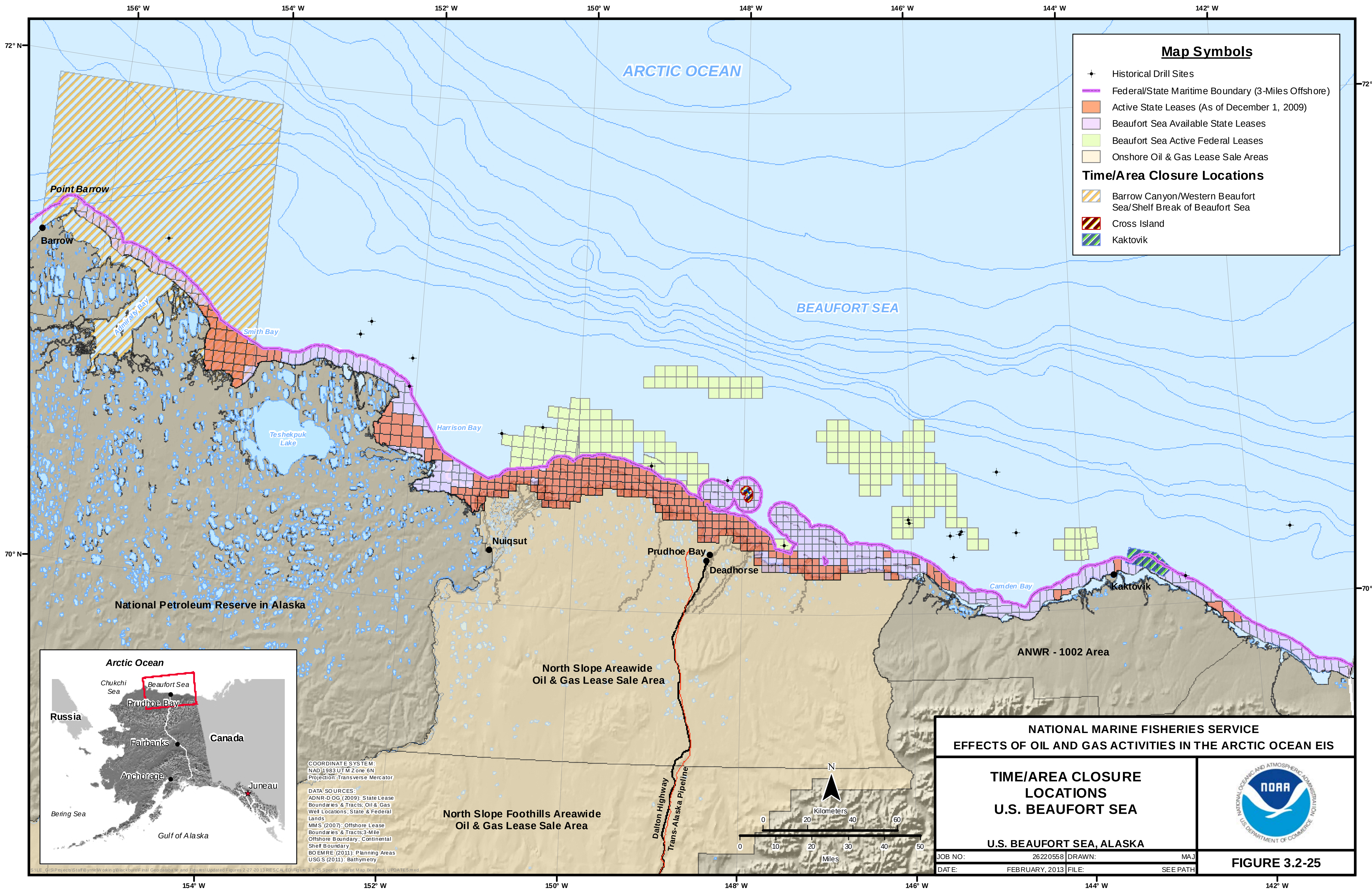

Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Bearded Seal Distribution
Seals Present (Year-round)
Seals Present (November - May)
Concentration Area* (March - June)
Concentration Area* (July - September)
High Concentration Area (October - April)
Occasional Occurrence*
* Areas based on Audubon Arctic Marine Synthesis Atlas (January 2010), for conceptual purposes only.
Arctic Ocean
Beaufort Sea
Chukchi Sea
Prudhoe Bay
Russia
Fairbanks
Canada
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
Audubon (2009), Angliss, R.P., (2008),NOAA (1988, 2002): Bearded Seal Distribution
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts,3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Admiralty Bay
Smith Bay
Icy Cape
Wainwright
Atqasuk
Teshekpuk Lake
Harrison Bay
Point Lay
Kasegaluk Lagoon
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Point Hope
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Kivalina
North Slope Borough
Northwest Arctic Borough
Noatak River
Canada
North Slope Borough
Yukon - Koyukuk Borough
Kotzebue Sound
Kotzebue
N
Kilometers
0 25 50 75 100 200
0 25 50 75 100 200
Miles
180° 178° W 176° W 174° W 172° W 170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W 140° W 138° W 136° W 134° W
170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W 140° W
70° N 68° N 66° N 64° N
74° N 72° N 70° N 68° N 66° N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
BEARDED SEAL DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-21

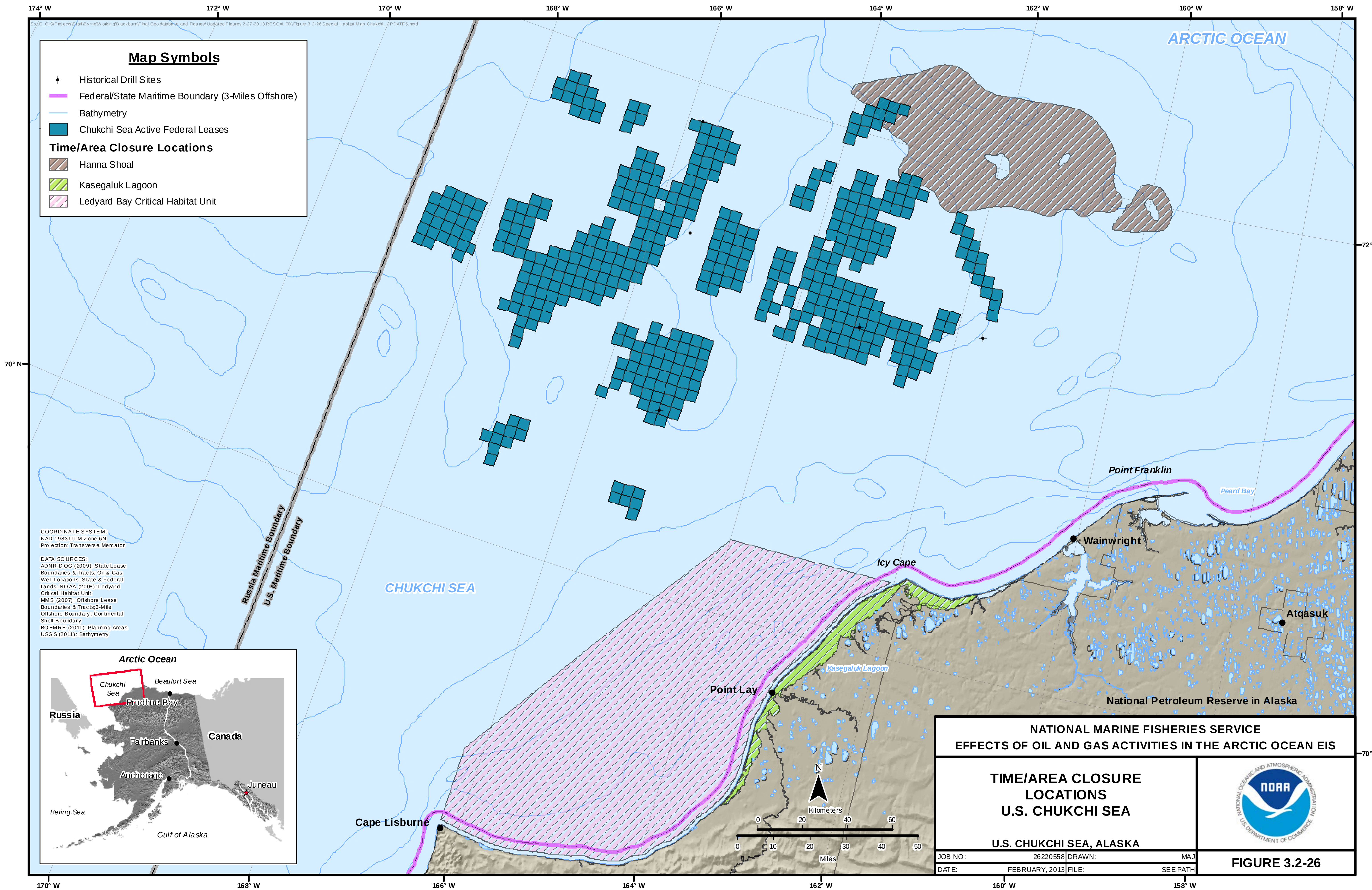


Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Pacific Walrus Distribution
Present: Mostly Females and Young (May - October)
Present: Males, Females, and Young (November - May)
Concentration Area: Mostly Females and Young (June - October)
Concentration Area: Males, Females, and Young (October - December)
Major Walrus Haulout* (≥ 100 Walrus)
* Areas based on Audubon Arctic Marine Synthesis Atlas (January 2010), for conceptual purposes only.
Arctic Ocean
Beaufort Sea
Chukchi Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
NOAA (2002, 1998): Walrus Distribution
NOAA (1998), Robards, M.A. et al (2007): Walrus Haulouts
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Wainwright
Icy Cape
Admiralty Bay
Smith Bay
Atqasuk
Teshekpuk Lake
Harrison Bay
Kasegaluk Lagoon
Point Lay
Cape Lisburne
Point Hope
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
U.S. Maritime Boundary
Canada Maritime Boundary
Canada
Kivalina
Noatak River
North Slope Borough
Northwest Arctic Borough
North Slope Borough
Yukon - Koyukuk Borough
Kotzebue Sound
Kotzebue
N
Kilometers
0 25 50 75 100 200
Miles
0 25 50 75 100 200
180° 178° W 176° W 174° W 172° W 170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W 140° W 138° W 136° W 134° W
170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W 140° W
70° N 68° N 66° N 64° N
74° N 72° N 70° N 68° N 66° N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
PACIFIC WALRUS DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-22


Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
Audubon (2009), NOAA (1998 & 2002), ADF&G (1997), Amstrup, Durner, Stirling, McDonald, USFWS (2011): Polar Bear Distribution
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Polar Bear Distribution
Southern Beaufort Sea Stock 95% Use Area
Chukchi/Bering Sea Stocks 95% Use Area
50% Core Use Area
Maternal Denning Area
Maternal Denning Concentration Area
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Point Barrow
Barrow
Point Franklin
Peard Bay
Admiralty Bay
Smith Bay
Icy Cape
Wainwright
Atqasuk
Teshekpuk Lake
Harrison Bay
Kasegaluk Lagoon
Point Lay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Point Hope
Russia Maritime Boundary
U.S. Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Dalton Highway
Trans-Alaska Pipeline
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Kivalina
Noatak River
North Slope Borough
Northwest Arctic Borough
Kotzebue Sound
Kotzebue
Canada
Kilometers
0 25 50 75 100 200
Miles
0 25 50 75 100 200
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
POLAR BEAR DISTRIBUTION
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-23


Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Polar Bear Critical Habitat
Sea Ice Critical Habitat
Barrier Islands Critical Habitat
No Disturbance Zone
Terrestrial Denning Critical Habitat
Feeding Area
Critical Habitat Exclusion Area
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
USFWS (2011): Polar Bear Critical Habitat Data
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Admiralty Bay
Smith Bay
Icy Cape
Wainwright
Atqasuk
Teshekpuk Lake
Harrison Bay
Point Lay
Kasegaluk Lagoon
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
ANWR - 1002 Area
Cape Lisburne
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
Point Hope
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Canada
Kivalina
North Slope Borough
Northwest Arctic Borough
Noatak River
Kotzebue Sound
Kotzebue
Kilometers
0 25 50 100
Miles
0 25 50 100
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
POLAR BEAR CRITICAL HABITAT
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.2-24


ARCTIC OCEAN
BEAUFORT SEA
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
Time/Area Closure Locations
Barrow Canyon/Western Beaufort Sea/Shelf Break of Beaufort Sea
Cross Island
Kaktovik
Point Barrow
Barrow
Admiralty Bay
Smith Bay
Harrison Bay
Teshekpuk Lake
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Dalton Highway
Trans-Alaska Pipeline
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM: NAD 1983 UTM Zone 6N Projection: Transverse Mercator
DATA SOURCES: ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts; 3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
Kilometers
Miles
156° W
154° W
152° W
150° W
148° W
146° W
144° W
142° W
72° N
70° N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
TIME/AREA CLOSURE LOCATIONS U.S. BEAUFORT SEA
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: FEBRUARY, 2013
FILE: SEE PATH
FIGURE 3.2-25



Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Chukchi Sea Active Federal Leases
Time/Area Closure Locations
Hanna Shoal
Kasegaluk Lagoon
Ledyard Bay Critical Habitat Unit
ARCTIC OCEAN
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
Point Franklin
Peard Bay
Wainwright
Icy Cape
Atqasuk
Kasegaluk Lagoon
Point Lay
National Petroleum Reserve in Alaska
Cape Lisburne
Kilometers
Miles
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands, NOAA (2008): Ledyard Critical Habitat Unit
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
Arctic Ocean
Chukchi Sea
Beaufort Sea
Russia
Prudhoe Bay
Fairbanks
Canada
Anchorage
Juneau
Bering Sea
Gulf of Alaska
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
TIME/AREA CLOSURE LOCATIONS U.S. CHUKCHI SEA
U.S. CHUKCHI SEA, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: FEBRUARY, 2013
FILE: SEE PATH
FIGURE 3.2-26

Figure 3.3-1 2009 Alaska Economic Performance Report.

Source: ADCCED 2011d

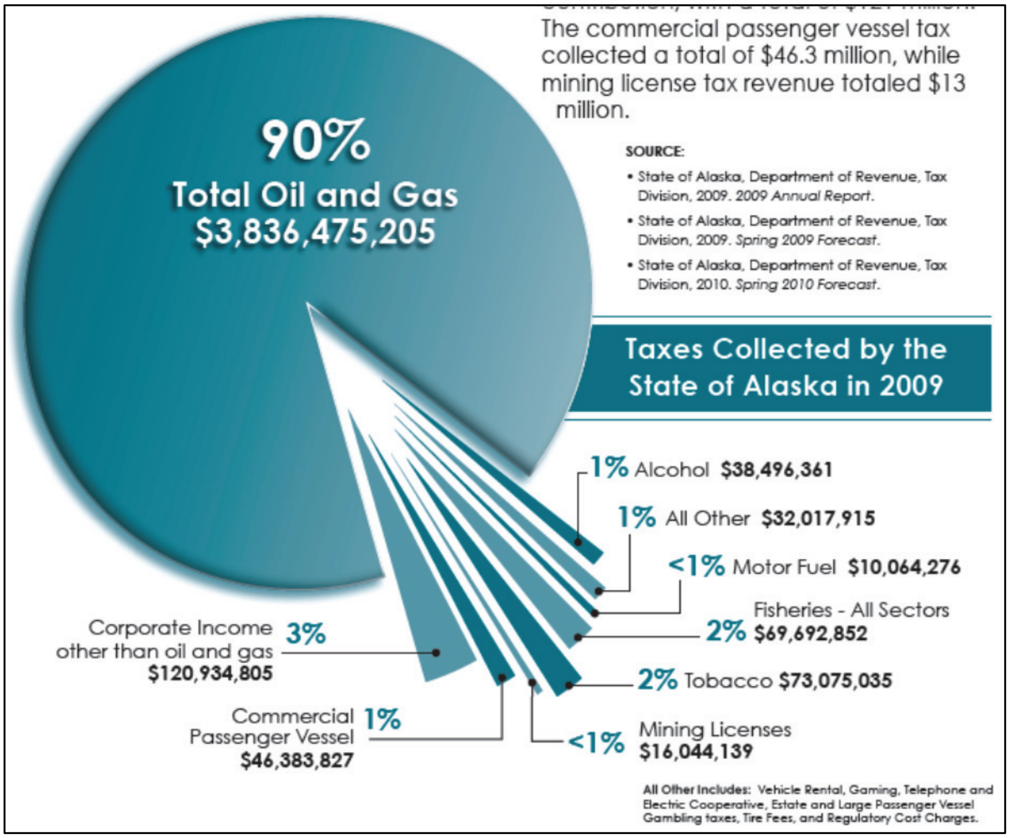


Figure 3.3-2 Statewide Employment by Section (February 2011).

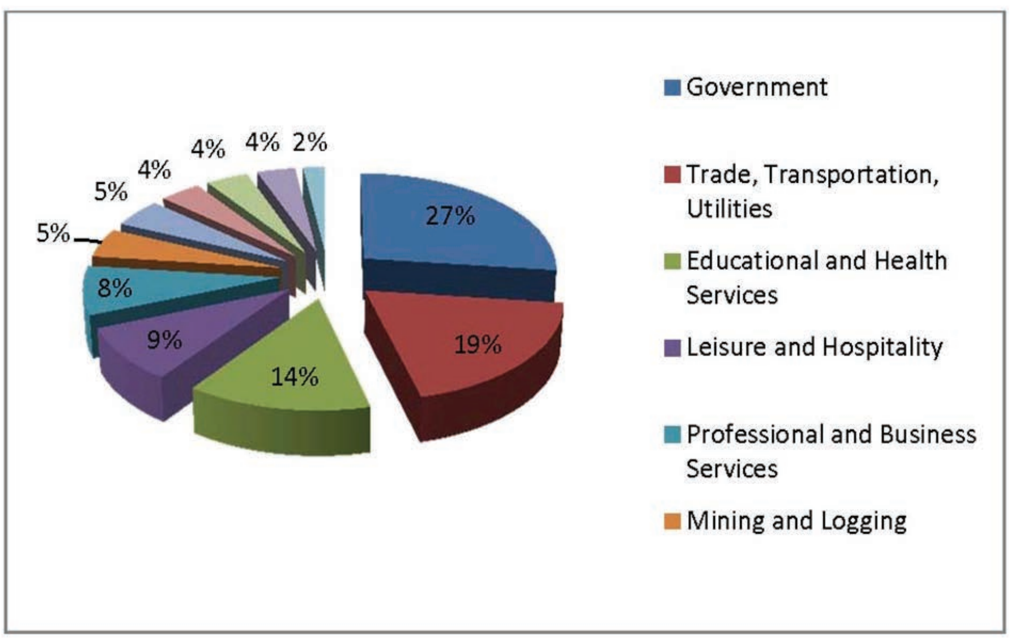


Figure 3.3-3 Local Capture of Large-Scale Resource Extraction from Remote Region Alaska (Million $).

Source: Goldsmith 2007 Calculated by URS in 2003 dollars

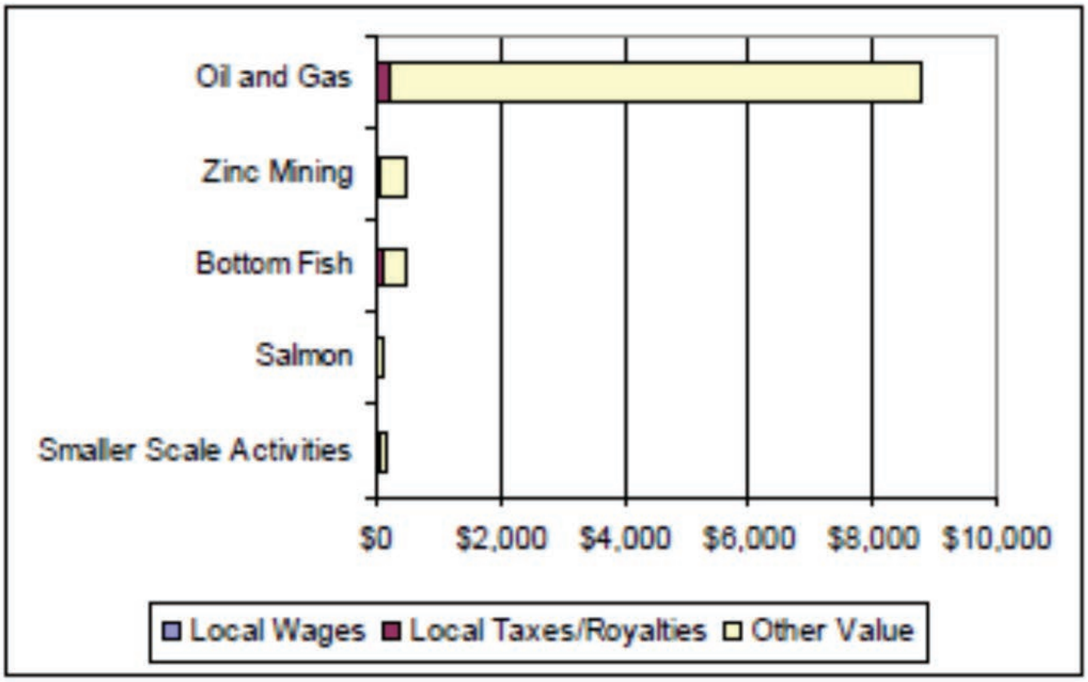


Figure 3.3-4a Top Employers in the NSB (2003).

Source: NSB 2003 Economic Profile and Census Report

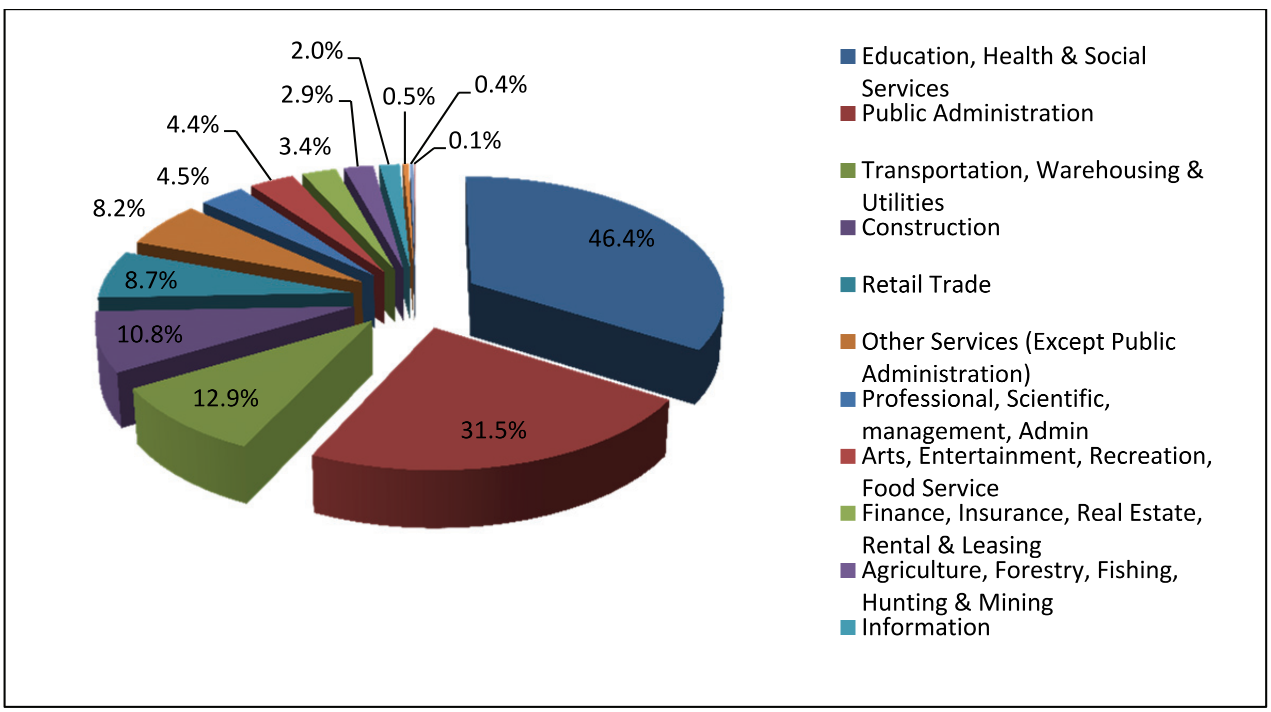


Figure 3.3-4b NSB Employment by Sector (2000).

Source: Alaska Department of Community & Regional Affairs, Community Database Online from 2000 Census

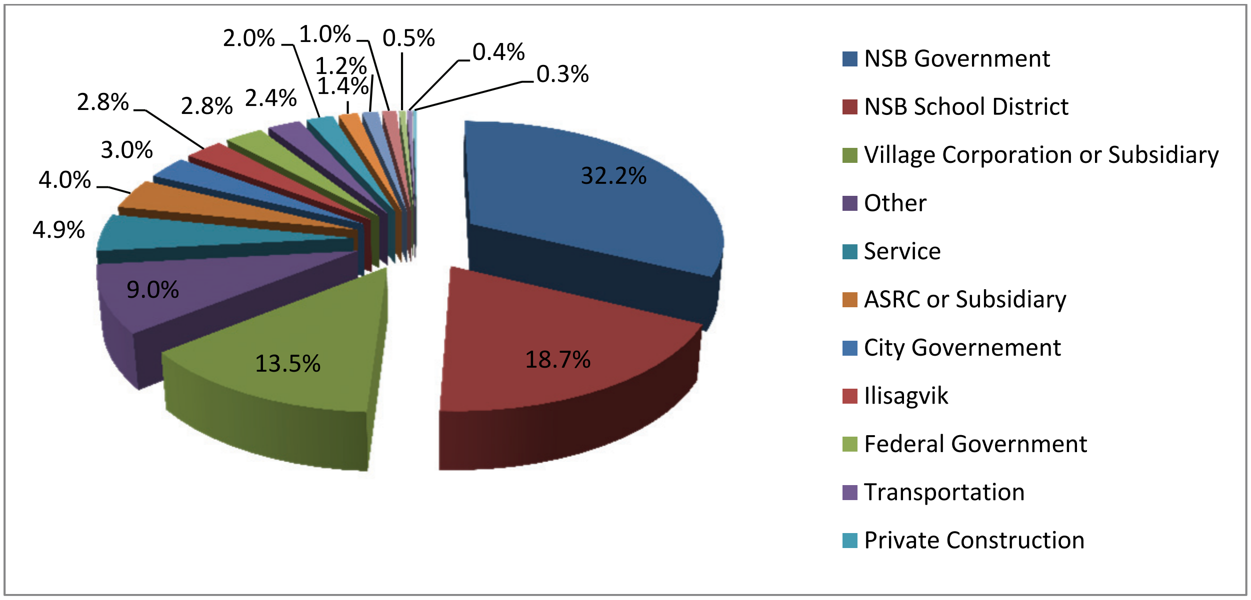


Figure 3.3-4c NAB Major Employment Sectors

Source: Alaska Department of Community & Economic Development, Community Database Online (from 2000 Census)

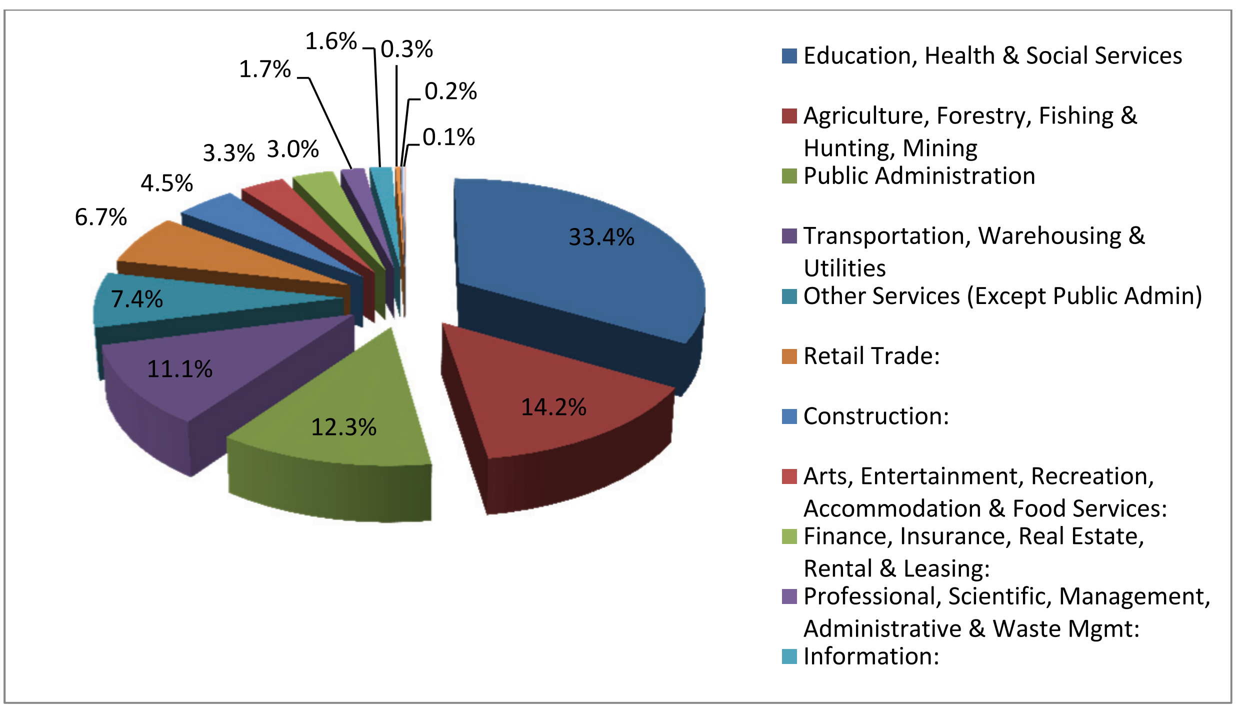


Figure 3.3-5 Percent of Resident Workers by Wage Range (2009).

Source: ADLWD 2011a

Note: Northern Region is indicated in blue (North Slope Borough, Northwest Arctic Borough, and Nome Census Area); State of Alaska is indicated in black.

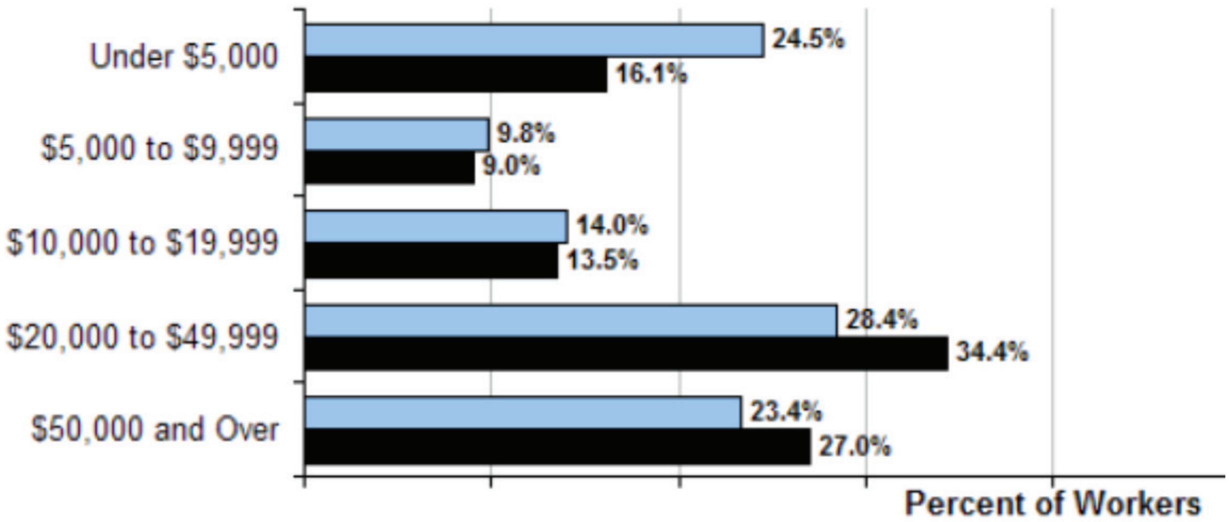


Figure 3.3-6 Efficiency (number landed / number struck) of the bowhead whale subsistence harvest 1973 to 2007.

Source: Suydam et al. 2007

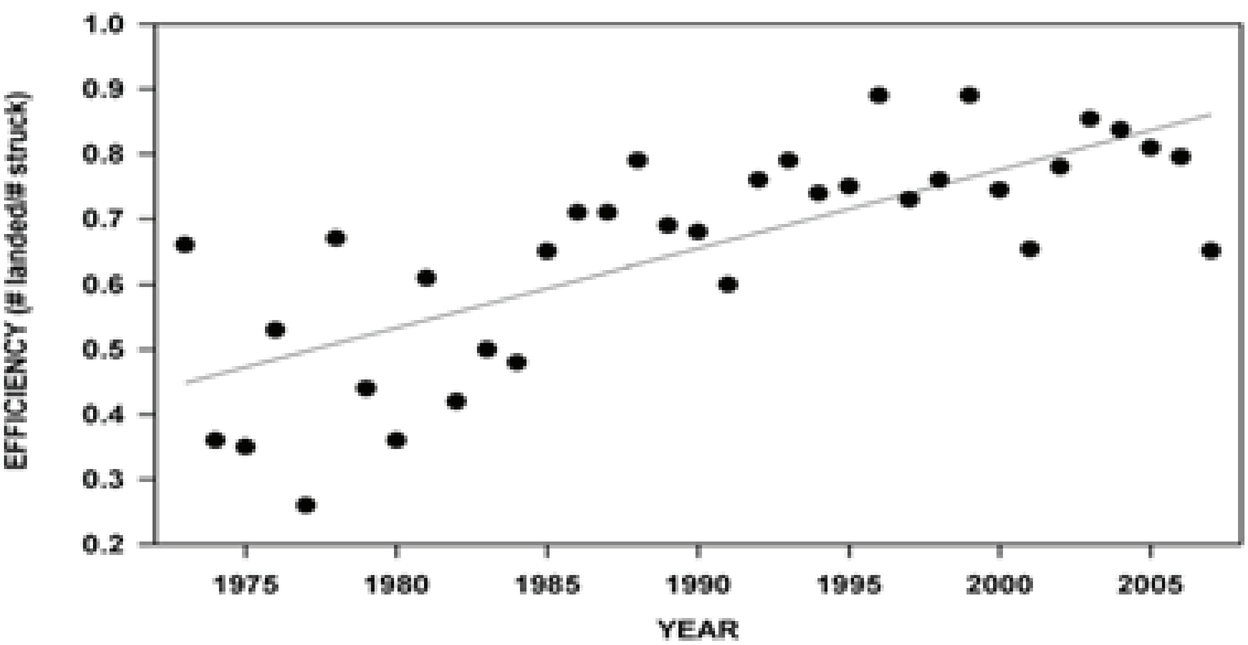


Figure 3.3-7 Number of bowheads landed, and struck by subsistence hunters in the U.S., Canada, and Russia from 1974 to 2006.

Source: NMFS 2008

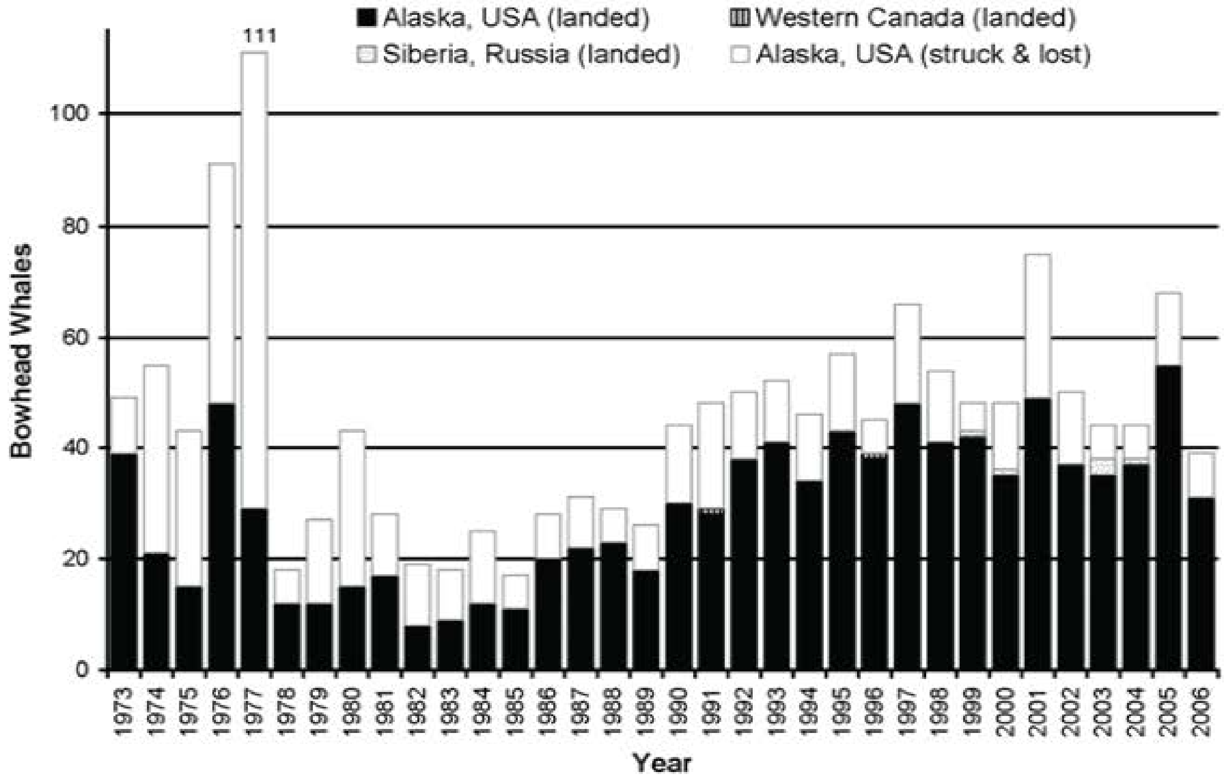


Figure 3.3-8 Winter sea ice in the Beaufort Sea

Source: http://www.photolib.noaa.gov/bigs/corp1014.jpg

Note: Stamukhi zone in the foreground and flatter, smoother, landfast ice in the background.

Figure 3.3-9 Ice floes in the Chukchi Sea

Source: http://www.aslo.org/photopost/showphoto.php/ photo/860/sort/1/size/medium/cat/all/page/2

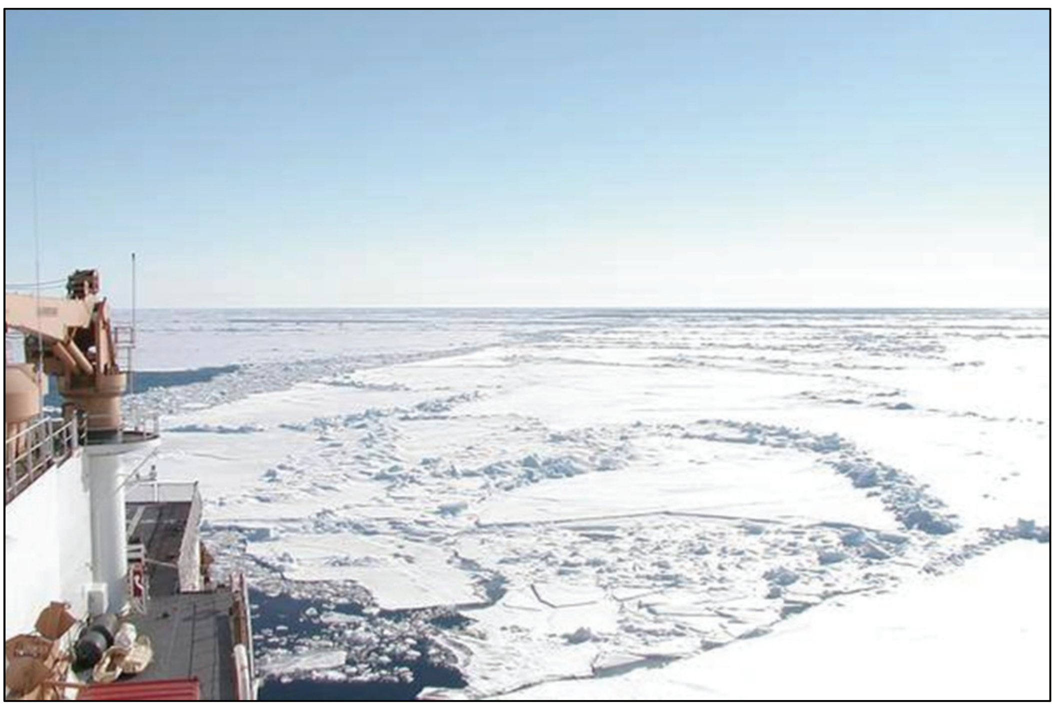


Figure 3.3-10 Coastal flow lead near Barrow, Alaska.

Source: http://boemre-new.gina.alaska.edu/

Note: Landfast ice is on the left and drifting pack ice on the right.

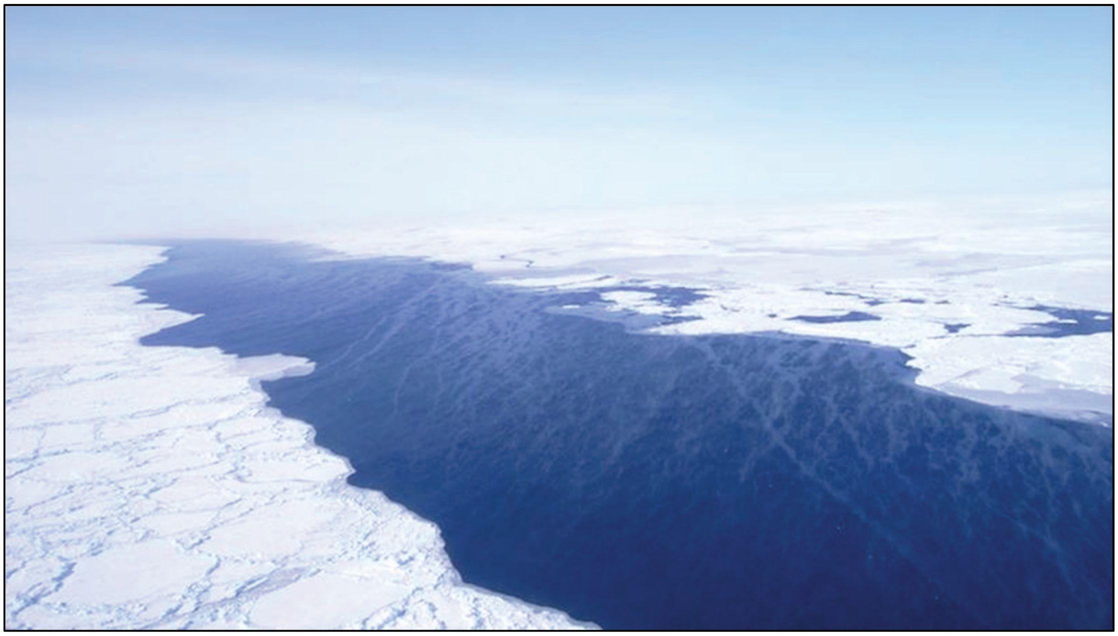


Figure 3.3-11 Open water off the coast of Barrow, Alaska (Summer).

Source: URS Corporation

Figure 3.3-12 Summer in Kotzebue, located on the Chukchi Sea.

Source: http://www.alaska-in-pictures.com/kotzebue-and-chukchi-sea-3103-pictures.htm

Figure 3.3-13 Vegetation located within the EIS project area.

Figure 3.3-14 Oil and Gas Development, Prudhoe Bay.

Source: URS Corporation

Figure 3.3-15 `Mars Ice Island, Beaufort Sea Alaska.

Source: http://www.alaska.boemre. gov/kids/shorts/iceislnd/iceislnd.htm

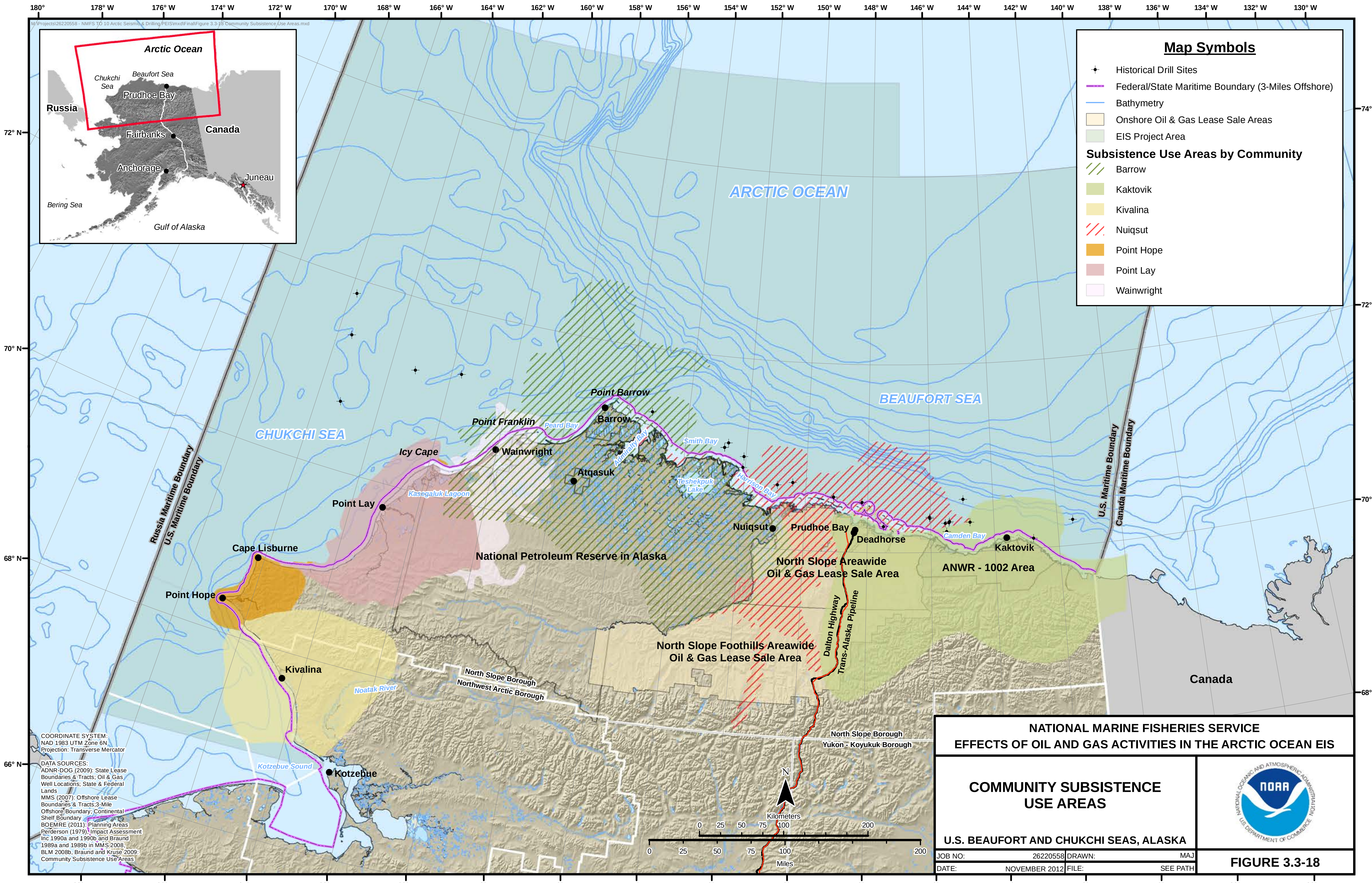
Image shows a 60 day exploratory well built offshore, 8 km off Cape Halkut near NPR-A.

Figure 3.3-16 Pioneer Natural Gas, Oooguruk exploratory drilling site.

Source: http://qa.pennenergy.com/ index/petroleum/display/ 337896/articles/offshore/volume-68/issue-8/Arctic-frontiers/oooguruk-project-offshore-alaska.html

Figure 3.3-17 BP, Liberty exploratory drilling site.

Source: http://www.onepennysheet.com/wp-content/uploads/2010/06/bp-liberty-project-in-ak-fake-island1.jpg



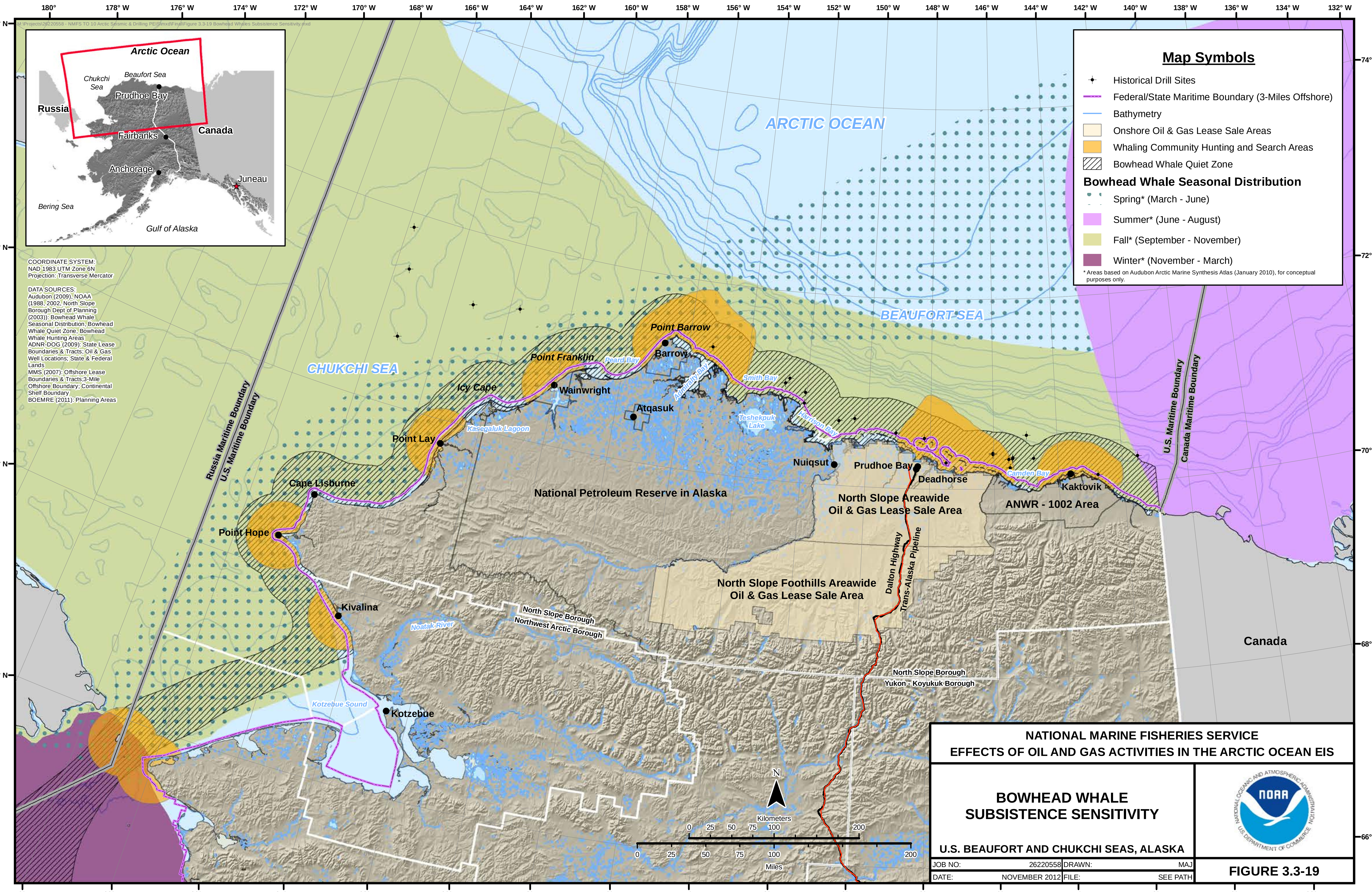
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

COMMUNITY SUBSISTENCE USE AREAS

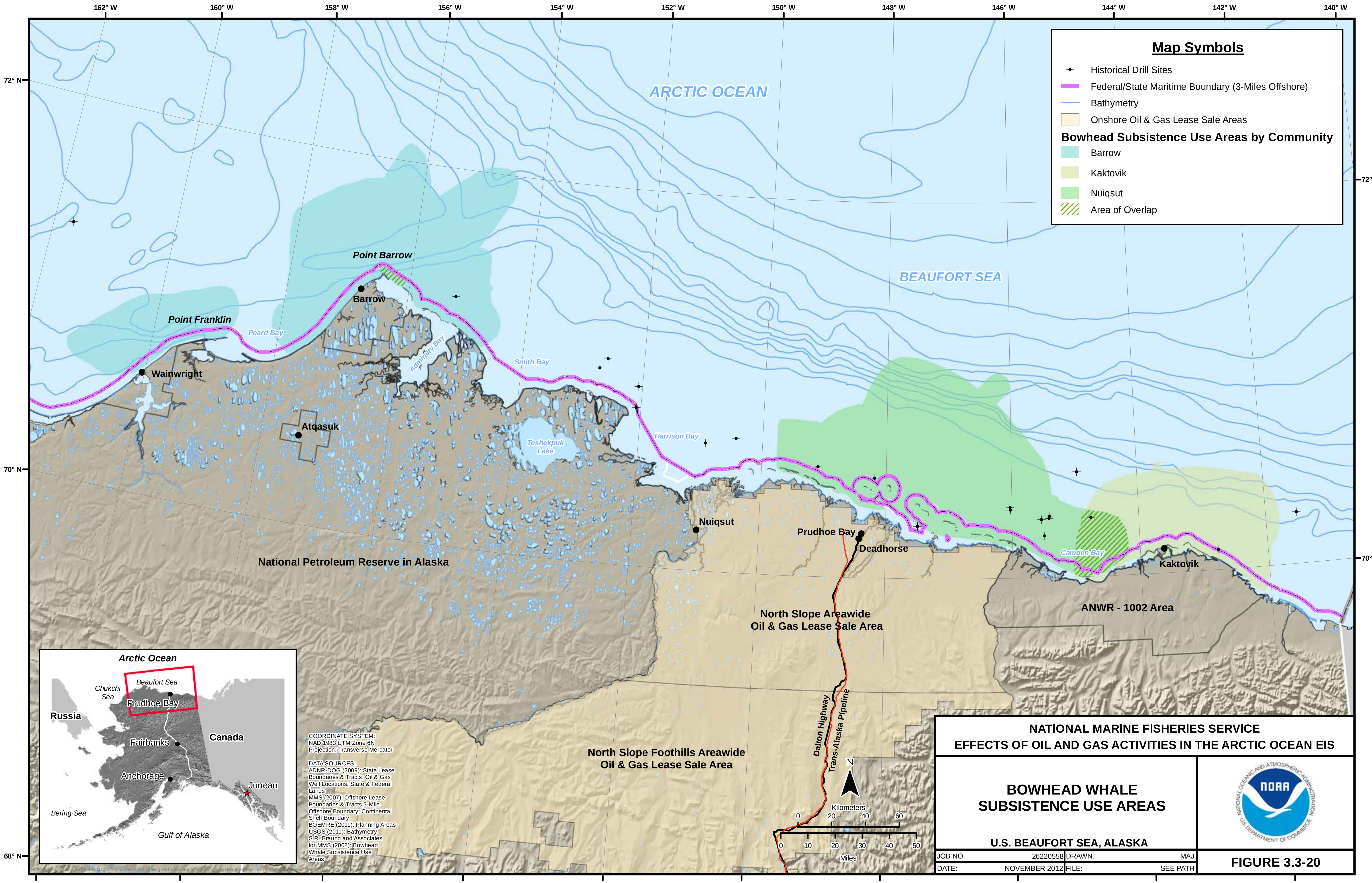
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA

JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.3-18



Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
Audubon (2009), NOAA (1988, 2002, North Slope Borough Dept of Planning (2003)): Bowhead Whale Seasonal Distribution, Bowhead Whale Quiet Zone, Bowhead Whale Hunting Areas
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Whaling Community Hunting and Search Areas
Bowhead Whale Quiet Zone
Bowhead Whale Seasonal Distribution
Spring* (March - June)
Summer* (June - August)
Fall* (September - November)
Winter* (November - March)
* Areas based on Audubon Arctic Marine Synthesis Atlas (January 2010), for conceptual purposes only.
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
U.S. Maritime Boundary
Canada Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Wainwright
Icy Cape
Atqasuk
Admiralty Bay
Smith Bay
Teshekpuk Lake
Harrison Bay
Kasegaluk Lagoon
Point Lay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
Cape Lisburne
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Point Hope
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Kivalina
North Slope Borough
Northwest Arctic Borough
Noatak River
Canada
North Slope Borough
Yukon - Koyukuk Borough
Kotzebue Sound
Kotzebue
Kilometers
0 25 50 75 100 200
0 25 50 75 100 200
Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
BOWHEAD WHALE SUBSISTENCE SENSITIVITY
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.3-19

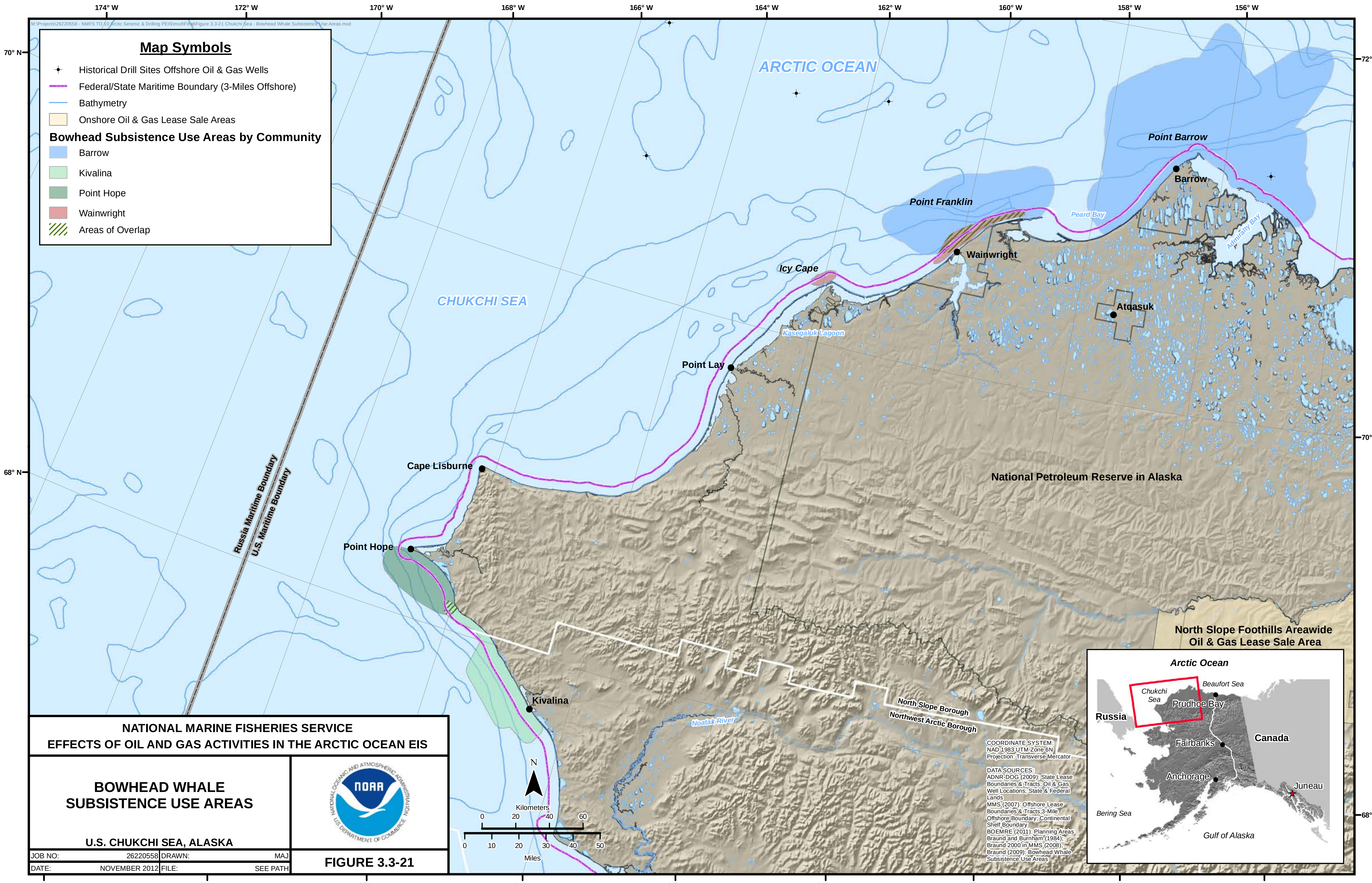


NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

BOWHEAD WHALE SUBSISTENCE USE AREAS

U.S. BEAUFORT SEA, ALASKA

FIGURE 3.3-20



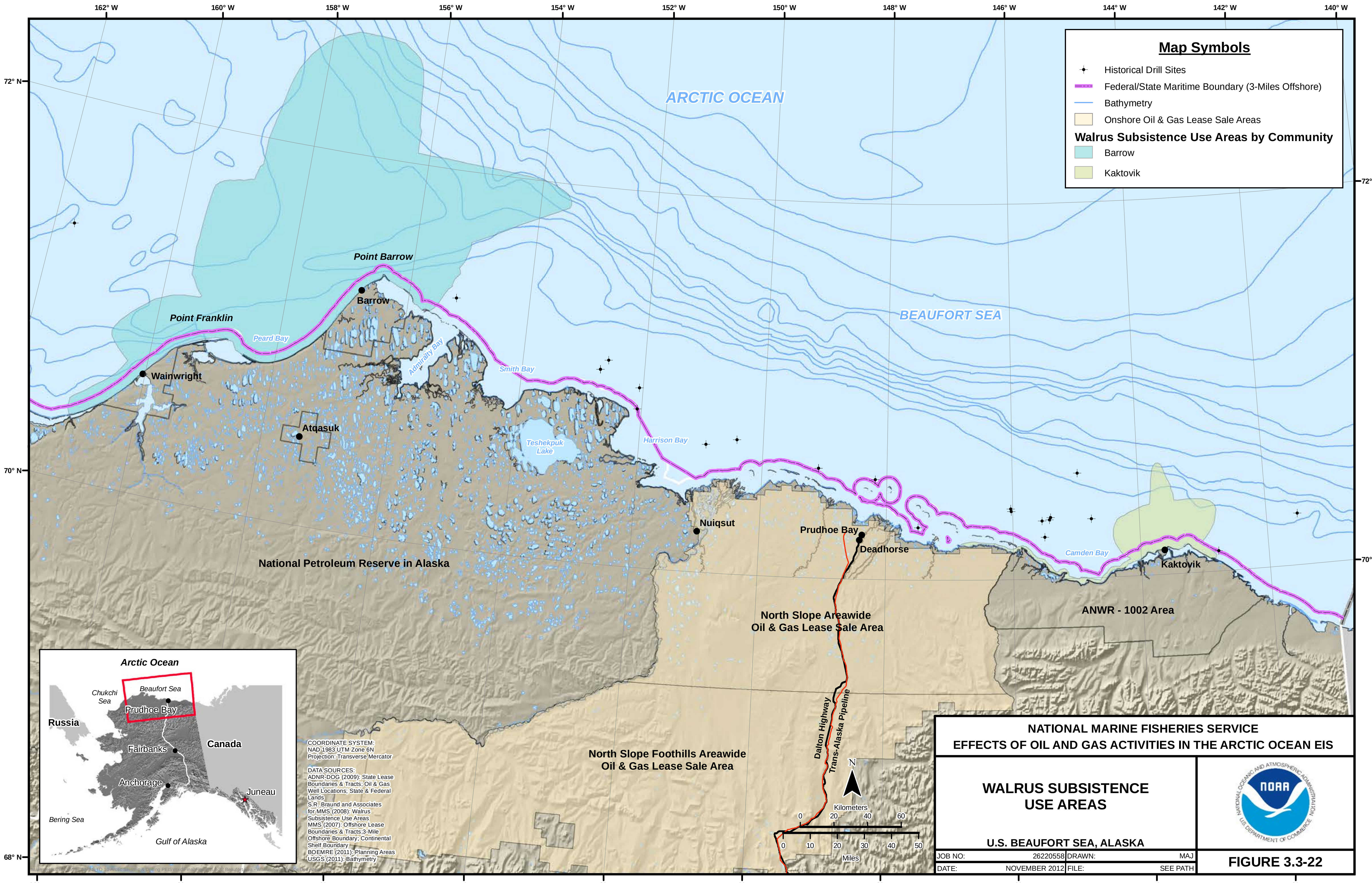
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

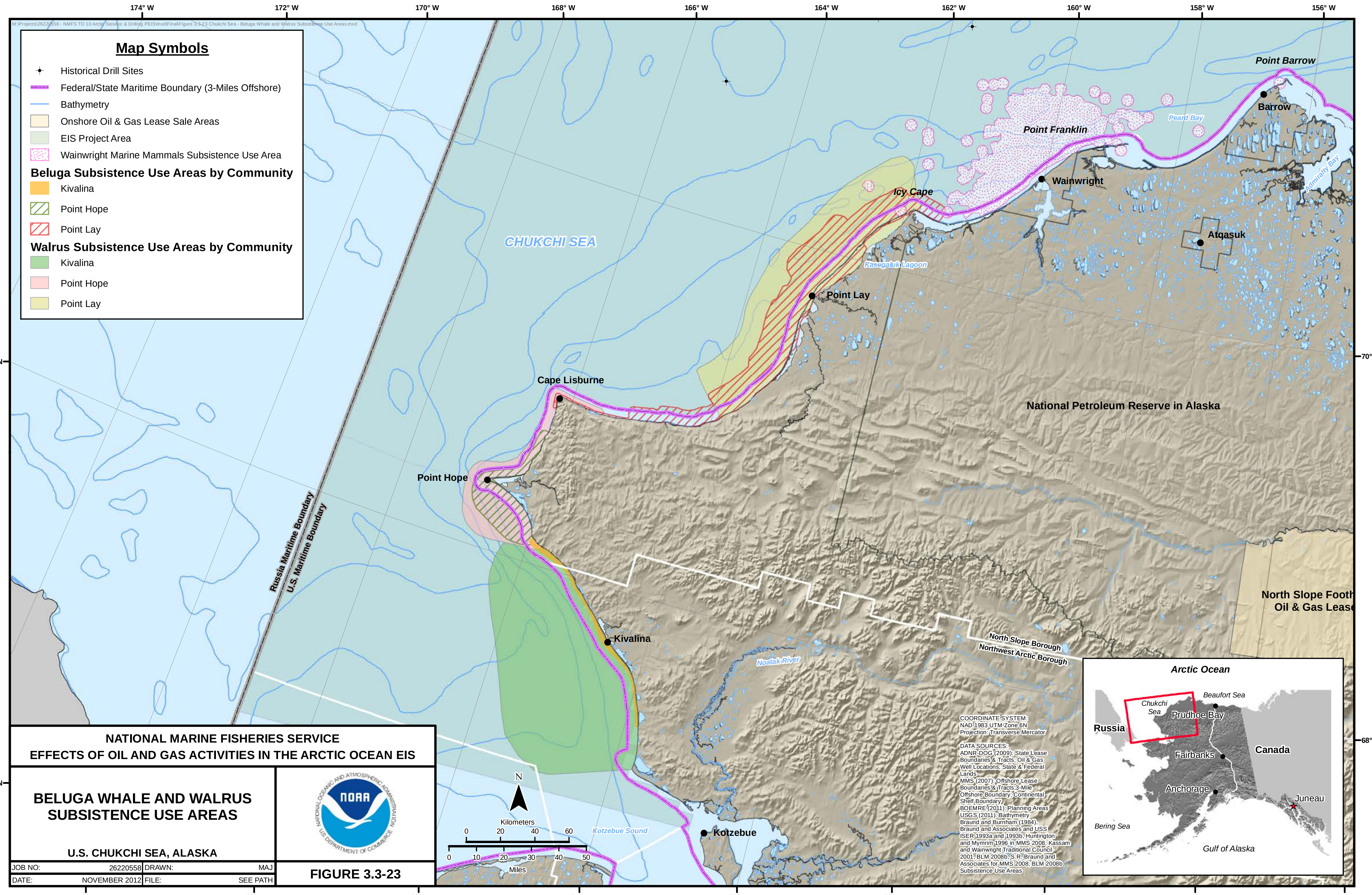
BOWHEAD WHALE SUBSISTENCE USE AREAS

U.S. CHUKCHI SEA, ALASKA

JOB NO: 26220558	DRAWN: MAJ
DATE: NOVEMBER 2012	FILE: SEE PATH

FIGURE 3.3-21


ARCTIC OCEAN
BEAUFORT SEA
Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Walrus Subsistence Use Areas by Community
Barrow
Kaktovik
Point Barrow
Barrow
Point Franklin
Peard Bay
Wainwright
Admiralty Bay
Smith Bay
Atqasuk
Teshekpuk Lake
Harrison Bay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Arctic Ocean
Beaufort Sea
Chukchi Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
S.R. Braund and Associates for MMS (2008): Walrus Subsistence Use Areas
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
N
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
162° W 160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W 140° W
160° W 158° W 156° W 154° W 152° W 150° W 148° W 146° W 144° W 142° W
72° N
70° N
68° N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
WALRUS SUBSISTENCE USE AREAS
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
FIGURE 3.3-22



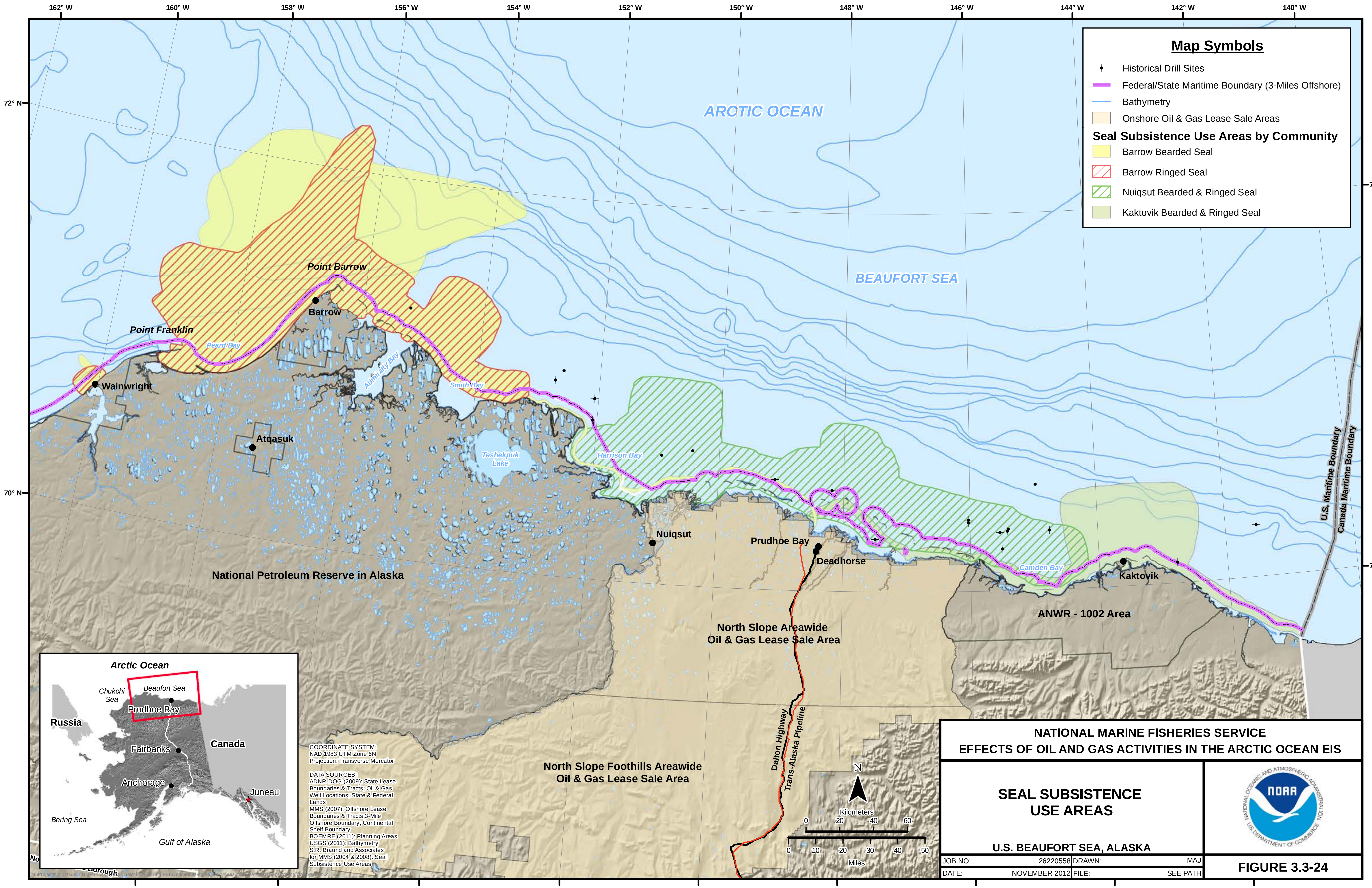
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

BELUGA WHALE AND WALRUS SUBSISTENCE USE AREAS

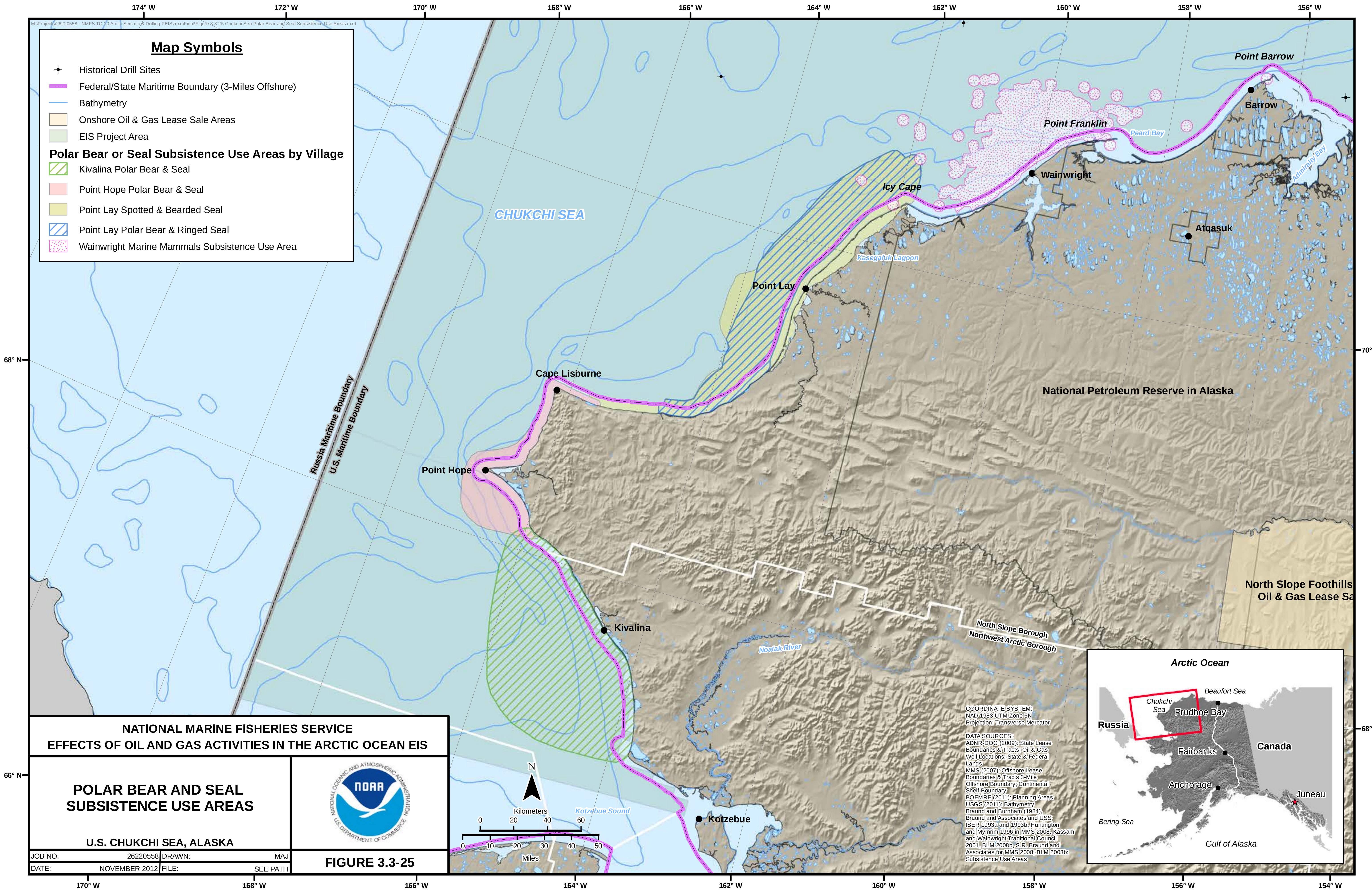
U.S. CHUKCHI SEA, ALASKA

JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.3-23



Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Seal Subsistence Use Areas by Community
Barrow Bearded Seal
Barrow Ringed Seal
Nuiqsut Bearded & Ringed Seal
Kaktovik Bearded & Ringed Seal
ARCTIC OCEAN
BEAUFORT SEA
Point Barrow
Barrow
Point Franklin
Peard Bay
Wainwright
Admiralty Bay
Smith Bay
Atqasuk
Teshekpuk Lake
Harrison Bay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
U.S. Maritime Boundary
Canada Maritime Boundary
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Fairbanks
Canada
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
S.R. Braund and Associates for MMS (2004 & 2008): Seal Subsistence Use Areas
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
SEAL SUBSISTENCE USE AREAS
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.3-24



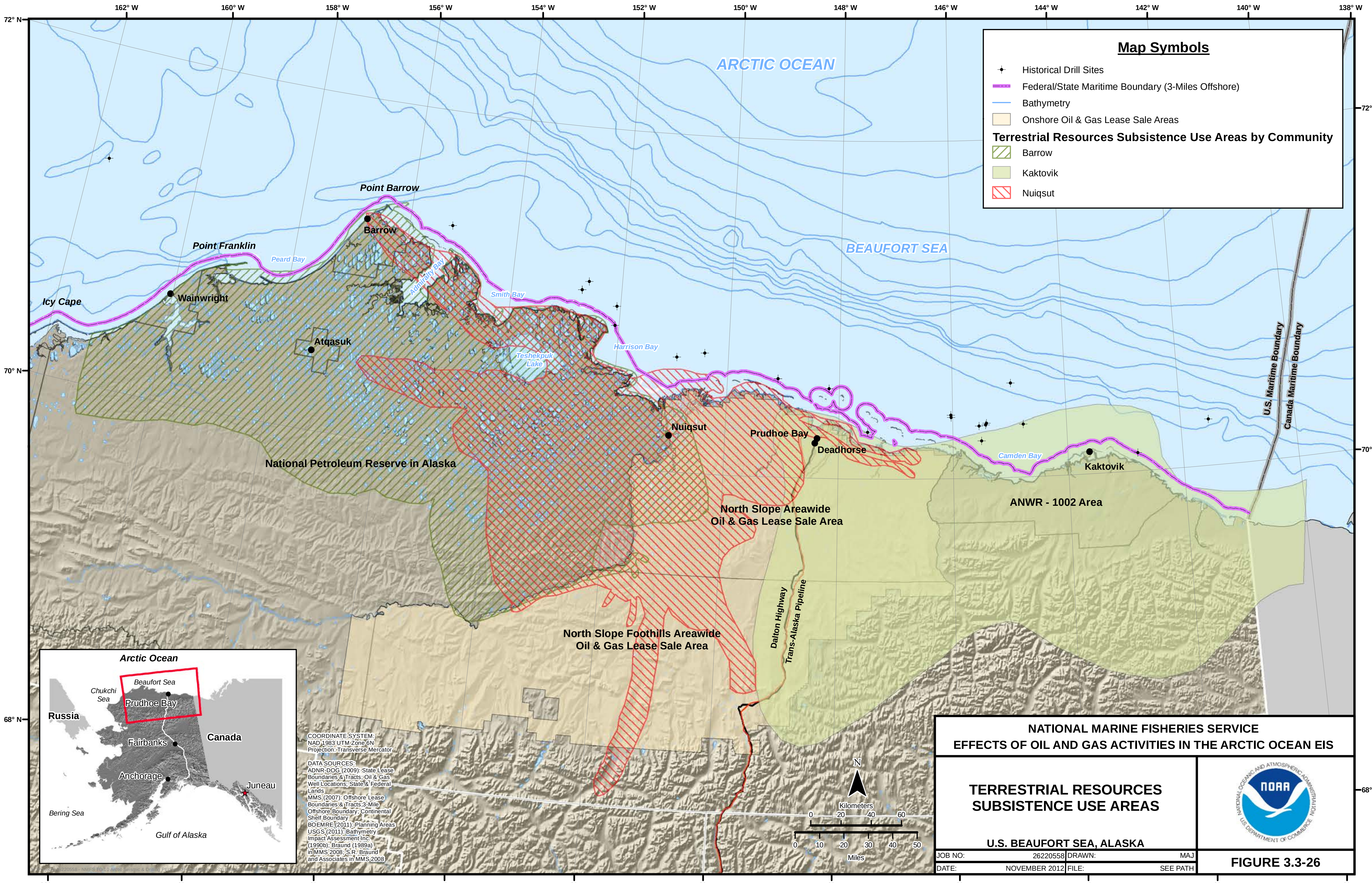
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

POLAR BEAR AND SEAL SUBSISTENCE USE AREAS

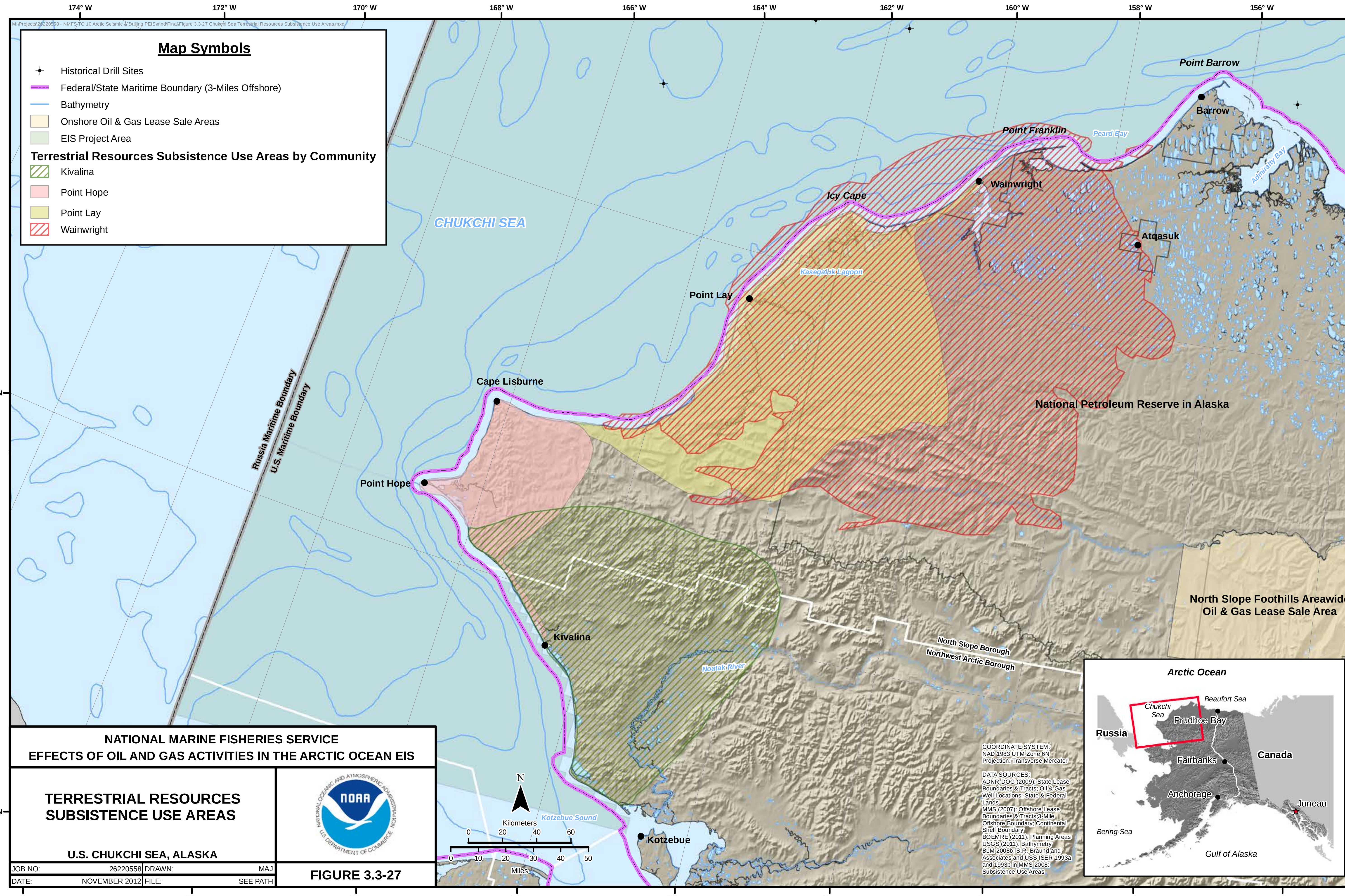
U.S. CHUKCHI SEA, ALASKA

JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.3-25



Map Symbols
Historical Drill Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Onshore Oil & Gas Lease Sale Areas
Terrestrial Resources Subsistence Use Areas by Community
Barrow
Kaktovik
Nuiqsut
ARCTIC OCEAN
BEAUFORT SEA
Point Barrow
Barrow
Point Franklin
Peard Bay
Icy Cape
Wainwright
Atqasuk
Admiralty Bay
Smith Bay
Teshekpuk Lake
Harrison Bay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
U.S. Maritime Boundary
Canada Maritime Boundary
Arctic Ocean
Beaufort Sea
Chukchi Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
Impact Assessment Inc. (1990b); Braund (1989a) in MMS 2008; S.R. Braund and Associates in MMS 2008
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
TERRESTRIAL RESOURCES SUBSISTENCE USE AREAS
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 3.3-26



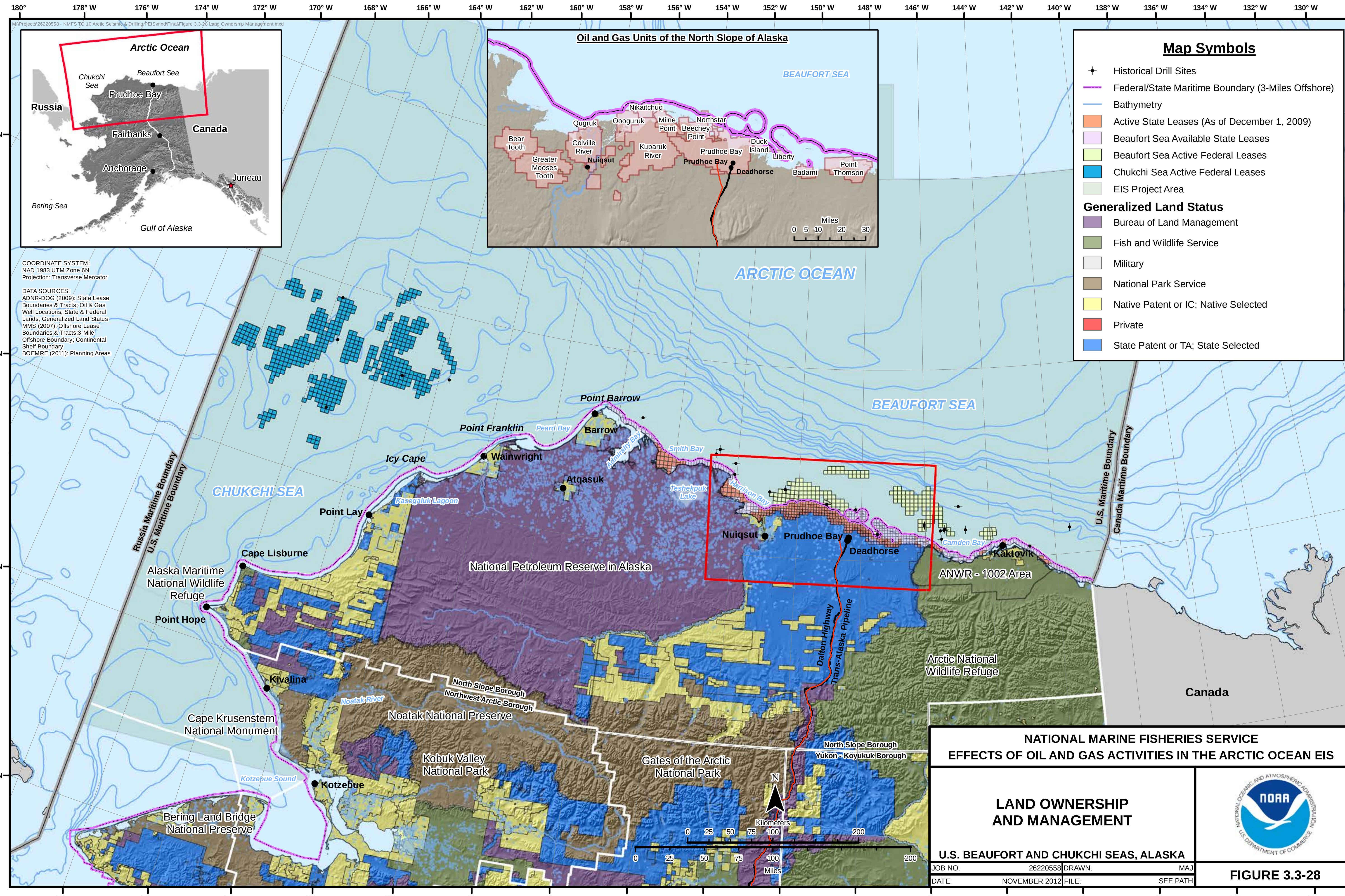
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

TERRESTRIAL RESOURCES SUBSISTENCE USE AREAS

U.S. CHUKCHI SEA, ALASKA

JOB NO:	26220558	DRAWN:	MAJ
DATE:	NOVEMBER 2012	FILE:	SEE PATH

FIGURE 3.3-27



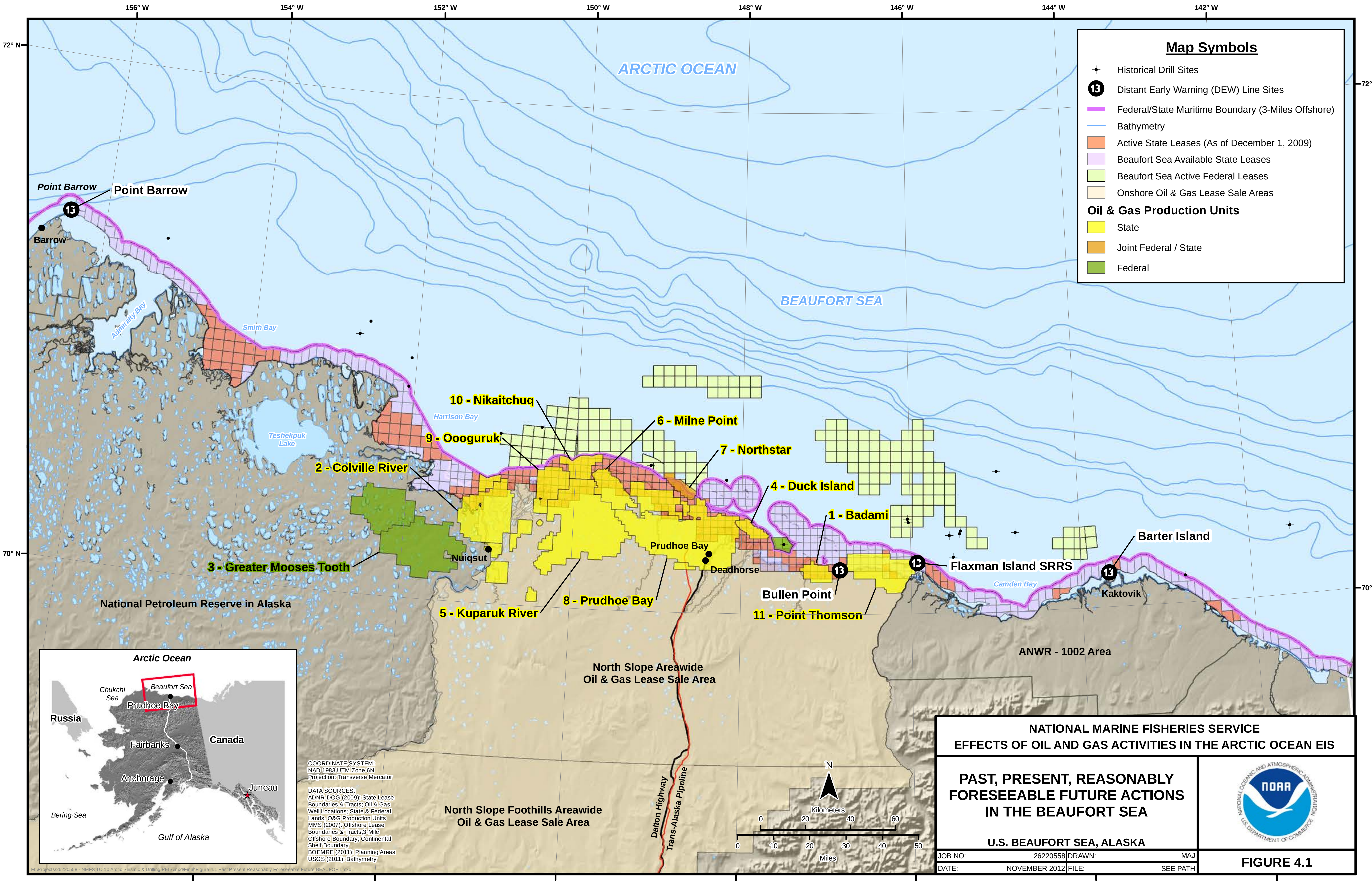
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

LAND OWNERSHIP AND MANAGEMENT

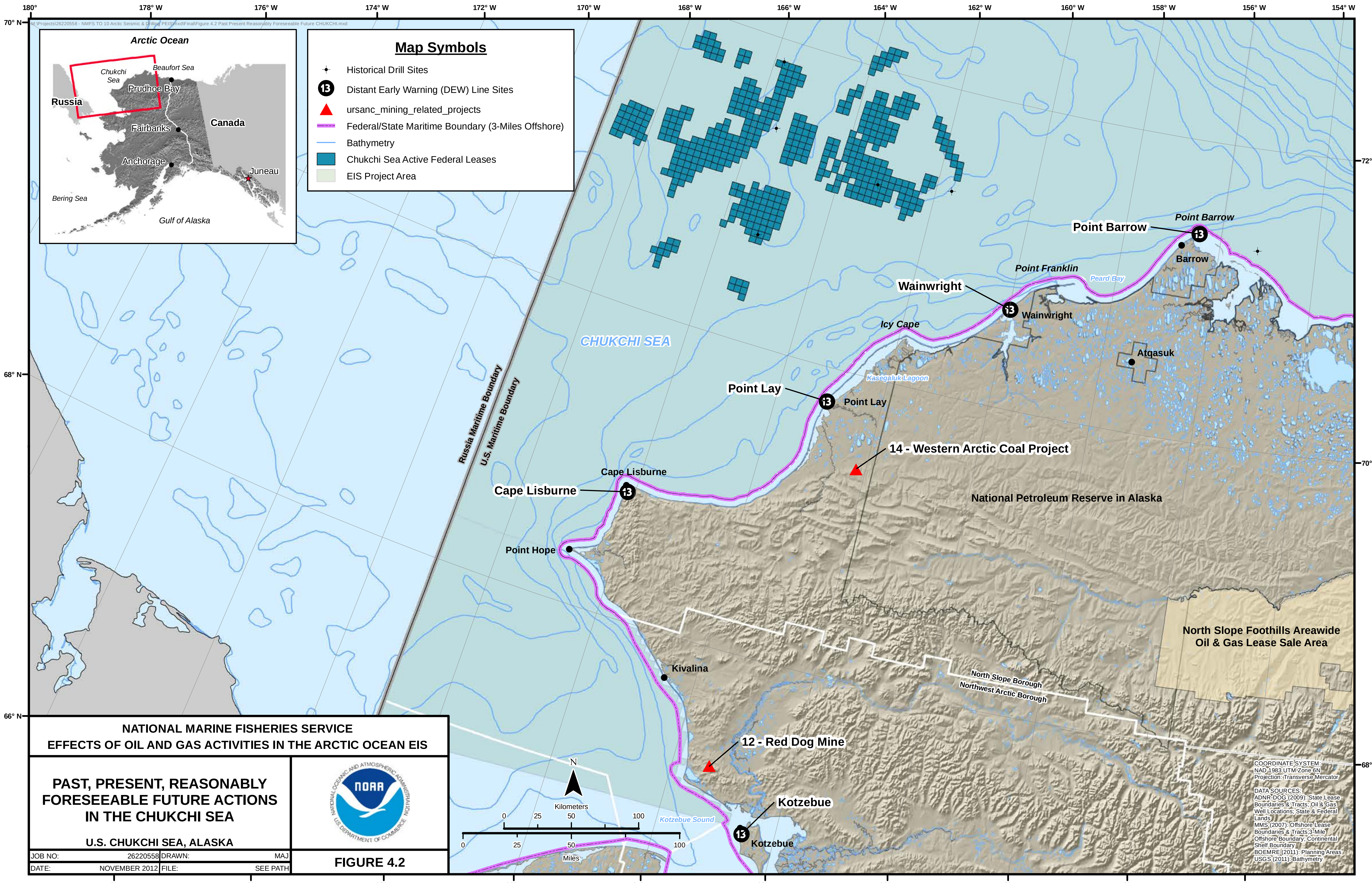
U.S. BEAUFORT AND CHUKCHI SEAS, ALASKA

FIGURE 3.3-28

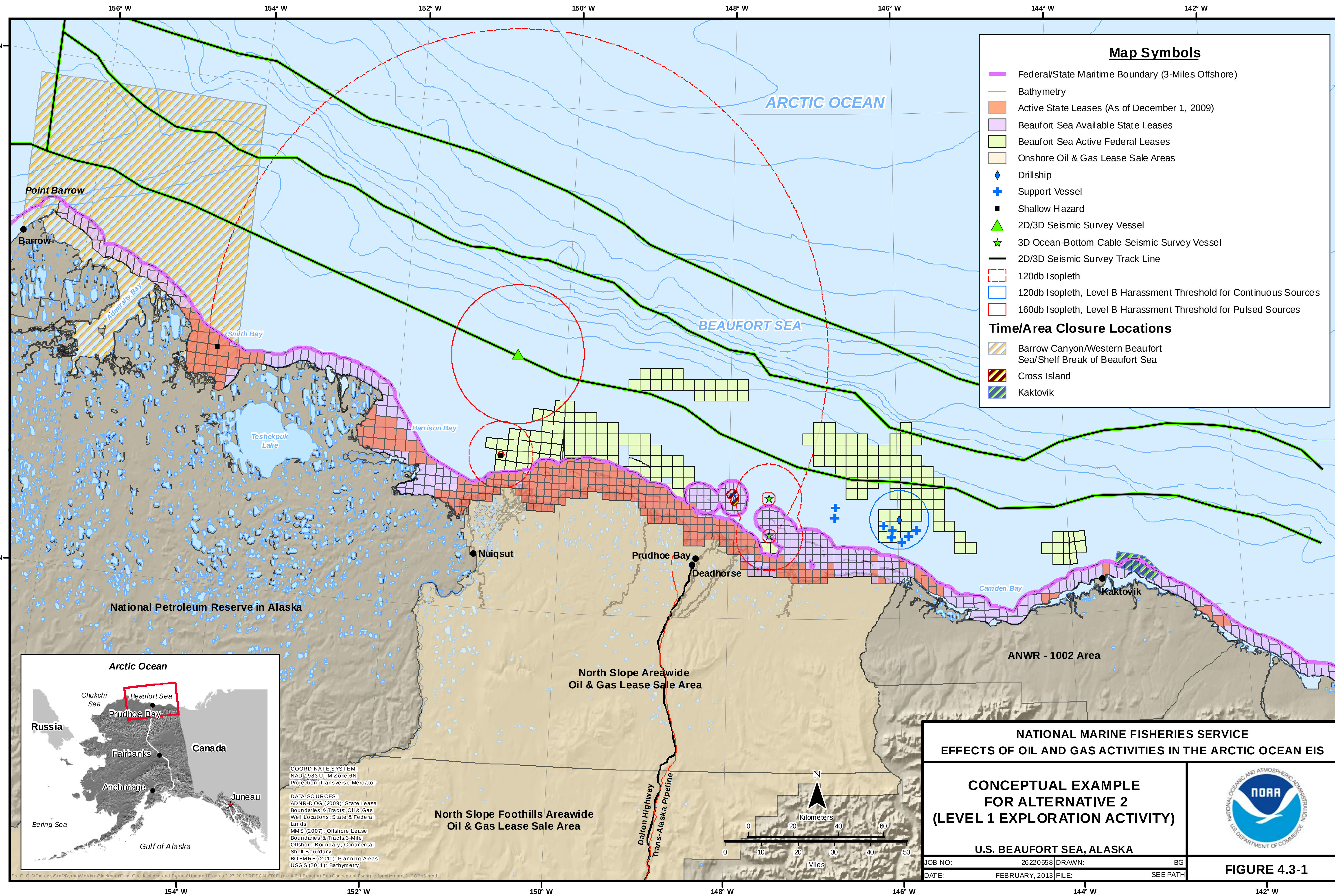
CHAPTER 4 FIGURES



ARCTIC OCEAN
BEAUFORT SEA
Map Symbols
Historical Drill Sites
Distant Early Warning (DEW) Line Sites
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
Oil & Gas Production Units
State
Joint Federal / State
Federal
Point Barrow
Barrow
Admiralty Bay
Smith Bay
Harrison Bay
Teshekpuk Lake
10 - Nikaitchuq
9 - Oooguruk
6 - Milne Point
7 - Northstar
2 - Colville River
4 - Duck Island
1 - Badami
3 - Greater Mooses Tooth
Nuiqsut
Prudhoe Bay
Deadhorse
Bullen Point
Flaxman Island SRRS
Barter Island
Camden Bay
Kaktovik
5 - Kuparuk River
8 - Prudhoe Bay
11 - Point Thomson
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
156° W
154° W
152° W
150° W
148° W
146° W
144° W
142° W
72° N
70° N
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands, O&G Production Units
MMS (2007): Offshore Lease Boundaries & Tracts,3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
N
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
PAST, PRESENT, REASONABLY FORESEEABLE FUTURE ACTIONS IN THE BEAUFORT SEA
U.S. BEAUFORT SEA, ALASKA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 4.1

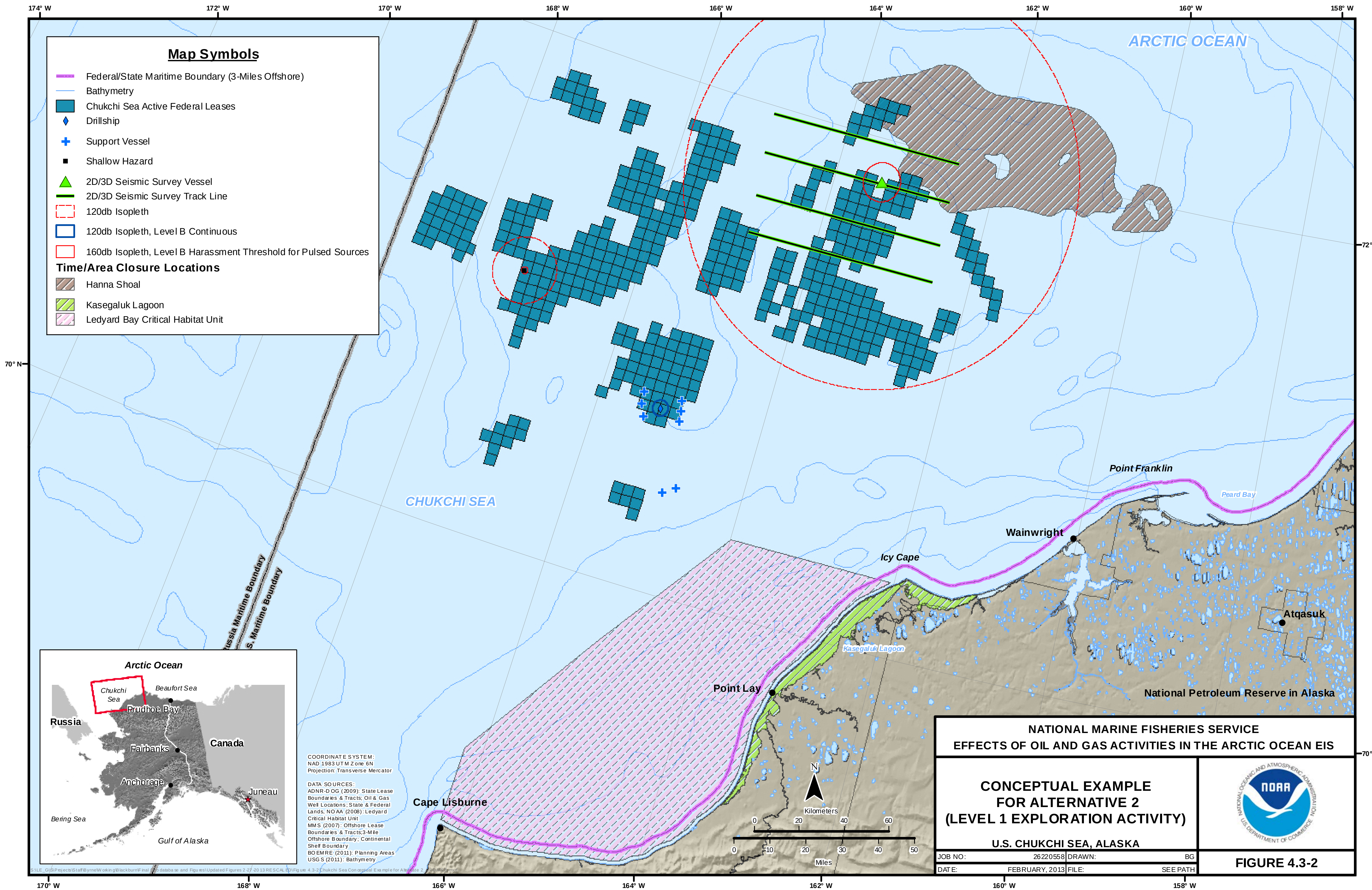


Arctic Ocean
Beaufort Sea
Chukchi Sea
Prudhoe Bay
Russia
Fairbanks
Canada
Anchorage
Juneau
Bering Sea
Gulf of Alaska
Map Symbols
Historical Drill Sites
Distant Early Warning (DEW) Line Sites
ursanc_mining_related_projects
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Chukchi Sea Active Federal Leases
EIS Project Area
CHUKCHI SEA
Russia Maritime Boundary
U.S. Maritime Boundary
Point Barrow
Barrow
Point Franklin
Peard Bay
Wainwright
Icy Cape
Atqasuk
Kasegaluk Lagoon
Point Lay
14 - Western Arctic Coal Project
Cape Lisburne
National Petroleum Reserve in Alaska
Point Hope
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Kivalina
North Slope Borough
Northwest Arctic Borough
12 - Red Dog Mine
Kotzebue
Kotzebue Sound
N
Kilometers
0 25 50 100
Miles
0 25 50 100
COORDINATE SYSTEM: NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES: ADNR-DOG (2009): State Lease Boundaries & Tracts, Oil & Gas Well Locations, State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts, 3-Mile Offshore Boundary, Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
180° 178° W 176° W 174° W 172° W 170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W
70° N 68° N 66° N 72° N 70° N 68° N
172° W 170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
PAST, PRESENT, REASONABLY FORESEEABLE FUTURE ACTIONS IN THE CHUKCHI SEA
U.S. CHUKCHI SEA, ALASKA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE
JOB NO: 26220558
DRAWN: MAJ
DATE: NOVEMBER 2012
FILE: SEE PATH
FIGURE 4.2



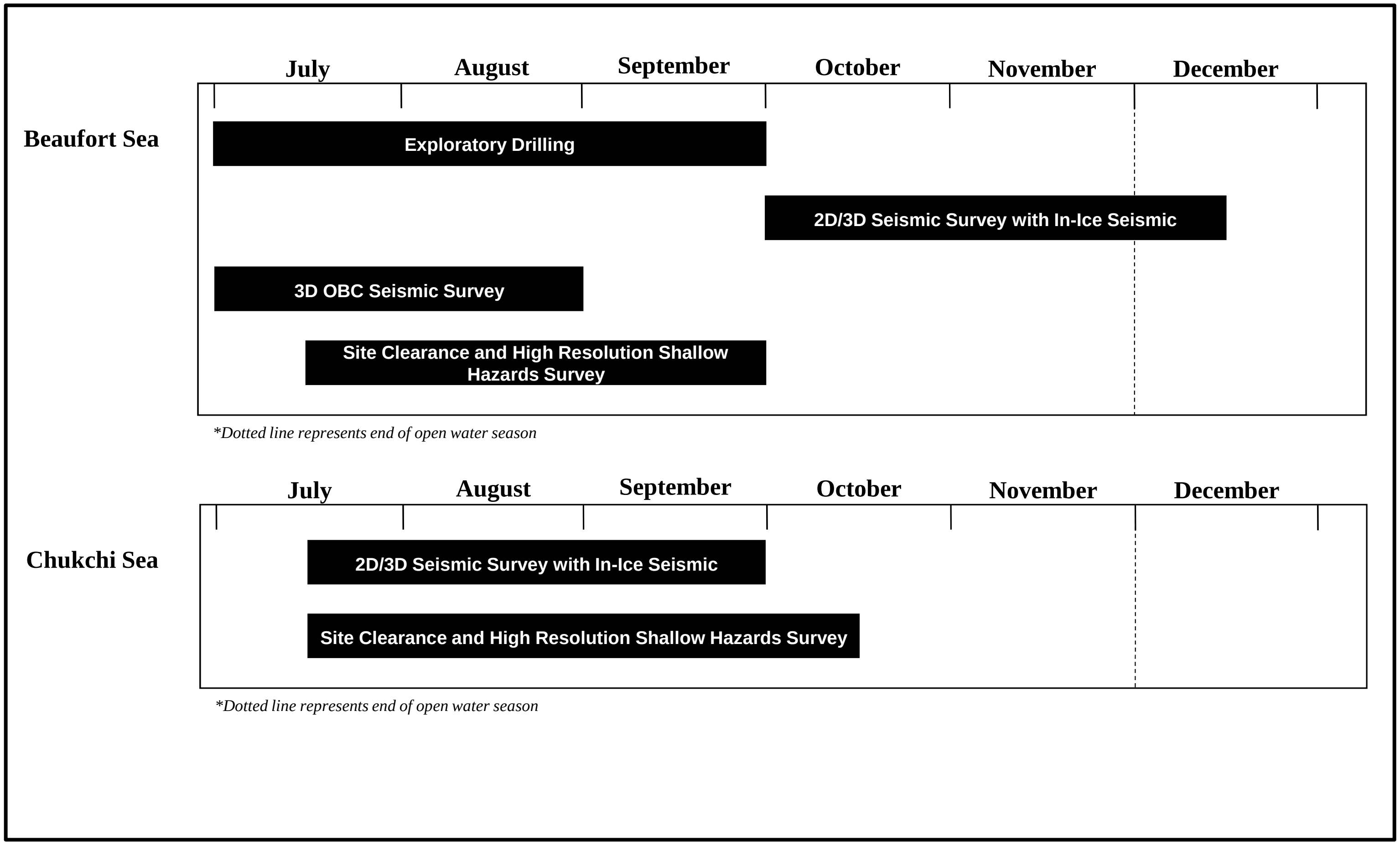
Map Symbols
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
Drillship
Support Vessel
Shallow Hazard
2D/3D Seismic Survey Vessel
3D Ocean-Bottom Cable Seismic Survey Vessel
2D/3D Seismic Survey Track Line
120db Isopleth
120db Isopleth, Level B Harassment Threshold for Continuous Sources
160db Isopleth, Level B Harassment Threshold for Pulsed Sources
Time/Area Closure Locations
Barrow Canyon/Western Beaufort Sea/Shelf Break of Beaufort Sea
Cross Island
Kaktovik
ARCTIC OCEAN
BEAUFORT SEA
Point Barrow
Barrow
Admiralty Bay
Smith Bay
Harrison Bay
Teshekpuk Lake
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
ANWR - 1002 Area
North Slope Areawide Oil & Gas Lease Sale Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
Dalton Highway
Trans-Alaska Pipeline
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts; 3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
Kilometers
0 20 40 60
Miles
0 10 20 30 40 50
156° W
154° W
152° W
150° W
148° W
146° W
144° W
142° W
72° N
70° N
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
CONCEPTUAL EXAMPLE FOR ALTERNATIVE 2 (LEVEL 1 EXPLORATION ACTIVITY)
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558
DRAWN: BG
DATE: FEBRUARY, 2013
FILE: SEE PATH

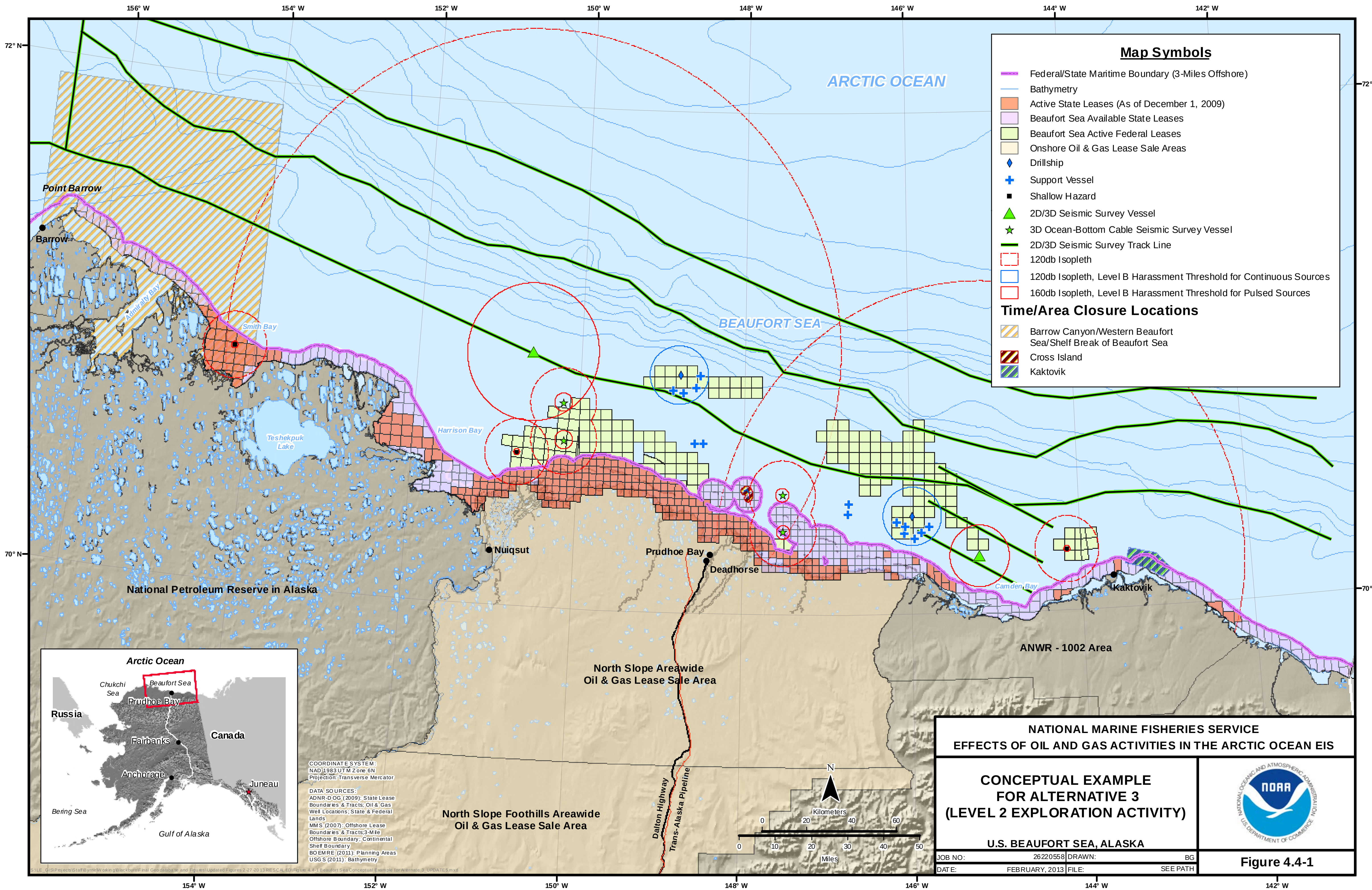
FIGURE 4.3-1



Map Symbols
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Chukchi Sea Active Federal Leases
Drillship
Support Vessel
Shallow Hazard
2D/3D Seismic Survey Vessel
2D/3D Seismic Survey Track Line
120db Isopleth
120db Isopleth, Level B Continuous
160db Isopleth, Level B Harassment Threshold for Pulsed Sources
Time/Area Closure Locations
Hanna Shoal
Kasegaluk Lagoon
Ledyard Bay Critical Habitat Unit
ARCTIC OCEAN
CHUKCHI SEA
Point Franklin
Peard Bay
Wainwright
Icy Cape
Atqasuk
Kasegaluk Lagoon
Point Lay
National Petroleum Reserve in Alaska
Cape Lisburne
Russia Maritime Boundary
U.S. Maritime Boundary
174° W
172° W
170° W
168° W
166° W
164° W
162° W
160° W
158° W
72° N
70° N
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands, NOAA (2008): Ledyard Critical Habitat Unit
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
N
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
CONCEPTUAL EXAMPLE
FOR ALTERNATIVE 2
(LEVEL 1 EXPLORATION ACTIVITY)
U.S. CHUKCHI SEA, ALASKA
JOB NO: 26220558
DRAWN: BG
DATE: FEBRUARY, 2013
FILE: SEE PATH
FIGURE 4.3-2

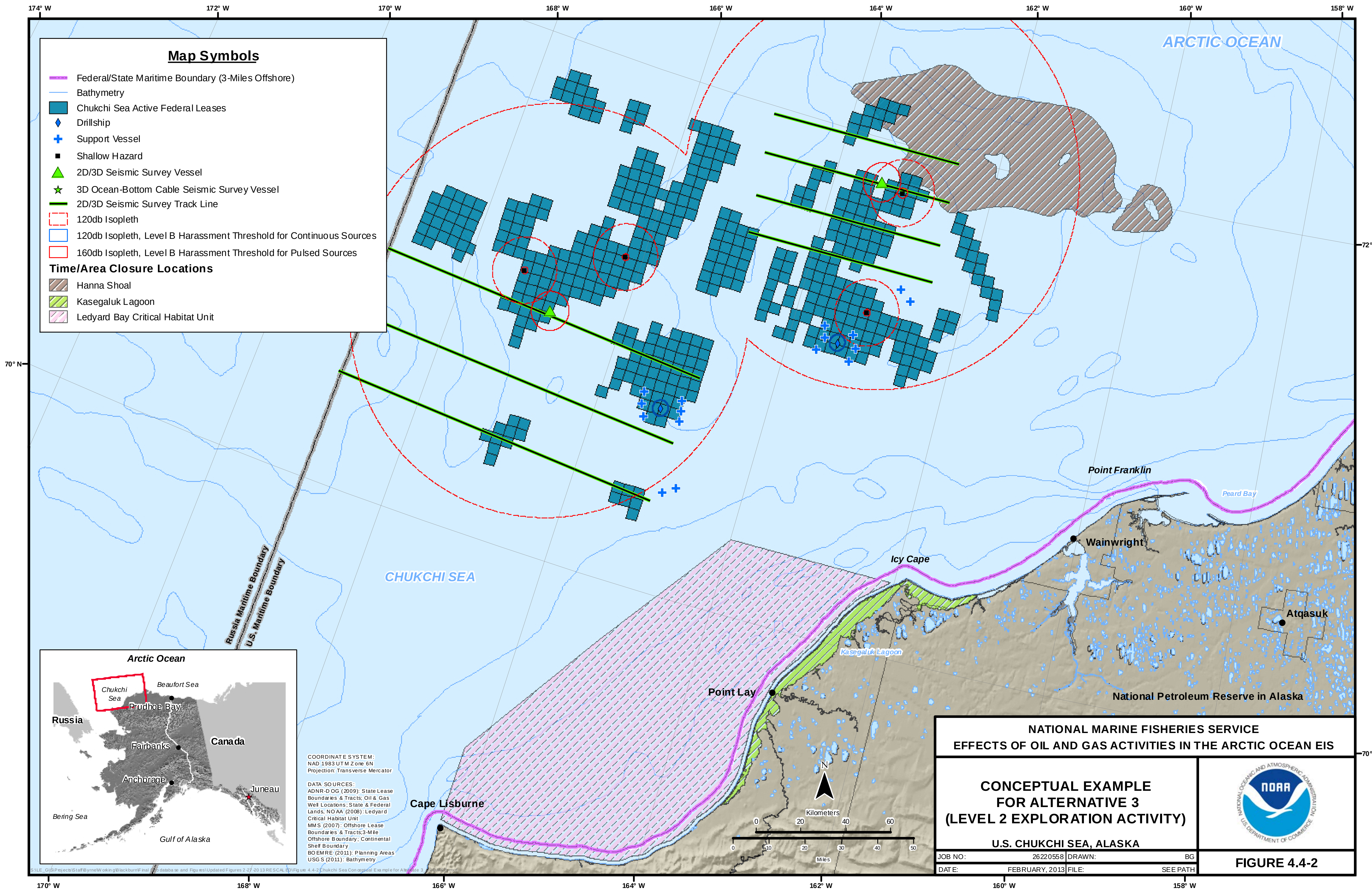
Figure 4.3-3 Temporal Conceptual Example under Alternative 2 (Level 1 Exploration Activity)





ARCTIC OCEAN
BEAUFORT SEA
Map Symbols
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
Drillship
Support Vessel
Shallow Hazard
2D/3D Seismic Survey Vessel
3D Ocean-Bottom Cable Seismic Survey Vessel
2D/3D Seismic Survey Track Line
120db Isopleth
120db Isopleth, Level B Harassment Threshold for Continuous Sources
160db Isopleth, Level B Harassment Threshold for Pulsed Sources
Time/Area Closure Locations
Barrow Canyon/Western Beaufort Sea/Shelf Break of Beaufort Sea
Cross Island
Kaktovik
Point Barrow
Barrow
Admiralty Bay
Smith Bay
Teshekpuk Lake
Harrison Bay
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Dalton Highway
Trans-Alaska Pipeline
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
N
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
CONCEPTUAL EXAMPLE FOR ALTERNATIVE 3 (LEVEL 2 EXPLORATION ACTIVITY)
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558
DRAWN: BG
DATE: FEBRUARY, 2013
FILE: SEE PATH
156° W
154° W
152° W
150° W
148° W
146° W
144° W
142° W
72° N
70° N

Figure 4.4-1



NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

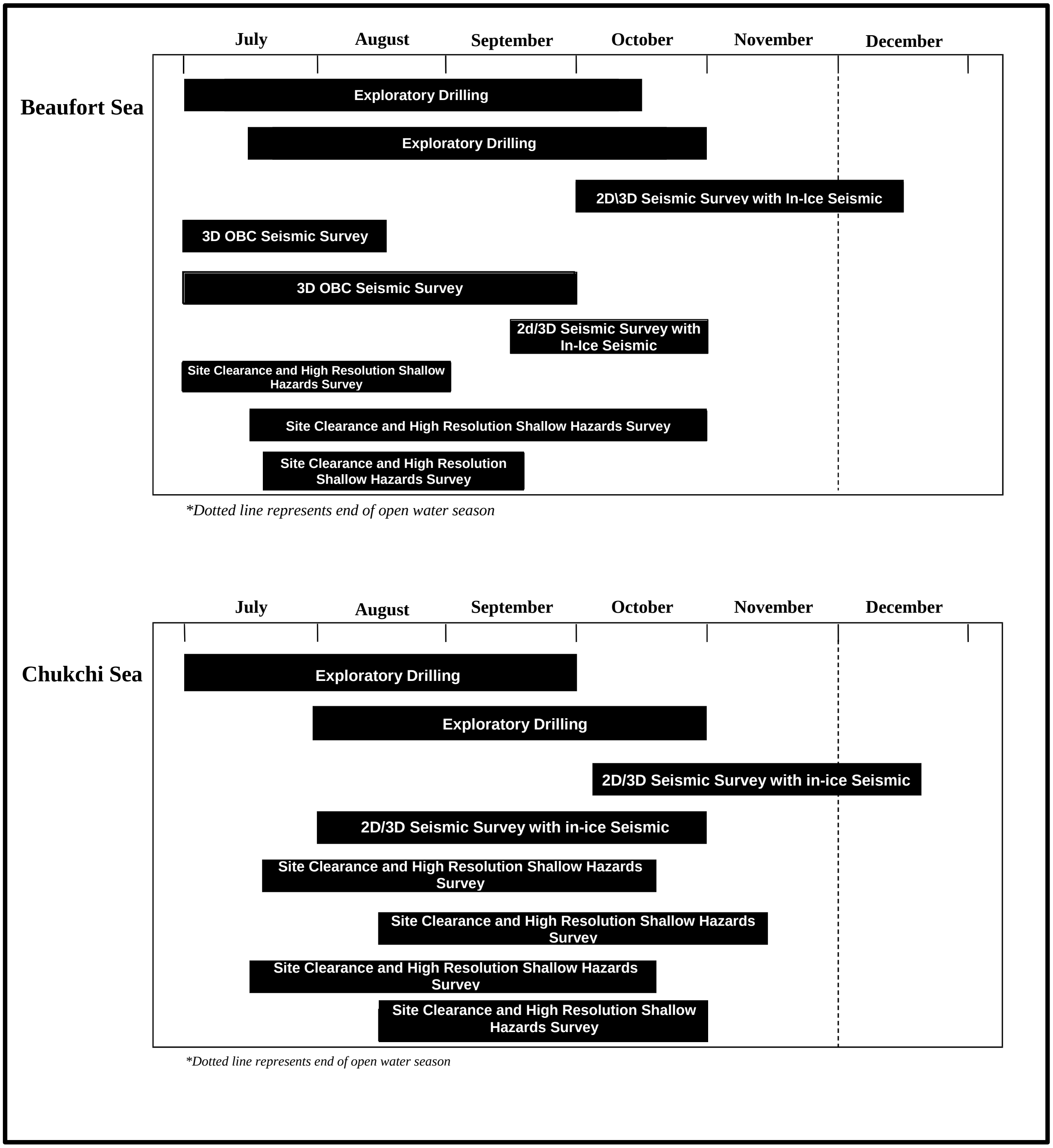
CONCEPTUAL EXAMPLE FOR ALTERNATIVE 3 (LEVEL 2 EXPLORATION ACTIVITY)

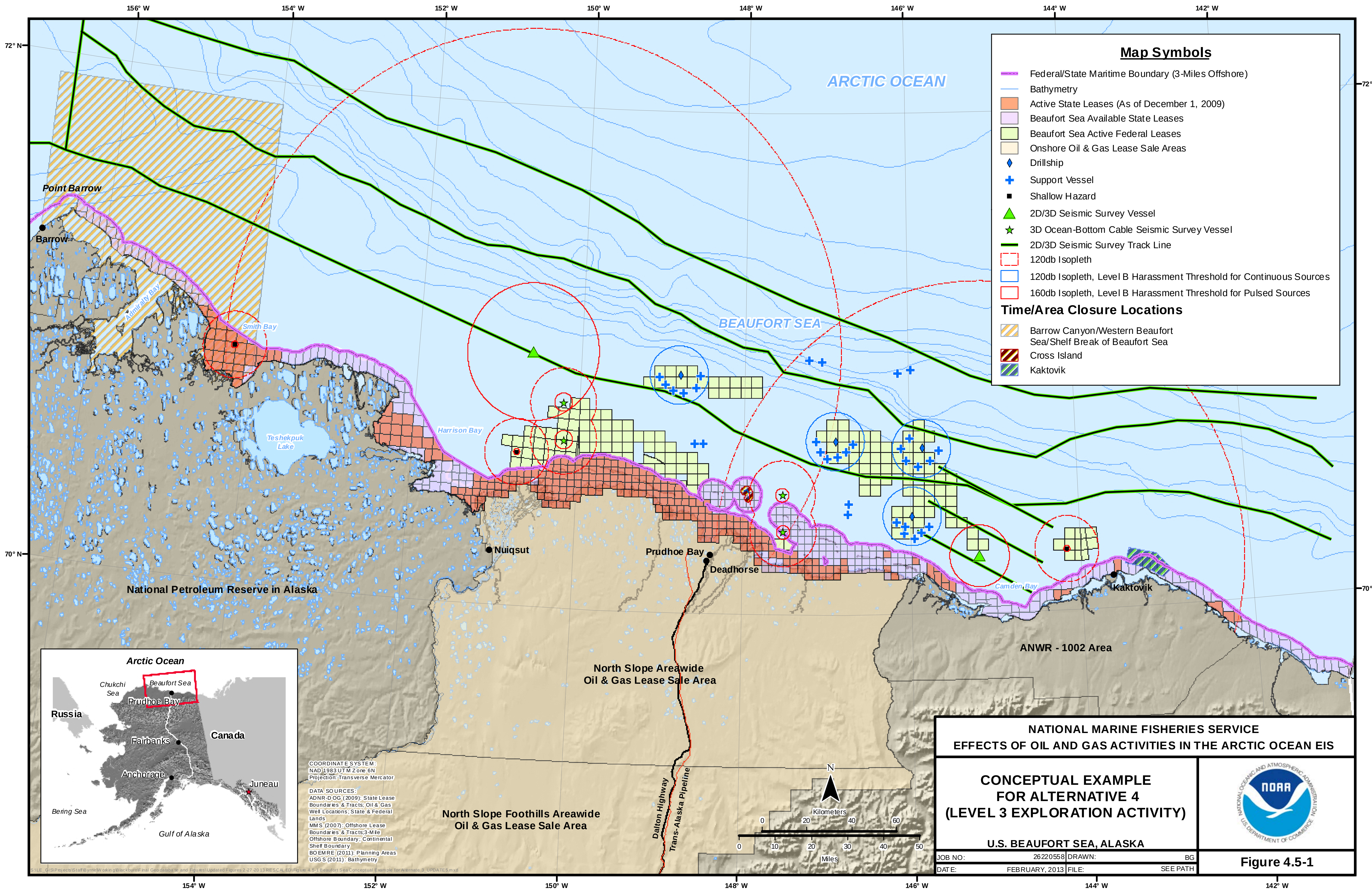
U.S. CHUKCHI SEA, ALASKA

JOB NO:	26220558	DRAWN:	BG
DATE:	FEBRUARY, 2013	FILE:	SEE PATH

FIGURE 4.4-2

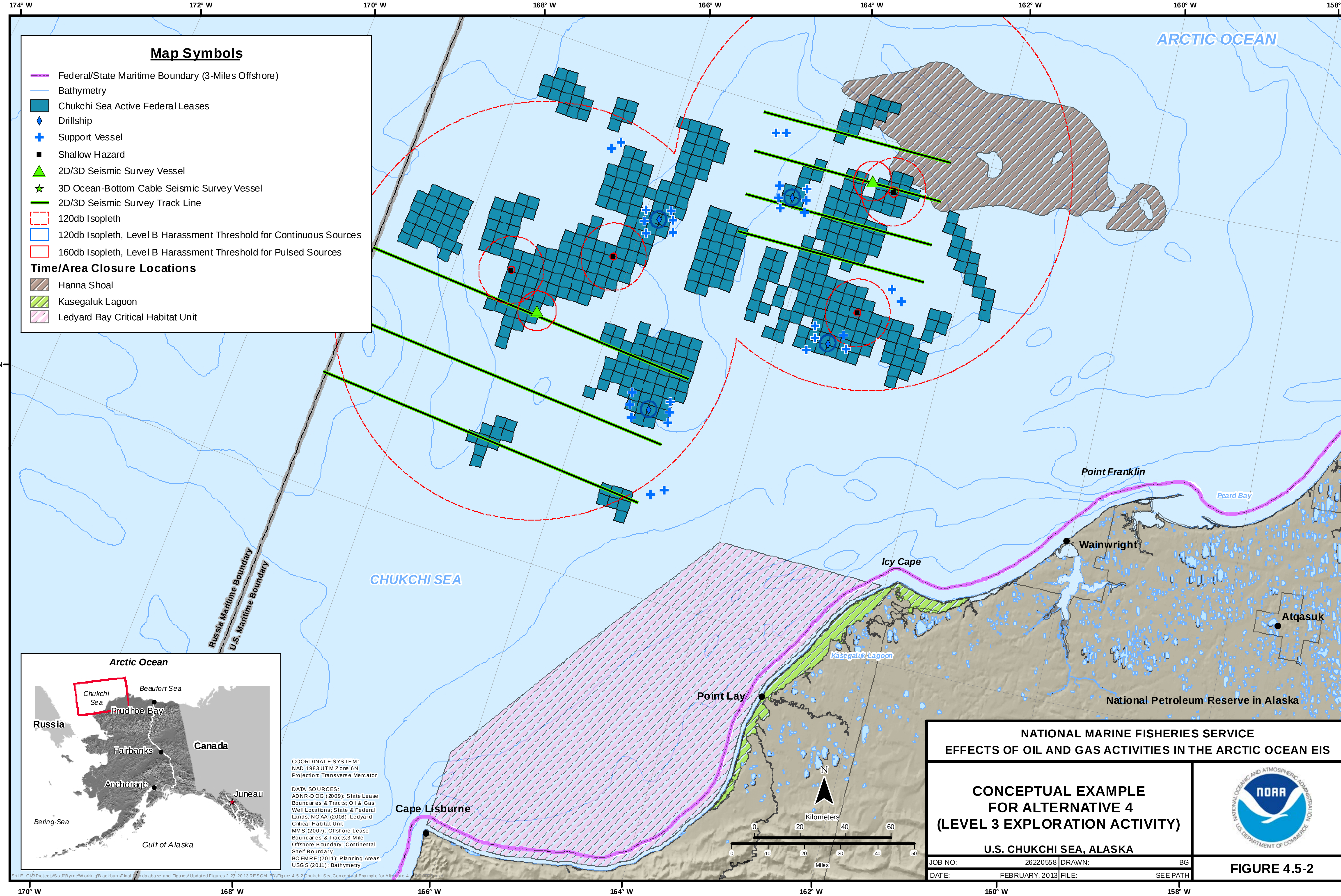
Figure 4.4-3 Temporal Conceptual Examples under Alternative 3 (Level 2 Exploration Activity)





Map Symbols
Federal/State Maritime Boundary (3-Miles Offshore)
Bathymetry
Active State Leases (As of December 1, 2009)
Beaufort Sea Available State Leases
Beaufort Sea Active Federal Leases
Onshore Oil & Gas Lease Sale Areas
Drillship
Support Vessel
Shallow Hazard
2D/3D Seismic Survey Vessel
3D Ocean-Bottom Cable Seismic Survey Vessel
2D/3D Seismic Survey Track Line
120db Isopleth
120db Isopleth, Level B Harassment Threshold for Continuous Sources
160db Isopleth, Level B Harassment Threshold for Pulsed Sources
Time/Area Closure Locations
Barrow Canyon/Western Beaufort Sea/Shelf Break of Beaufort Sea
Cross Island
Kaktovik
ARCTIC OCEAN
BEAUFORT SEA
Point Barrow
Barrow
Admiralty Bay
Smith Bay
Harrison Bay
Teshekpuk Lake
Nuiqsut
Prudhoe Bay
Deadhorse
Camden Bay
Kaktovik
National Petroleum Reserve in Alaska
North Slope Areawide Oil & Gas Lease Sale Area
North Slope Foothills Areawide Oil & Gas Lease Sale Area
ANWR - 1002 Area
Dalton Highway
Trans-Alaska Pipeline
156° W
154° W
152° W
150° W
148° W
146° W
144° W
142° W
72° N
70° N
Arctic Ocean
Chukchi Sea
Beaufort Sea
Prudhoe Bay
Russia
Canada
Fairbanks
Anchorage
Juneau
Bering Sea
Gulf of Alaska
COORDINATE SYSTEM:
NAD 1983 UTM Zone 6N
Projection: Transverse Mercator
DATA SOURCES:
ADNR-DOG (2009): State Lease Boundaries & Tracts; Oil & Gas Well Locations; State & Federal Lands
MMS (2007): Offshore Lease Boundaries & Tracts;3-Mile Offshore Boundary; Continental Shelf Boundary
BOEMRE (2011): Planning Areas
USGS (2011): Bathymetry
N
Kilometers
0 20 40 60
0 10 20 30 40 50
Miles
NATIONAL MARINE FISHERIES SERVICE
EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS
CONCEPTUAL EXAMPLE FOR ALTERNATIVE 4 (LEVEL 3 EXPLORATION ACTIVITY)
U.S. BEAUFORT SEA, ALASKA
JOB NO: 26220558
DRAWN: BG
DATE: FEBRUARY, 2013
FILE: SEE PATH

Figure 4.5-1



NATIONAL MARINE FISHERIES SERVICE

EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS

CONCEPTUAL EXAMPLE FOR ALTERNATIVE 4 (LEVEL 3 EXPLORATION ACTIVITY)

U.S. CHUKCHI SEA, ALASKA

JOB NO:	26220558	DRAWN:	BG
DATE:	FEBRUARY, 2013	FILE:	SEE PATH

FIGURE 4.5-2

Figure 4.5-3 Temporal Conceptual Examples under Alternative 4 (Level 3 Exploration Activity)

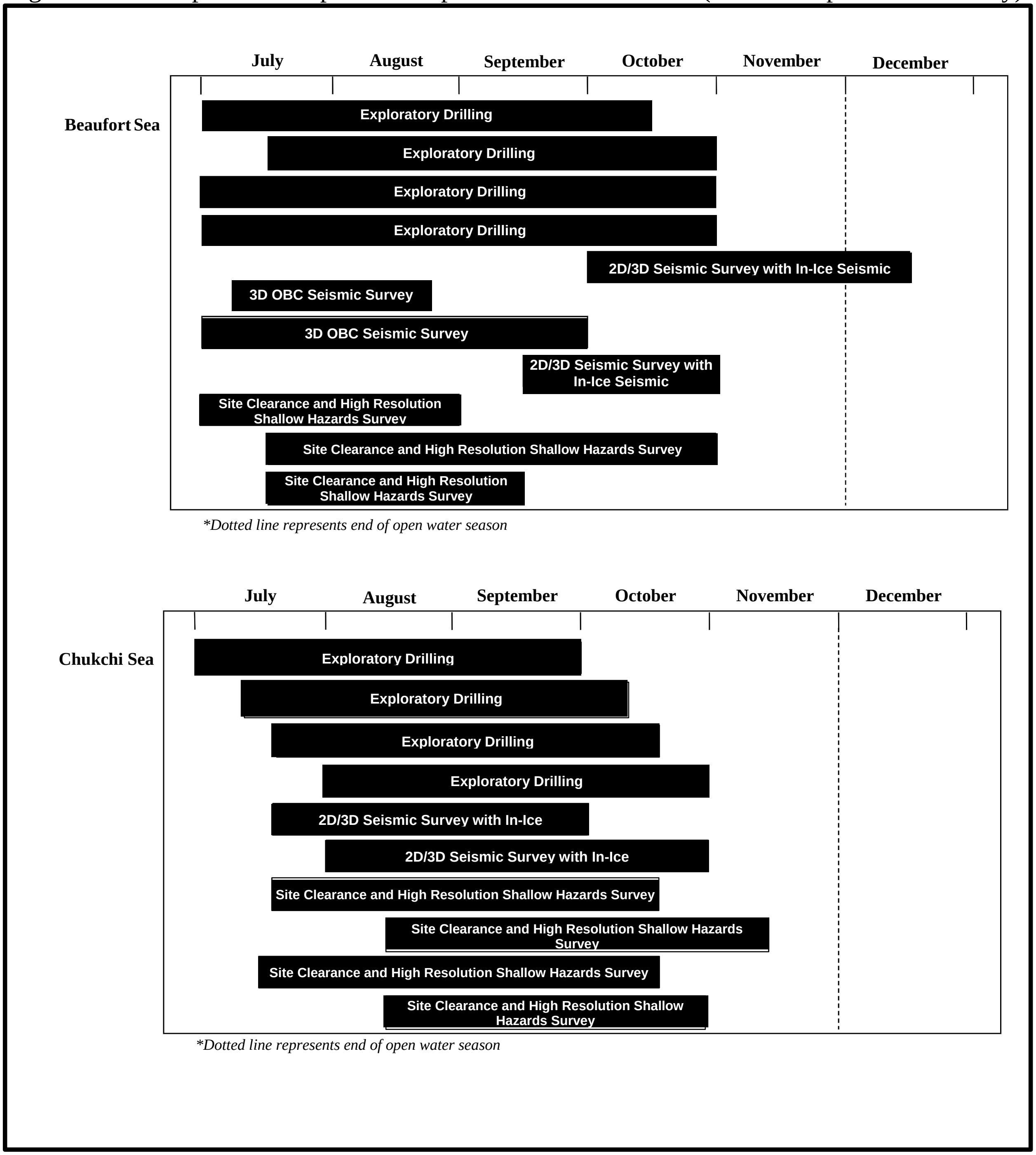


Figure 4.6-1 Example of dose-response curve used for Navy mid-frequency active sonar (Finneran and Jenkins 2012)

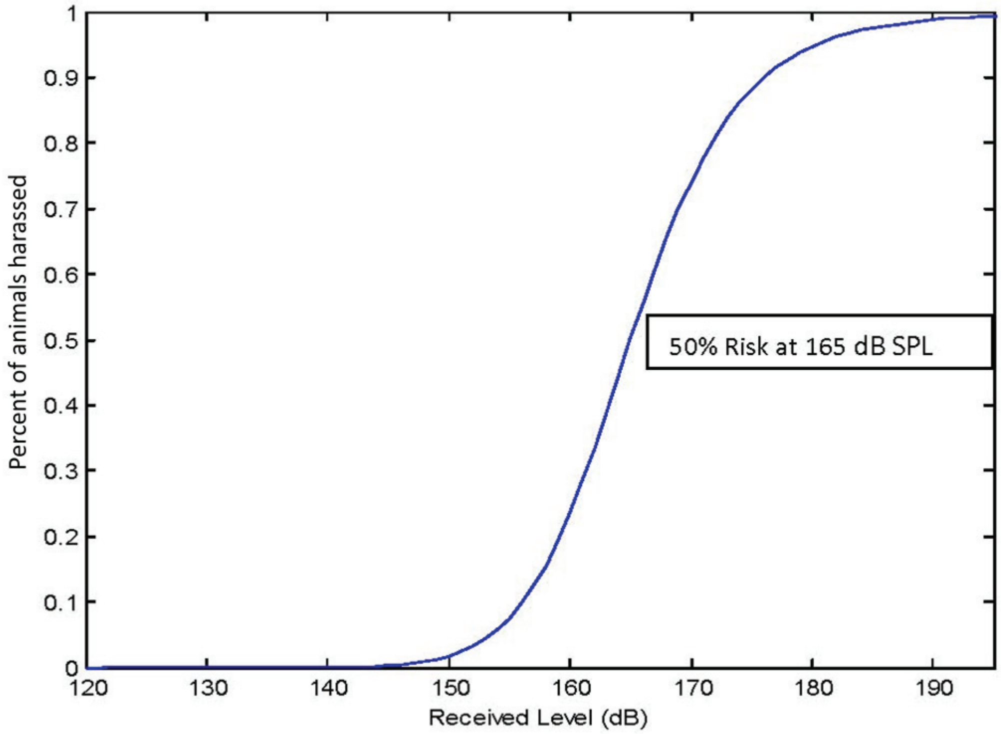


Figure 4.6-2 This graph illustrates proposed weighting functions that could be applied to cetaceans for the thresholds outlined above, if the methods outlined in Finneran and Jenkins (2012) were used. Note, in graphic LF = low frequency hearing specialists, MF = mid frequency hearing specialists, and HF = high frequency hearing specialists.

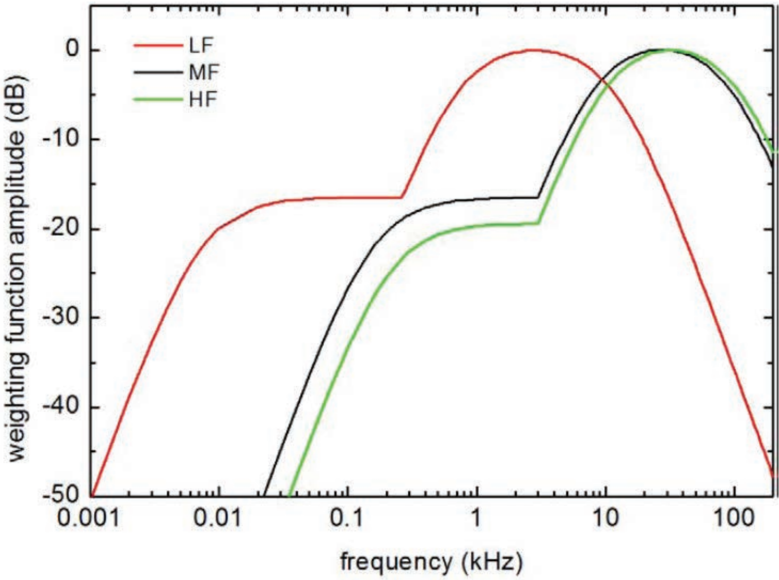


Figure 4.6-3 This graph illustrates the weighting functions that could be applied to pinnipeds for the thresholds outlined above (m-weighting, Southall et al., 2007, Finneran and Jenkins (2012)).

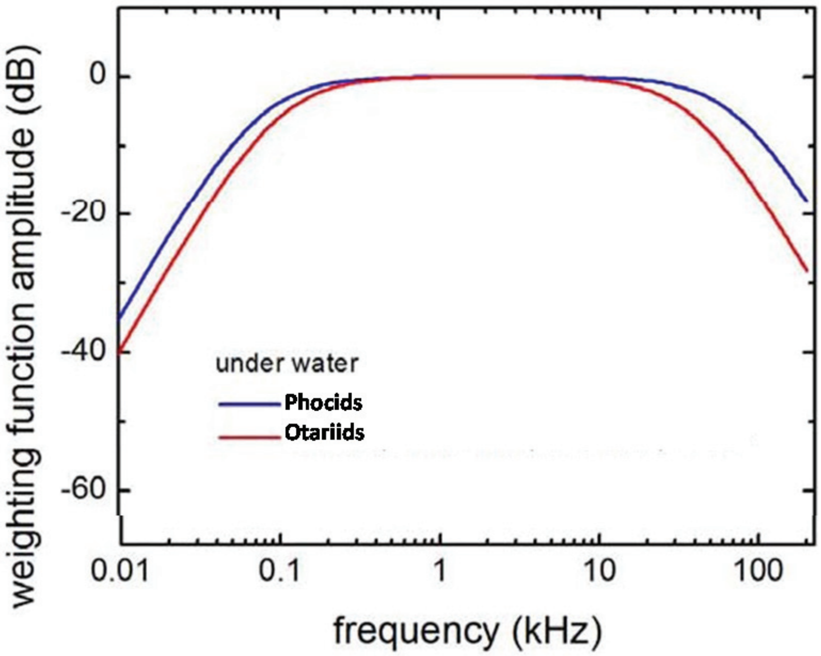


Figure 4.7-1 Dispersion and fate of water-based drill cuttings and drilling fluids discharged to the ocean. About 90% of the discharged solids settle rapidly and form a mud/cuttings pile within several hundred meters of the point of discharge.

Source: Neff 2005

This mud/cuttings pile would affect water depths near the drilling activity. The remaining 10% of the discharged solids remain suspended and drift with prevailing currents away from the drilling site to settle elsewhere.

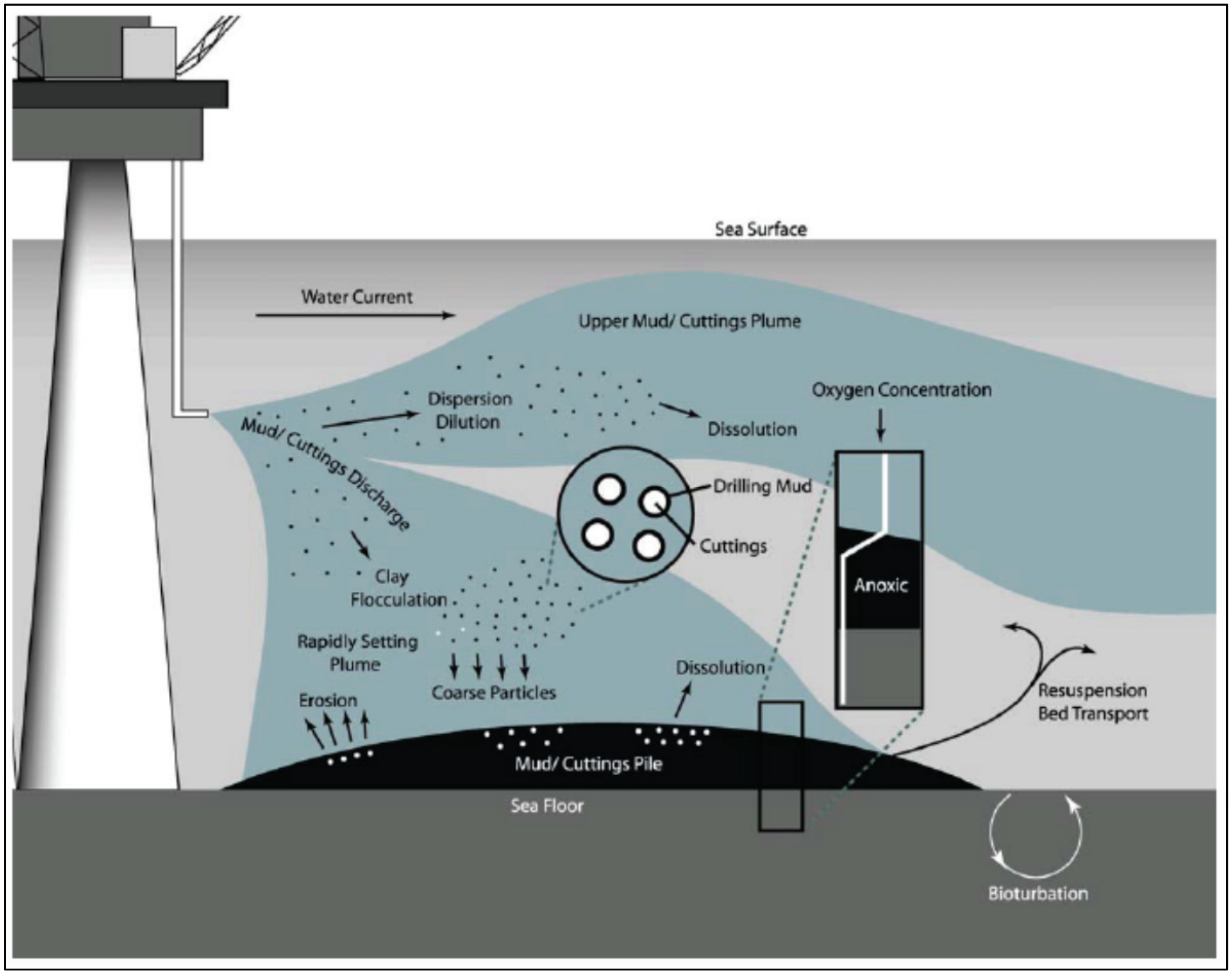
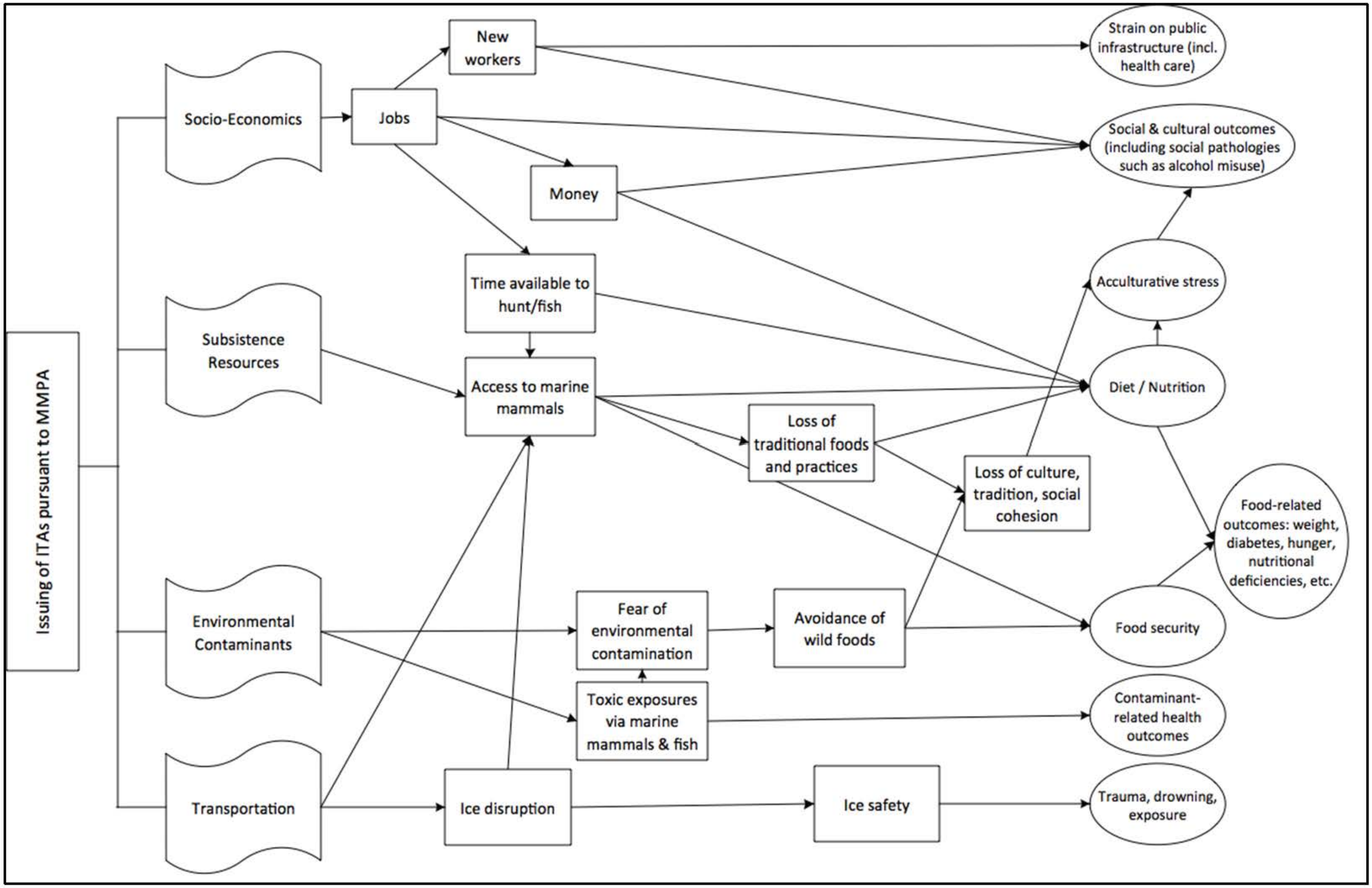


Figure 4.7-2 Logic framework for potential impacts to human health.



APPENDIX A

Standard and Additional Mitigation Measures

Table of Contents

Appendix A: Standard and Additional Mitigation Measures Addressing Impacts to Marine Mammals and Subsistence Activities

NMFS Standard Mitigation Measures

The mitigation measures[1] (and the identified mitigation monitoring needed to support them) listed below are planned for inclusion as a requirement under every MMPA ITA issued for the type of activity identified.

A. DETECTION-BASED MEASURES INTENDED TO REDUCE NEAR-SOURCE ACOUSTIC EXPOSURES AND IMPACTS ON MARINE MAMMALS WITHIN A GIVEN DISTANCE OF THE SOURCE

2D/3D and in-ice seismic surveys and site clearance and high resolution shallow hazards surveys

Mitigation Measure A1. Establishment and execution of 180 dB shutdown/power down radius for cetaceans and 190 dB shutdown/power down radius for ice seals.

NMFS has established acoustic thresholds that identify the received sound levels above which hearing impairment or other injury could potentially occur; these thresholds are 180 and 190 dB re 1 µPa (rms) for cetaceans and pinnipeds, respectively (NMFS 1995, 2000). All further received sound level criteria reported in this appendix will be re 1 µPa (rms). The established 180- and 190-dB re 1 µPa (rms) criteria are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before direct data on temporary threshold shift (TTS) (from which PTS is primarily extrapolated) for marine mammals became available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. Since the establishment of these acoustic criteria, NMFS has recommended and included shutdown/powerdown zones at the 180/190 dB isopleths as standard required mitigation measures in MMPA authorizations for seismic surveys. Typical language in past ITAs includes:

- Establish and have trained Protected Species Observers (PSOs) monitor a preliminary exclusion zone for cetaceans surrounding the airgun array on the source vessel where the received level would be 180 dB or greater. The radius for the zone will vary based on the airgun array used, water depth, and numerous other factors related to the water and seafloor properties. This final distance of the radius will be established by modeling and/or a sound source verification test.
- Establish and monitor a preliminary exclusion zone for pinnipeds surrounding the airgun array on the source vessel where the received level would be at or above 190 dB with trained PSOs. The radius for the zone will vary based on the airgun array used, water depth, and numerous other factors related to the water and seafloor properties. The final distance of the radius will be established by modeling and/or a sound source verification test.
- Immediately power-down the seismic airgun array and/or other acoustic sources, whenever any cetaceans or walrus are sighted approaching close to or within the area

[1] These measures have been included in past ITAs issued by NMFS in the Arctic Ocean.

delineated by the 180 dB, or pinnipeds or polar bears are sighted approaching close to or within the area delineated by the 190 dB isopleth.

- If the power-down operation cannot reduce the received sound pressure level at the cetacean or pinniped to less than 180 dB or 190 dB, respectively, then the holder of the ITA must immediately shutdown the seismic airgun array and/or other acoustic sources.
- The seismic airgun array cannot be powered up unless the marine mammal exclusion zones are visible and no marine mammals are detected within the appropriate safety zones for a minimum of 15 minutes (small odontocetes, pinnipeds) or 30 minutes (for mysticetes). The seismic array can be ramped up once the PSOs have no further visual detection of the animal(s) within the exclusion zone, and they are confident that no marine mammals remain within the appropriate exclusion zone.

Mitigation Measure A2. Specified ramp-up procedures for airgun arrays.

Ramp-up is the gradual introduction of sound to deter marine mammals from potentially damaging sound intensities and from approaching the exclusion zone. This technique involves the gradual increase (usually approximately 5-6 dB per 5-minute increment) in emitted sound levels, beginning with firing a single airgun and gradually adding airguns over a period of 20 to 40 minutes, until the desired operating level of the full array is obtained. Ramp-up procedures are instituted based on the assumption that any marine mammals in the vicinity of seismic operations will become aware of the noise source before it rises to potentially harmful levels and to leave the area. The 180- and 190-dB exclusion zones described in the previous measure are used for the ramp-up procedures as well. Typical language in past ITAs includes:

- Conduct a 30-minute period of marine mammal observations by at least two trained PSOs to verify that the exclusion zone is clear prior to commencing ramp-up at the commencement of seismic operations and at any time the airgun array has been shut down for a certain period of time. The period of shutdown requiring a full ramp-up is based on the size of the airgun array but is typically between 8 and 10 minutes.
- Do not commence ramp-up if the entire exclusion zones are not visible for at least 30 minutes prior to ramp-up in either daylight or nighttime and do not commence ramp-up at night unless the seismic source has maintained a sound pressure level at the source of at least 180 dB during the interruption of full seismic survey operations. If a sound source of at least 180 dB has been maintained during the interruption of seismic operations, then the 30 minute pre-ramp-up visual survey is waived.
- Ramp-up the airgun arrays at no greater than 6 dB per 5-minute period starting with the smallest airgun in the array and then adding additional guns in sequence until the full array is firing if no marine mammals are observed in the safety zones and periods specified above. Ramp-up procedures should be used at the commencement of seismic operations and any time after the airgun array has been shut down for a certain period of time.

Mitigation Measure A3. Protected Species Observers (PSOs) required on all seismic source vessels and ice breakers, as well as on dedicated monitoring vessels.

PSOs are a key component both for the purposes of implementing mitigation measures, such as shutdowns and ramp-ups, and for gathering information pursuant to the monitoring requirements of the ITA (latter addressed separately). Some of the mitigation monitoring requirements in past ITAs include:

- The holder of the ITA must designate trained, NMFS-approved, individuals (PSOs) to be onboard the source vessel to conduct the visual monitoring programs required under this Authorization and to record the effects of seismic surveys and the resulting noise on marine mammals.
- To the extent possible, PSOs should be on duty for four consecutive hours or less, although more than-one four-hour shift per day is acceptable. PSOs will not work more than three shifts in a 24-hour period (i.e. 12 hours total per 24-hour period).
- Monitoring is to be conducted by the PSOs onboard the active seismic vessel (including in-ice surveys), to (A) ensure that no marine mammals enter the appropriate exclusion zone whenever the seismic sources are on, and (B) to record marine mammal activity. At least two observers must be on watch the 30 minutes prior to full ramp up, during ramp ups, and for as much of the other operating hours as possible. At all other times, at least one observer must be on active watch (1) whenever the seismic source is operating during the daytime; (2) during any nighttime power-ups of the airguns; and (3) at night, whenever one or more power-down situations the preceding day were due to marine mammal presence.
- At all times, the crew must be instructed to keep watch for marine mammals. If any are sighted, the bridge watch-stander must immediately notify the PSO(s) on-watch. If a marine mammal is within or closely approaching its designated exclusion zone, the seismic acoustic sources must be immediately powered down or shutdown.
- Monitoring will consist of recording: (A) the species, group size, age/size/sex categories (if determinable), the general behavioral activity, heading (if consistent), bearing and distance from seismic vessel, sighting cue, behavioral pace, and apparent reaction of all marine mammals seen near the seismic vessel and/or its airgun array (e.g. none, avoidance, approach, paralleling, etc.); (B) the time, location, heading, speed, and activity of the vessel (shooting or not), along with sea state, visibility, cloud cover and sun glare at (1) any time a marine mammal is sighted, (2) at the start and end of each watch, and (3) during a watch (whenever there is a change in one or more variable); and, (C) the identification of all vessels that are visible within 5 km (3.1 mi) of the seismic-vessel whenever a marine mammal is sighted, and the time observed, bearing, distance, heading, speed and activity of the other vessel(s).

On-ice Seismic Surveys

Mitigation Measure A4. All activities must be conducted at least 152 m (500 ft) from any observed ringed seal lair.

- This measure requires survey crews to be trained in seal detection and to search for ringed seal lairs around intended seismic survey operation sites and prohibits seismic activities within a 152 m (500 ft) radius of ringed seal lairs. Additionally, while traveling on ice roads, the area shall be monitored for marine mammals, especially ringed seal lairs.
- No ice roads may be built between the mobile camp and work site. Travel between mobile camp and work site shall also be monitored for marine mammals and be done by vehicles driving through on a snow road. Vehicles must avoid any pressure ridges, ice ridges, and ice deformation areas where seal structures are likely to be present.

Mitigation Measure A5. No energy source may be placed over a ringed seal lair.

- A 152 m (500 ft) exclusion zone must be established around all located active subnivean seal structures, within which no seismic or impact work may be conducted.

Exploratory Drilling Activities

Mitigation Measure A6. PSOs required on all drill ships (including rigs and ships) and ice management vessels.

- PSO requirements would be the same as those identified for Standard Mitigation Measure A3. PSOs are required on all types of drilling units and all support vessels. PSOs will watch during active drilling operations and transits.

B. NON-DETECTION-BASED MEASURES INTENDED TO MORE BROADLY LESSEN THE SEVERITY OF ACOUSTIC IMPACTS ON MARINE MAMMALS OR REDUCE OVERALL NUMBERS TAKEN BY ACOUSTIC SOURCE

This measure would be required for all activities that occur during the open-water season (i.e. 2D/3D seismic including in-ice surveys, site clearance and high resolution shallow hazards surveys, and exploratory drilling activities).

Mitigation Measure B1. Specified flight altitudes for all support aircraft except for take-off, landing, and emergency situations.

- Aircraft shall not operate below 457 m (1,500 ft) unless the aircraft is engaged in approaching, landing or taking off, or unless engaged in providing assistance to a whaler or in poor weather (low ceilings) or any other emergency situations. Aircraft shall not operate below 305 m (1,000 ft) during marine mammal monitoring when operating outside of active subsistence areas. Aircraft engaged in marine mammal monitoring shall not operate below 457 m (1,500 ft) in areas of active subsistence use; such areas are to be identified through communications with the Communication Centers.
- Except for airplanes engaged in marine mammal monitoring, aircraft shall use a flight path that keeps the aircraft at least five miles inland until the aircraft is directly (south) of its offshore destination, then at that point it shall fly directly to its destination. This is applicable to the Beaufort Sea only.
- Helicopters shall not hover or circle above groups of marine mammals or within 457 m (1,500 ft) of such groups.

C. MEASURES INTENDED TO REDUCE/LESSEN NON-ACOUSTIC IMPACTS ON MARINE MAMMALS

These measures would be required for all activities that occur during the open-water season (i.e. 2D/3D seismic including in-ice surveys, CSEM surveys, site clearance and high resolution shallow hazards surveys, and exploratory drilling activities).

Mitigation Measure C1. Specified procedures for changing vessel speed and/or direction to avoid collisions with marine mammals.

General operation conditions include:

- Reduce vessel speed when within 274 m (900 ft) of whales and those vessels capable of steering around such groups should do so. Vessels may not be operated in such a way as to separate members of a group of whales from other members of the group.
- Avoid multiple changes in direction and speed when within 274 m (900 ft) of whales. In addition, operators should check the waters immediately adjacent to a vessel to ensure that no whales will be injured when the vessel's propellers (or screws) are engaged.
- Do not operate support vessels (including small boats), to the extent that they are being used, at a speed that would make collisions with whales likely. Vessel speeds shall be less than 10 knots in the proximity of feeding whales or whale aggregations.
- When weather conditions require, such as when visibility drops, adjust vessel speed accordingly to avoid the likelihood of injury to whales. Vessel speeds should be reduced to at least 10 knots.

D. MEASURES INTENDED TO ENSURE NO UNMITIGABLE ADVERSE IMPACT TO SUBSISTENCE USES

These measures would be required for all activities that occur during the open-water season and in-ice (i.e. 2D/3D seismic including in-ice surveys, CSEM surveys, site clearance and high resolution shallow hazards surveys, and exploratory drilling activities).

Mitigation Measure D1. Shutdown of exploration activities occurring in specific areas of the Beaufort Sea corresponding to the start and conclusion of the fall bowhead whale hunts in Nuiqsut (Cross Island) and Kaktovik beginning on August 25. The following includes typical language from recent IHAs that required shutdown in the Beaufort Sea to account for fall bowhead whaling.

- No geophysical activity from the Canadian Border to the Canning River (146 deg. 4 min. W) beginning on or around August 25 to close of the Kaktovik’s and Nuiqsut’s fall bowhead whale.
- The bowhead whale subsistence hunt will be considered closed for a particular village when the village Whaling Captains’ Association declares the hunt ended or the village quota has been exhausted (as announced by the village Whaling Captains’ Association or the Alaska Eskimo Whaling Commission [AEWC]), whichever occurs earlier.
- From Pt. Storkerson (~148 deg. 42 min. W) to Thetis Island (~150 deg. 10.2 min. W);
    - Inside the Barrier Islands: No geophysical activity prior to August 5. Geophysical activity is allowed from August 5 until completion of operations. Geophysical activity allowed in this area after August 25 shall include a source array of no more than 12 airguns, a source layout no greater than 8 m x 6 m (26.2 ft x 19.7 ft), and a single source volume no greater than 14.4 liters (880 in^3).
    - Outside the Barrier Islands: No geophysical activity from August 25 to close of fall bowhead whale hunting in Nuiqsut. Geophysical activity is allowed at all other times.
- From Canning River (~146 deg. 4 min. W) to Pt. Storkerson (~148 deg. 42 min. W), no geophysical activity from August 25 to the close of bowhead whale subsistence hunting in Nuiqsut.
- Around Barrow, no geophysical activity from Pitt Point on the east side of Smith Bay (~152 deg. 15 min. W) to a location about half way between Barrow and Peard Bay

(~157 deg. 20 min. W) from September 15 to the close of the fall bowhead whale hunt in Barrow.

Mitigation Measure D2. Establishment and utilization of Communication Centers in subsistence communities to address potential interference with marine mammal hunts on a real-time basis throughout the season.

To address potential interference with marine mammal hunts on a real-time basis, exploration companies have been required to participate in the establishment and interaction with Communication Centers in affected subsistence communities. The Communication Centers are to be operated on a 24-hour basis during the fall bowhead whale hunt.

- Upon notification by a Communication Center operator of an at-sea emergency, the holder of the ITA shall provide such assistance as necessary to prevent the loss of life, if conditions allow the holder of the ITA to safely do so.
- Upon request for emergency assistance made by a subsistence whale hunting organization, or by a member of such an organization, in order to prevent the loss of a whale, the holder of the ITA shall assist towing of a whale taken in a traditional subsistence whale hunt, if conditions allow the holder of the ITA to safely do so.

Mitigation Measure D3. Required flight altitudes and paths for all support aircraft in areas where subsistence occurs, except during take-off, landing, and emergency situations.

Aircraft shall avoid concentrations or groups of whales. Operators shall, at all times, conduct their activities at a maximum distance from such concentrations of whales.

- Aircraft shall not operate below 457 m (1,500 ft) unless the aircraft is engaged in, approaching, landing or taking off, or unless engaged in providing assistance to a whaler or in poor weather (low ceilings) or any other emergency situations.
- Aircraft engaged in marine mammal monitoring shall not operate below 457 m (1,500 ft).
- Except for airplanes engaged in marine mammal monitoring, aircraft operating in the Beaufort Sea shall use a flight path that keeps the aircraft at least five miles inland until the aircraft is directly (south) of its offshore destination, then at that point it shall fly directly (north) to its destination.
- When weather conditions do not allow a 457 m (1,500 ft) flying altitude, such as during severe storms or when cloud cover is low, aircraft may be operated below the 457 m (1,500 ft) altitude. However, when aircraft are operated at altitudes below 457 m (1,500 ft) because of weather conditions, the operator must avoid whale concentrations and concentration areas and should take precautions to avoid flying directly over or within 1,372 m (4,501 ft) of groups of whales.

BOEM Standard Mitigation Measures

The following measures are typically required by BOEM in G&G permits issued under the OCS Lands Act. These measures are not standardized in regulations. However, they have typically been required in recent years and are adjusted periodically, as needed.

- No solid or liquid explosives shall be used without specific approval.
- Permittee operations shall be conducted in a manner to ensure that they will not cause pollution, cause undue harm to aquatic life, create hazardous or unsafe conditions, or unreasonably interfere with other uses of the area. If any difficulties are encountered with other uses of the area or any of

the above mentioned scenarios occur during operations under this permit, they shall be reported to the Regional Supervisor, Resource Evaluation. Serious or emergency conditions shall be reported without delay.

- The Permittee shall maintain a minimum spacing of 15 miles between their deep penetration seismic-source vessels and any other concurrently operating deep penetration seismic-source vessel. If there is not 15 miles between seismic-source vessels, one source vessel must cease operations. The BOEM must be notified by means of the weekly report whenever a shutdown of operations occurs in order to maintain this minimum distance.
- Permittee operators shall use the lowest sound levels feasible to accomplish their data-collection needs.
- When any operator becomes aware of the potentially harassing effects of operations on whales, or when any operator is unsure of the best course of action to avoid harassment of whales, every measure to avoid further harassment shall be taken until NMFS is consulted for instructions or directions. However, human safety shall take precedence at all times over the guidelines and distances recommended herein for the avoidance of disturbance and harassment of whales.
- The Permittee shall notify BOEM, NMFS, and U.S. Fish and Wildlife Service (USFWS) in the event of any loss of cable, streamer, or other equipment that could pose a danger to marine mammals and other wildlife resources.
- To help avoid causing bird collisions with seismic survey and support vessels, seismic and surface support vessels will minimize the use of high-intensity work lights, especially within the 20-meter-bathymetric contour. High-intensity lights will be used only as necessary to illuminate active, on-deck work areas during periods of darkness or inclement weather (such as rain or fog), otherwise they shall be turned off. Deck lights, interior lights, and lights used during navigation could remain on for safety. Nothing in this mitigation measure is intended to reduce personnel safety or prevent compliance with other regulatory requirements (e.g., U.S. Coast Guard or Occupational Safety and Health Administration) for marking or lighting of equipment and work areas.
- All bird collisions (with vessels and aircraft) shall be documented and reported within 3 days to BOEM. Minimum information shall include species, date, time, location and weather, identification of the vessel or aircraft involved, and its operational status when the strike occurred. Bird photographs are not required, but would be helpful in verifying species. Permittees/operators are advised that the USFWS does not recommend recovery or transport of dead or injured birds due to avian influenza concerns.

Additional Mitigation Measures

The following mitigation measures (and mitigation monitoring needed to support them) will be evaluated in Chapter 4 and may be required by NMFS in ITAs or by BOEM in G&G permits or ancillary activity notices to make the necessary findings under the MMPA and OCS Lands Act, respectively, for the type of activity identified.

A. DETECTION-BASED MEASURES INTENDED TO REDUCE NEAR-ARRAY ACOUSTIC EXPOSURES AND IMPACTS ON MARINE MAMMALS WITHIN A GIVEN DISTANCE OF THE SOURCE

Additional Mitigation Measure A1. Prior to conducting the authorized survey, the seismic array operator shall conduct SSV tests for their airgun array configurations in the area in which the survey is proposed to occur.

This measure would be implemented for seismic, including in-ice, and site clearance and high resolution shallow hazards surveys. Before conducting the activity, the operators shall conduct sound source verification (SSV) tests to verify the radii of the safety and monitoring zones within real-time conditions in the field, providing for more accurate radii to be used. When moving an operation into a new area, the operator shall re-verify the new radii of the exclusion zones. The purpose of this mitigation measure is to establish and monitor more accurate safety zones based on empirical measurements, as compared to the zones based on modeling and extrapolation from different datasets. Using a hydrophone system, the vessel operator is required to conduct SSV tests for all airgun arrays and vessels and, at a minimum, report the following results to NMFS within five days of completing the test:

- The empirical distances from the airgun array and other acoustic sources utilized during the effectiveness of the ITA to broadband received levels of 190 dB down to 120 dB in 10 dB increments and the radiated sounds vs. distance from the source vessel.
- Measurements are to be made at the beginning of the survey for locations not previously modeled in the Arctic Seas.

Additional Mitigation Measure A2. All PSOs shall be provided with and use appropriate night-vision devices (e.g. Forward Looking Infrared [FLIR] imaging devices, 360° thermal imaging devices), Big Eyes, and reticulated and/or laser range finding binoculars in order to detect marine mammals within the exclusion zones.

- This measure would be required for all activities requiring the use of PSOs.
- All PSOs could be provided with and use appropriate night-vision devices, Big Eyes, and reticulated and/or laser range finding binoculars in order to detect marine mammals within the Exclusion Zone.

Additional Mitigation Measure A3. Operators shall limit seismic airgun operations in situations of low visibility when the entire safety radius cannot be observed (e.g., nighttime or bad weather). These limitations could mean cease airgun operations entirely, reduce the time that operations are conducted in this limited visibility situation, or reduce the number of airguns operating so that the exclusion radius is entirely visible.

- This measure would be implemented for seismic, including in-ice, and site clearance and high resolution shallow hazards surveys.

Additional Mitigation Measure A4. Seismic operators shall use passive (or active) acoustic monitoring systems, in addition to visual monitoring, to detect marine mammals approaching or within the exclusion zone and trigger the shutdown of airguns.

- This measure would be implemented for seismic, including in-ice, and site clearance and high resolution shallow hazards surveys.

Additional Mitigation Measure A5. Enhancement of monitoring protocols and mitigation shutdown zones to minimize impacts in specific biologic situations (e.g. expansion of shutdown zone to 120 dB or 160 dB when cow/calf groups and feeding or resting aggregations are detected, respectively).

This measure would be implemented for any activity that implements standard shutdown zones. Some characteristic mitigation language that has been used in past ITAs for these measures include:

- For seismic activities (including shallow hazards and site clearance and other marine surveys where active acoustic sources will be employed) in the Beaufort Sea after August 25, a 120-dB monitoring zone for bowhead whales will be established and monitored for the next 24 hours if four or more bowhead whale cow/calf pairs are observed at the surface during an aerial monitoring program within the area where an ensonified 120-dB zone around the vessel's track is projected. To the extent practicable, such monitoring should focus on areas upstream (eastward) of the bowhead migration. No seismic surveying shall occur within the 120-dB safety zone around the area where these whale cow-calf pairs were observed, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 120-dB safety zone of seismic-surveying operations.
- A 160-dB vessel monitoring zone for bowhead and gray whales will be established and monitored in the Chukchi Sea and after August 25 in the Beaufort Sea during all seismic surveys. Whenever an aggregation of bowhead whales or gray whales (12 or more whales of any age/sex class that appear to be engaged in a non-migratory, significant biological behavior (e.g. feeding, socializing)) are observed during an aerial or vessel monitoring program within the 160-dB safety zone around the seismic activity, the seismic operation will not commence or will shut down, until two consecutive surveys (aerial or vessel) indicate they are no longer present within the 160-dB safety zone of seismic-surveying operations.

B. NON-DETECTION-BASED MEASURES INTENDED TO MORE BROADLY LESSEN THE SEVERITY OF ACOUSTIC IMPACTS ON MARINE MAMMALS OR REDUCE OVERALL NUMBERS TAKEN BY ACOUSTIC SOURCE

These measures would be required for all activities that occur during the open-water season (i.e. 2D/3D seismic surveys including in-ice seismic, site clearance and high resolution shallow hazards surveys, and exploratory drilling activities).

Additional Mitigation Measure B1. Temporal/spatial limitations to minimize impacts in particular important habitats, including Kaktovik, Barrow Canyon, Hanna Shoal, the shelf break of the Beaufort Sea, Kasegaluk Lagoon, and Ledyard Bay.

All, or a subset of, oil and gas activities would be limited (e.g., either completely prohibited, or the overall time reduced) in the areas specified here during the listed timeframes. Additionally, buffer zones around these time/area closures could potentially be included. Buffer zones would require that activities emitting pulsed sounds would need to operate far enough away from these closure areas so that sounds at 160 dB do not propagate into the area or that activities emitting continuous sounds would need to operate far enough away from these closure areas so that sounds at 120 dB do not propagate into the area. In the event that a buffer zone of this size was impracticable, a buffer zone avoiding the ensonification of the important habitat above 180 dB could be used. Table A-1 below outlines the time/area closure locations, dates, and species or subsistence hunts that would be protected by the closures.

2D/3D Seismic Surveys, Including In-Ice Surveys ONLY

Additional Mitigation Measure B2. Restriction of number of surveys (of same level of detail) that can be conducted in the same area in a given amount of time (i.e. to avoid needless collection of identical data).

- Require industry to organize a way to interact with one another to identify when and if duplicative surveys are likely to occur (survey type to gather same type of data within five years) and outline efforts to avoid or describe justification.

Additional Mitigation Measure B3. Separate seismic surveys are prohibited from operating within 145 km (90 mi) of one another.

C. MEASURES INTENDED TO REDUCE/LESSEN NON-ACOUSTIC IMPACTS ON MARINE MAMMALS

These measures would be required for all activities that occur during the open-water season (i.e. 2D/3D seismic surveys including in-ice seismic, CSEM surveys, site clearance and high resolution shallow hazards surveys, and exploratory drilling activities).

Additional Mitigation Measure C1. Vessels and aircraft avoidance of concentrations of groups of ice seals by 0.8 km (0.5 mi).

- Seismic survey and associated support vessels shall observe a 0.8 km (0.5 mi) safety radius around ice seal or Pacific walrus groups hauled out onto land or ice.
- Vessels must reduce speed when walruses are observed in the water. Vessels capable of steering around these animals must do so. Vessels may not be operated in such a manner as to separate members of a group of ice seals or walruses from other members of a group. Vessels should avoid multiple changes in direction and speed when ice seals or walruses are present.
- Under no circumstances, other than an emergency, should aircraft be operated at an altitude lower than 457 m (1,500 ft) when within 0.8 km (0.5 mi) of ice seal or Pacific walrus groups.
- Helicopters may not hover or circle above such areas or within 762 m (2,500 lateral ft) of such areas.

- Seismic survey operators shall adhere to any mitigation measures identified by the USFWS to protect polar bears from being harassed and/or injured.
- Vessels must reduce speed when polar bears are observed in the water. Vessels capable of steering around these animals must do so. Vessels may not be operated in such a manner as to separate members of a group of polar bears from other members of a group. Vessels should avoid multiple changes in direction and speed when polar bears are present.
- Currently, proposed polar bear critical habitat mitigation includes a 1.6 km (1 mi) no disturbance zone around the barrier islands, and sea ice habitat.

Additional Mitigation Measure C2. Specified shipping or transit routes to avoid important habitat in areas where marine mammals may occur in high densities.

Exploratory Drilling Activities ONLY

Additional Mitigation Measure C3. Requirements to ensure reduced, limited, or zero discharge of any or all of the specific discharge streams identified with potential impacts to marine mammals or marine mammal prey or habitat.

Discharge streams identified with potential impacts to marine mammals or marine mammal habitat include the following:

- Drill cuttings;
- Drilling fluids;
- Sanitary waste;
- Bilge water;
- Ballast water; and
- Domestic waste (i.e. gray water).

Additional Mitigation Measure C4. Operators are required to recycle drilling muds.

- Operators are required to recycle drilling muds (e.g. use those muds on multiple wells) based on operational considerations to reduce discharges.

On-ice Seismic Surveys

Additional Mitigation Measure C5. Use trained seal-lair sniffing dogs for areas with water deeper than 3 m (9.8 ft) depth contour to locate seal structures under snow in the work area and camp site before initiation of activities.

- Seal lairs are to be avoided by 152 m (500 ft).

Additional Mitigation Measure C6. Use trained seal-lair sniffing dogs to survey the ice road and establish a route where no ringed seal structures are present.

D. MEASURES INTENDED TO ENSURE NO UNMITIGABLE ADVERSE IMPACT TO SUBSISTENCE USES

These measures would be required for all activities that occur during the open-water season (i.e. 2D/3D seismic surveys, including in-ice seismic, CSEM surveys, site clearance and high resolution shallow hazards surveys, and exploratory drilling activities).

Additional Mitigation Measure D1. No transit of exploration vessels into the Chukchi Sea prior to July 15 or until the beluga hunt is completed at Point Lay.

- Any vessel conducting geophysical work in the Chukchi Sea should remain at least 8 km (5 mi) offshore during transit except for emergencies or human/navigation safety.
- Geophysical activity shall not be conducted within 96.5 km (60 mi) of any point on the Chukchi Sea coast.

Additional Mitigation Measure D2. Vessels transiting east of Bullen Point to the Canadian border should remain at least 8 km (5 mi) offshore during transit along the coast, except for emergencies or human/navigation safety.

Additional Mitigation Measure D3. Shutdown of exploration activities in the Beaufort Sea for the Nuiqsut (Cross Island) and Kaktovik bowhead whale hunts based on real-time reporting of whale presence and hunting activity rather than a fixed date.

Additional Mitigation Measure D4. Shutdown of exploration activities in the Beaufort Sea for the Barrow bowhead whale hunts from Pitt Point on the east side of Smith Bay to a location about half way between Barrow and Peard Bay from September 15 to the close of the fall bowhead whale hunt in Barrow.

Additional Mitigation Measure D5. Shutdown of exploration activities in the Chukchi Sea for the Barrow (the area circumscribed from the mouth of Tuapaktushak Creek due north to the coastal zone boundary, to Cape Halkett due east to the coastal zone boundary) and Wainwright (the area circumscribed from Point Franklin due north to the coastal zone boundary, to the Kuk River mouth due west to the coastal zone boundary) bowhead whale hunts based on real-time reporting of whale presence and hunting activity rather than a fixed date.

Additional Mitigation Measure D6. Shutdown of exploration activities in the Chukchi Sea for the Point Hope and Point Lay bowhead whale hunts based on real-time reporting of whale presence and hunting activity rather than a fixed date.

Additional Mitigation Measure D7. Transit restrictions into the Chukchi Sea modified to allow offshore travel under certain conditions (e.g. 32 km [20 mi] from the coast) if beluga whale, fall bowhead whale (Barrow and Wainwright), and other marine mammal hunts would not be affected.

Exploratory Drilling Activities ONLY

Additional Mitigation Measure D8. For exploratory drilling operations in the Beaufort Sea west of Cross Island, no drilling equipment or related vessels used for at-sea oil and gas operations shall be moved onsite at any location outside the barrier islands west of Cross Island until the close of the bowhead whale hunt in Barrow.

Table A-1. Proposed Time/Area closure locations under Additional Mitigation Measure B1. This table identifies the species and subsistence hunts that would be mitigated by implementing these closures.

	Kaktovik	Barrow Canyon and the Western Beaufort Sea	Beaufort Sea Shelf Break	Hanna Shoal	Kasegaluk Lagoon and Ledyard Bay
Proposed closure period	August 25 - September 15	Mid-July - October	Mid-July - late September	September 15 - early October	Mid-June - mid-July for the Lagoon and July 1 – November 15 for the LBCHU
Bowhead Whale	Migrating and feeding: late August - October	Migrating and feeding: late August - October	Migrating: late August - October	Part of migratory corridor: September - October	Do not occur (migrate offshore)
Beluga Whale	Uncommon	Migrating and feeding: mid-July - late August	Feeding: mid-July - late September	Unknown	Feeding, molting, calving: June and July
Spotted Seal	Present	Present	Present	Present	Present; Some feeding habitat
Walrus	Not present	Not present	Not Present	Feeding: July - August	Resting habitat: Spring and early winter
Whaling Hunts	bowheads: late August - mid-September	bowheads: September - October	Uncommon	None	belugas: mid-June - mid-July in the Lagoon only
Sealing Hunts	Mostly October - June	Mostly November - January and spring	Uncommon	None	Mostly October - June

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APPENDIX B

Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis

April 2012

Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis

J. J. Finneran and A. K. Jenkins
SSC Pacific

SSC Pacific

ACKNOWLEDGMENTS

This technical report relies heavily upon two prior documents:

OPNAV Recommended Phase II Threshold Criteria, dated 20 January 2012.

Marine Mammal and Sea Turtle Criteria and Thresholds for Navy Effects Analyses, dated August 2010

We wish to thank the following individuals whom contributed to the aforementioned documents and to the completion of this technical report: Chip Johnson, Julie Rivers and Roy Sokolowski (COMPACFLT); Sean Hanser (NAVFAC Pacific); Dorian Houser, Sarah Kotecki, and Jason Mulsow (Navy Marine Mammal Program); Danielle Buonantony, Anurag Kumar, and Mandy Shoemaker (NAVFAC Atlantic), Amy Farak, Peter Hulton, and Stephanie Watwood (NUWC Newport); Robert Gisiner and Heather Havens (OPNAV N45); Jene Nissen (USFF).

CONTENTS

ACRONYMS AND ABBREVIATIONS

dB	decibel
dB re 1 μPa	decibels referenced to 1 microPascal
dB re 1 $\mu Pa^2 \cdot s$	decibels referenced to 1 microPascal- squared – seconds
GI	gastrointestinal
HF	high-frequency
Hz	hertz
kHz	kilohertz
LF	low-frequency
MF	mid-frequency
psi	pounds per square inch
PTS	permanent threshold shift
SEL	sound exposure level
SPL	sound pressure level
TM	tympanic membrane
TTS	temporary threshold shift

1 INTRODUCTION

The U.S. Navy is required to assess the potential impacts to marine species from training and testing activities to remain in compliance with a suite of Federal environmental laws and regulations including, but not limited to, the Marine Mammal Protection Act, Endangered Species Act, and the National Environmental Policy Act. In cases where these activities introduce high-levels of sound or explosive energy into the marine environment, an effects analysis must be conducted. The acoustic effects analysis begins with mathematical modeling to predict the sound transmission patterns from Navy sources. These data are then coupled with marine species distribution and abundance data to determine the sound levels likely to be received by various marine species. Finally, criteria and thresholds are applied to estimate the specific effects that animals exposed to Navy-generated sound may experience.

Sounds produced from naval activities can be divided into seven categories: (1) Sonars and other active acoustic sources; (2) Explosive detonations; (3) Ship noise; (4) Aircraft noise; (5) Gunfire and other launch noise; (6) Pile driving; and (7) Airguns. This report summarizes the criteria and thresholds for marine mammals and sea turtles exposed to underwater explosive detonations and sonars and other acoustic sources. Pile driving and seismic airguns, although impulsive sources, lack the potential for shock wave generation and are therefore not treated as explosives, but rather rely on unique criteria and thresholds agreed upon by Navy and NMFS. The criteria and thresholds for pile driving and airguns are therefore not included in this document.

2 CRITERIA AND THRESHOLDS FOR MARINE MAMMALS

2.1 INTRODUCTION

The criteria and thresholds for marine mammals are similar to those proposed by Southall et al. (2007): Marine mammal species are divided into a number of functional hearing groups, with all species in the same group assumed to be equally susceptible to noise. Within each functional hearing group, auditory weighting functions are used to emphasize frequencies where sensitivity to noise is high and de-emphasize frequencies where sensitivity is low. Individual criteria and thresholds are defined for explosive and (non-explosive) acoustic sources. The criteria and thresholds presented here for explosive sources are similar to those proposed by Southall et al. (2007) for impulsive sources, and the criteria and thresholds presented here for acoustic sources are similar to the Southall et al. (2007) non-impulsive criteria.

2.2 FUNCTIONAL HEARING GROUPS

To facilitate the acoustic and explosive effects analyses, marine mammals are divided into eight functional hearing groups, and the same criteria and thresholds are used for all species within a group. Species were grouped by considering their known or suspected auditory sensitivity, ear anatomy, and acoustic ecology (i.e., how they use sounds), as has been done previously (e.g., Ketten, 2000; Southall *et al.*, 2007). Appendix A summarizes the specific families and subfamilies contained in each functional hearing group.

2.2.1 Low-frequency (LF) cetaceans

Low-frequency cetaceans include all of the mysticetes.

No direct measurements of hearing sensitivity in any LF cetacean are available. Sensitivity to LF sound by baleen whales has been inferred from observed vocalization frequencies, observed reactions to playback of sounds, and anatomical analyses of the auditory system (Houser et al., 2001; Parks et al., 2007). Baleen whales are estimated to hear from 15 Hz – 20 kHz, with good sensitivity from 20 Hz – 2 kHz (Ketten, 1998). Mathematical models of the humpback whale's ear developed from anatomical features and optimization techniques (Houser *et al.*, 2001) suggest that humpbacks are sensitive to frequencies between 40 Hz and 16 kHz, but best sensitivity is likely to occur between 100 Hz and 8 kHz. Based on these data, functional hearing limits for LF cetaceans are defined as 7 Hz – 22 kHz.

2.2.2 Mid-frequency (MF) cetaceans

Mid-frequency cetaceans include most delphinid species (e.g., bottlenose dolphin, common dolphin, killer whale, pilot whale; see high-frequency cetacean list for exceptions), beaked whales, bottlenose whales, and sperm whales (but not pygmy and dwarf sperm whales of the genus *Kogia*, which are treated as high-frequency species).

Hearing sensitivity has been directly measured for a number of species within this group, including Atlantic bottlenose dolphins (Johnson, 1967), belugas (Finneran et al., 2005; White, 1977), Indo-Pacific bottlenose dolphins (Houser et al., 2008), Black Sea bottlenose dolphins

(Popov et al., 2007), striped dolphins (Kastelein et al., 2003), white-beaked dolphins (Nachtigall et al., 2008), Risso's dolphins (Nachtigall et al., 2005), killer whales (Szymanski et al., 1999), false killer whales (Yuen et al., 2005), common dolphins (Touhey-Moore et al., unpublished), Atlantic white-sided dolphins (Touhey-Moore et al., unpublished), Gervais' beaked whales (Finneran et al., 2009), Blainville's beaked whale (Pacini et al., 2011), short-finned pilot whales (Schlundt et al., 2011), and long-finned pilot whales (Pacini et al., 2010). All audiograms exhibit the same general U-shape, with a nominal hearing range between approximately 150 Hz and up to 160 kHz; these two frequencies were used as the lower and upper cutoff frequencies for the functional hearing limits.

2.2.3 High-frequency (HF) cetaceans

High-frequency cetaceans include the porpoises (genus *Phocoena*, *Neophocaena*, *Phocoenoides*), river dolphins, *Kogia* species, and *Cephalorhynchus* species.

Hearing has been tested for harbor porpoises (Kastelein et al., 2002a), Yangtze finless porpoises (Popov et al., 2005), Amazon River dolphins (Popov and Supin, 1990b), and Tucuxi dolphins (Popov and Supin, 1990a). All audiograms exhibit the same general U-shape with nominal hearing range between 200 Hz and 180 kHz; these two frequencies were used as the lower and upper cutoff frequencies for the functional hearing limits.

2.2.4 Phocids

Phocids include all earless seals or "true seals," including the ice seals (harp, hooded, bearded, ringed, ribbon, spotted, Weddell, leopard, Ross, and crabeater seals); harbor or common seals; gray seals; inland seals (e.g., Caspian and Baikal seals); elephant seals (northern and southern); and monk seals (Hawaiian and Mediterranean). Since these animals are amphibious, separate criteria and thresholds are included for airborne and underwater exposure.

Phocid hearing limits are estimated to be 75 Hz – 30 kHz and 75 Hz – 75 kHz in air and water, respectively (Kastak and Schusterman, 1999; Kastelein et al., 2009; Møhl, 1968; Reichmuth, 2008; Terhune and Ronald, 1971; 1972).

2.2.5 Otariids and Odobenids

Otariids include all eared seals (fur seals and sea lions) and odobenids are walruses (the only extant species). Separate criteria/thresholds are included for airborne and underwater exposure. Since these animals are amphibious, separate criteria and thresholds are included for airborne and underwater exposure.

Otariid hearing limits are estimated to be 100 Hz – 35 kHz and 100 Hz – 50 kHz in air and water, respectively (Babushina et al., 1991; Kastak and Schusterman, 1998; Kastelein et al., 2005b; Moore and Schusterman, 1987; Mulsow and Reichmuth, 2007; Mulsow et al., 2011a; Mulsow et al., 2011b; Schusterman et al., 1972).

The ear morphology of the walrus is intermediate between the otariid and phocid ear; however, current data indicate that the hearing of the walrus is more similar to that of otariids (Kastelein et al., 2002c). Therefore, the hearing limits defined for otariids are also applied to walruses.

2.2.6 Mustelids

Mustelids include sea otters (in air and under water). Since these animals are amphibious, separate criteria and thresholds are included for airborne and underwater exposure.

Like the pinnipeds, sea otters are amphibious mammals in the order Carnivora. No published data are available for sea otter hearing, though it is reasonable to expect hearing ability similar to other mustelids (otters). Behavioral measures of hearing in air for two North American river otters indicate a functional hearing of approximately 450 Hz – 35 kHz (Gunn, 1988), which is similar to the in-air hearing range of otariids. Based on the limited available information and the fact that the otariid ear is very similar to the ear of other carnivores (Nummela, 2008), the functional hearing limits for otariid are used for sea otters.

2.2.7 Ursids

Ursids include polar bears (in air and under water). Since these animals are amphibious, separate criteria and thresholds are included for airborne and underwater exposure.

Like the pinnipeds and sea otters, polar bears are amphibious mammals in the order Carnivora. Hearing threshold measurements of polar bears (in air) have shown good sensitivity up to approximately 20 kHz, with a rapid decline in sensitivity above 20 kHz (Bowles et al., 2008; Nachtigall et al., 2007). Based on the limited available information and the fact that the otariid ear is very similar to the ear of other carnivores (Nummela, 2008), the functional hearing limits for otariid are used for polar bears.

2.2.8 Sirenians

Sirenians contain manatees and dugongs.

Gerstein et al. (1999) obtained behavioral audiograms for two West Indian manatees and found an underwater hearing range of approximately 400 Hz – 76 kHz, with best sensitivity around 16 – 18 kHz. Mann et al. (2009) obtained masked behavioral audiograms from two manatees; sensitivity was shown to range from 250 Hz – 90 kHz, although the detection level at 90 kHz was 80 dB above the manatee's frequency of best sensitivity (16 kHz). This audible frequency range is similar to that of phocids (Gerstein *et al.*, 1999; Southall *et al.*, 2007), therefore the functional hearing range for phocids (75 Hz – 75 kHz) was applied to the Sirenians.

2.3 AUDITORY WEIGHTING FUNCTIONS

Human occupational noise exposure guidelines rely on numeric thresholds based on “weighted” noise levels. Weighted noise levels are calculated by applying frequency-dependent filters, or “weighting functions,” to the noise sound pressure measured in the workplace. The weighting functions are designed to emphasize frequencies (i.e., to add “weight”) where people are sensitive to noise and to de-emphasize frequencies (i.e., subtract weight) where people are not very sensitive. The weighted noise levels at each frequency are then combined to generate a single, weighted exposure value. This technique allows the use of a single, weighted threshold value, regardless of the noise frequency. The alternative would be to have a large number of individual threshold values, one for every frequency that might be encountered.

Weighting functions for humans were derived from equal loudness contours — graphs representing the sound pressure levels (SPLs) that give rise to a sensation of equal loudness magnitude in a human listener as a function of sound frequency (Suzuki and Takeshima, 2004). Equal loudness contours are in turn derived from subjective loudness experiments, where human listeners are asked to judge the relative loudness of two tones with different frequencies (e.g., Fletcher and Munson, 1933; Robinson and Dadson, 1956). For humans, the most commonly encountered weighting functions are the “A-weighting” and “C-weighting” functions. A-weighting resembles the human auditory sensitivity curve, and is the most common weighting function prescribed in noise regulations. The C-weighting curve is flatter, subtracts less energy at the extreme high and low frequencies, and better matches human sensitivity to louder sounds.

For marine mammals, several approaches have been used to define auditory weighting functions. See Appendix B for a summary of weighting functions and parameters specific for each functional hearing group.

2.3.1 Development of marine mammal auditory weighting functions

The first broadly applied marine mammal weighting functions were developed by Southall et al. (2007). Cetaceans and pinnipeds were divided into five functional hearing groups: LF cetaceans, MF cetaceans, HF cetaceans, pinnipeds in air, and pinnipeds in water. At the time, there were no equal loudness data for marine mammals. Although the use of species’ hearing sensitivities as weighting functions seems logical, existing audiograms for odontocetes typically possessed a much steeper reduction in sensitivity at low-frequencies compared to the dolphin and beluga temporary threshold shift (TTS) data, which showed little variation between 3 and 20 kHz. For these reasons, Southall et al. based their proposed weighting functions on the shape of the human “C-weighting” network, with the parameters adjusted so the weighting function shape better matched the known or suspected hearing range for each species group. The group of resulting weighting functions was referred to as the “M-weighting” functions (Southall *et al.*, 2007).

The “M-weighting” functions are described by the equation:

$$W(f) = K + 20\log_{10}\left[\frac{b^2 f^2}{(a^2 + f^2)(b^2 + f^2)}\right], \qquad (1)$$

where f is the frequency (Hz), $W(f)$ is the weighting function amplitude (dB) at each frequency, a and b are constants related to the upper and lower hearing limits, respectively, and K is a constant used to normalize the equation at a particular frequency. Specific values for the constants a and b are given in Table 1 (Southall *et al.*, 2007). Figure 1 shows the resulting weighting functions. The M-weighting functions are nearly flat between the lower and upper cutoff frequencies (a and b, respectively) specified in Table 1. For this reason, they were believed to over-estimate the effects of noise at high and low frequencies and thus to be protective (Southall *et al.*, 2007).

Table 1. Parameters for the "M-weighting" functions defined by Southall et al. (2007).

Species Group	*K*	*a* (Hz)	*b* (Hz)
LF cetaceans	0	7	22,000
MF cetaceans	0	150	160,000
HF cetaceans	0	200	180,000
Pinnipeds in water	0	75	75,000
Pinnipeds in air	0	75	30,000

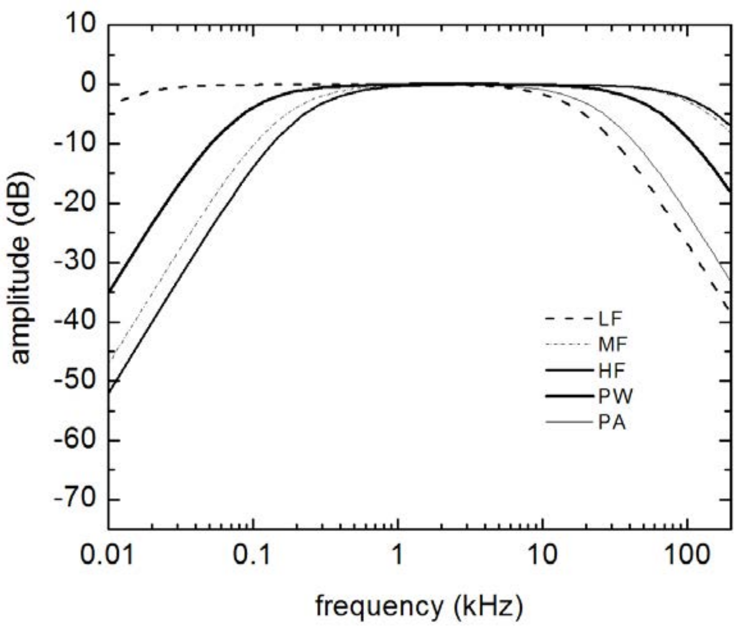

Figure 1. Marine mammal auditory weighting functions proposed by Southall et al. (2007). LF – low-frequency cetacean, MF – mid-frequency cetacean, HF – high-frequency cetacean, PW – pinnipeds in water, PA – pinnipeds in air.

The next advancement of marine mammal weighting functions occurred in 2011, when subjective loudness measurements were made with a bottlenose dolphin, the first time such an experiment has been conducted with a non-human animal (Finneran and Schlundt, 2011). From the subjective loudness data, equal loudness contours were derived, using the same procedures as those used to derive human equal loudness contours (e.g., Suzuki and Takeshima, 2004). Finally, Eq. (1) was fit to the equal loudness contour data, providing a set of auditory weighting functions. Three weighting functions based on equal loudness contours (the “EQL weighting functions”) were presented by Finneran and Schlundt (2011); the functions were based on the equal loudness contours passing through 90, 105, and 115 dB re 1 µPa at 10 kHz.

Figure 2 compares the Finneran and Schlundt (2011) bottlenose dolphin EQL weighting functions with the Southall et al. (2007) M-weighting function for MF cetaceans. Also shown in Fig. 2 is the relative susceptibility to noise, based on the TTS onset data for dolphins (Finneran, 2010; Finneran and Schlundt, 2009). In contrast to the onset of TTS, which represents an exposure threshold, the hazardousness of a noise exposure can also be described by the *susceptibility* of the listener, which represents the listener’s sensitivity to noise. The *relative susceptibility* is obtained by negating the onset TTS levels (in dB), then normalizing these data at some frequency. High values of susceptibility therefore indicate frequencies where noise is more hazardous. The susceptibility data can be directly compared to auditory weighting functions, which preferentially emphasize (apply larger weight to) frequencies where noise is more hazardous and de-emphasize those frequencies where noise is less hazardous. In Fig. 2, the EQL weighting functions, M-weighting function, and susceptibility data are all normalized at 3 kHz.

At frequencies above 3 kHz, the dolphin susceptibility to TTS increases (the TTS onset is lower); however, the MF cetacean weighting function proposed by Southall et al. (2007) is flat between 3 and 20 kHz and does not reflect the dependence of TTS on exposure frequency. In contrast, the EQL weighting functions predict larger effects from noise than the MF cetacean M-weighting function above 3 kHz, and better match the susceptibility data. The best fit to the susceptibility data is found with the EQL weighting function based on the 90-dB re 1 µPa equal loudness contour (adjusted R^2 = 0.831). Below 3 kHz, the EQL weighting functions are similar and predict increasingly lower effects compared to the MF cetacean M-weighting function. No MF cetacean TTS data exist for frequencies below 3 kHz and the equal loudness data only extend down to 2.5 kHz, therefore the accuracy of the EQL weighting functions at lower frequencies is unknown.

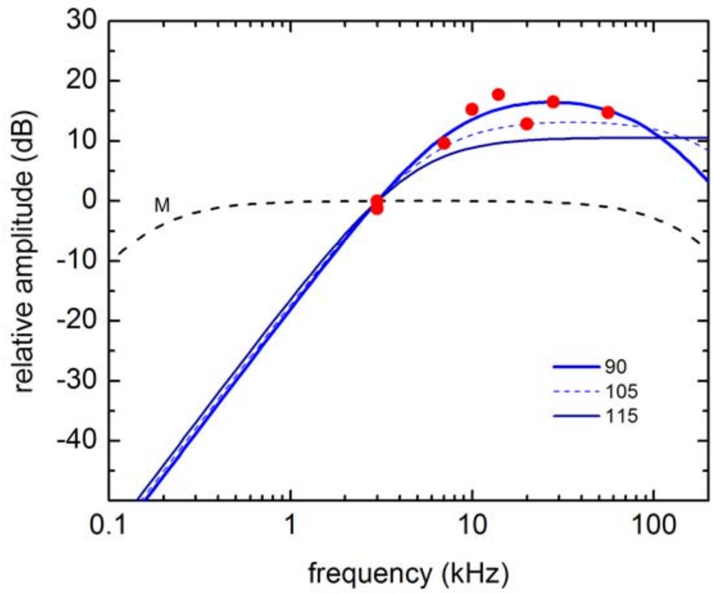

Figure 2. Comparison of dolphin auditory weighting function (solid lines), relative susceptibility to noise measured in a bottlenose dolphin (symbols), and Southall et al. mid-frequency cetacean “M-weighting” (dashed line).

2.3.1.1 Estimating EQL weighting functions for LF and HF cetaceans

Although equal loudness data only exist for bottlenose dolphins, EQL weighting functions can be estimated for other species by adjusting the parameters for Eq. (1), on a relative basis, to fit the known or suspected hearing range of each species group. This process can only be used for functional hearing groups that are closely related to the MF cetaceans (the group for whom the EQL functions exist) — the LF and HF cetaceans.

Because the frequency excitation pattern within the mammalian ear is organized logarithmically, not linearly (Ketten, 2000), the adjustment of the parameters *a* and *b* is done on a logarithmic basis. Specifically, the parameters *a* and *b* are adjusted so that the relationship, in terms of octaves, between *a* and *b* for the EQL weighting function and the functional hearing limits is preserved between the MF cetacean group and the other species groups. The extrapolation is performed using:

$$\frac{\log_2 a' - \log_2 f_L'}{\log_2 f_U' - \log_2 f_L'} = \frac{\log_2 a - \log_2 f_L}{\log_2 f_U - \log_2 f_L}, \qquad (2)$$

and

$$\frac{\log_2 b' - \log_2 f_L'}{\log_2 f_U' - \log_2 f_L'} = \frac{\log_2 b - \log_2 f_L}{\log_2 f_U - \log_2 f_L}, \qquad (3)$$

where *a* and *b* are the EQL weighting function parameters for MF cetaceans, a' and b' are the (extrapolated) parameters for the LF or HF species group, f_L and f_U are the lower and upper frequency limits for MF cetaceans (150 Hz and 160 kHz, respectively), and f_L' and f_U' are the lower and upper frequency limits for LF cetaceans or HF cetaceans. Taking the logarithm to the base 2 ($\log_2$) converts each frequency to octave spacing (re 1 Hz); this is done because the frequency organization of the inner ear is logarithmically spaced, not linearly (Ketten, 2000).

For low-frequency cetaceans, f_L' = 7 Hz and f_U' = 22 kHz, so application of Eqs. (2) and (3) yields a' = 674 Hz and b' = 12,130 Hz. A value of K = 0.94 is needed to normalize the peak of the curve to 0 dB.

For high-frequency cetaceans, f_L' = 200 Hz and f_U' = 180 kHz, so application of Eqs. (2) and (3) yields a' = 9,480 Hz and b' = 108,820 Hz. A value of K = 1.4 is needed to normalize the peak of the curve to 0 dB.

Parameters used to generate the LF, MF, and HF cetacean EQL weighting functions from Eq. (1) are given in Table 2. Graphs of the EQL weighting functions for the LF, MF, and HF cetaceans are shown in Fig. 3.

Table 2. Parameters for the EQL weighting functions for the LF, MF, and HF cetaceans. The MF cetacean function is based on the 90 dB re 1 µPa equal loudness contour for dolphins (Finneran and Schlundt, 2011). The LF and HF functions were extrapolated form the MF function based on the functional hearing limits for the LF and HF cetacean groups. The value of K was adjusted for each function to set the peak amplitude to 0 dB.

Functional Hearing Group	*K*	*a* (Hz)	*b* (Hz)
LF cetacean (extrapolated)	0.9	674	12,130
MF cetacean (based on dolphin 90-dB re 1 µPa equal loudness function)	1.4	7,829	95,520
HF cetacean (extrapolated)	1.4	9,480	108,820

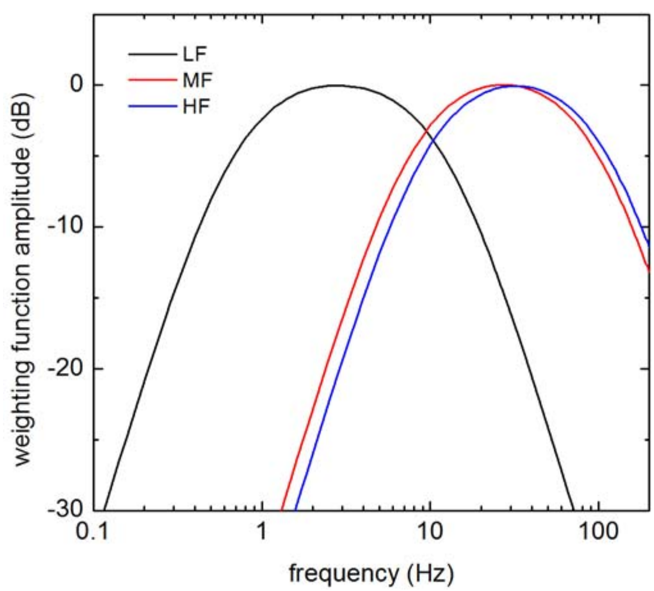

Figure 3. EQL weighting functions for the LF, MF, and HF cetaceans. The MF cetacean function is based on the 90 dB re 1 µPa equal loudness contour for dolphins (Finneran and Schlundt, 2011). The LF and HF functions were extrapolated form the MF function based on the functional hearing limits for the LF and HF cetacean groups.

2.3.2 Navy marine mammal weighting functions

Auditory weighting functions developed for Navy acoustics effects analyses utilize features of both the M-weighting functions and the EQL weighting functions. Two types of Navy weighting functions are defined: Type I weighting functions and Type II weighting functions.

Type I weighting functions are similar to the M-weighting functions and have two parameters (*a*, *b*) that define the lower and upper frequencies where the amplitude begins to decline (the "rolloff" or "cutoff" frequencies), and one parameter (*K*) that defines the amplitude of the flat portion of the curve. Type I functions are flat over a broad range of frequencies. As with the M-weighting functions, the cutoff frequencies are based on the known or estimated hearing range for each functional hearing group. The equation for the Type I weighting function is

$$W_I(f) = K + 20\log_{10}\left[\frac{b^2 f^2}{(a^2 + f^2)(b^2 + f^2)}\right], \qquad (4)$$

where $W_I(f)$ is the weighting function amplitude (in dB) at the frequency f (in Hz), and a, b, and K are constants defining the shape of the function for each functional hearing group.

Table 3 lists the parameters used to generate the Type I weighting functions from Eq. (4) for each functional hearing group defined in Section 2-2. The weighting functions are displayed in Fig. 4. The Navy Type I weighting functions for the cetaceans are identical to the Southall et al. (2007) M-weighting functions. The Type I weighting functions (in air and underwater) for the phocids are identical to the Southall et al. (2007) M-weighting functions for pinnipeds (the pinniped M-weighting functions were based on the hearing ranges for phocids seals). The Type I functions for otariids, odobenids, mustelids, ursids, and sirenians are based on the estimated functional hearing limits for these functional groups as defined in Section 2.2.

Table 3. Parameters for the Navy marine mammal Type I weighting functions.

Functional Hearing Group	*K*	*a* (Hz)	*b* (Hz)
LF cetaceans	0	7	22,000
MF cetaceans	0	150	160,000
HF cetaceans	0	200	180,000
Phocids (in water), Sirenians	0	75	75,000
Phocids (in air)	0	75	30,000
Otariids, Odobenids, Mustelids, Ursids (in water)	0	100	40,000
Otariids, Odobenids, Mustelids (in air)	0	100	30,000

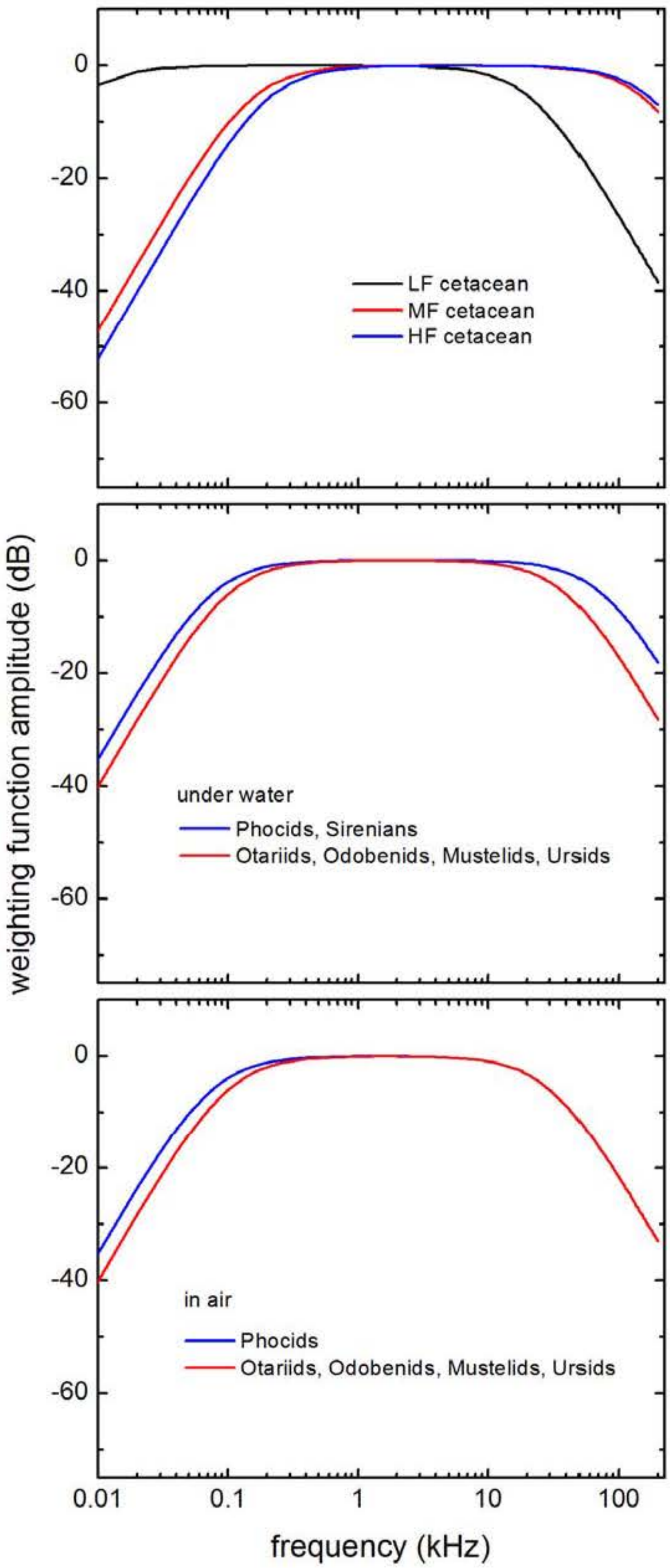

Figure 4. Navy Type I weighting functions.

Type II weighting functions modify the Type I functions (or M-weighting functions) by including a region of increased amplitude (increased susceptibility) based on the EQL weighting functions. Type II functions are only derived for the cetaceans, because the underlying data necessary for the functions are only available for bottlenose dolphins (MF cetaceans). Although TTS data exist for three pinniped species (harbor seal, California sea lion, northern elephant seal), most exposures consisted of octave band noise centered at 2.5 kHz, thus data are insufficient to either derive weighting functions in a manner analogous to that used for MF cetaceans or to verify the effectiveness of extrapolations from the MF cetacean group.

Type II functions are defined using two component curves: one based on the Type I weighting function and the other based on the EQL weighting function. At each frequency, the amplitude of the weighting function is defined using the larger value from the two component curves, as illustrated in Fig. 5. In practice, the Type I component will dominate below some frequency, denoted as the “inflection point” frequency, and the EQL component will dominate above the inflection point. The idea behind the Type II function is to enhance the Type I weighting function by accounting for the increased susceptibility to noise seen in the bottlenose dolphin TTS data at frequencies above 3 kHz. The EQL weighting functions are not used by themselves because of the uncertainty regarding the weighting function amplitude at low frequencies, below the range of the TTS and equal loudness data. The Type I function is used at lower frequencies as a protective approach since there are no TTS or equal loudness data below 2.5 – 3 kHz. The Type II weighting function represents a way to incorporate new data showing increased susceptibility to noise at higher frequencies with the broad, protective weighting functions proposed by Southall et al. (2007).

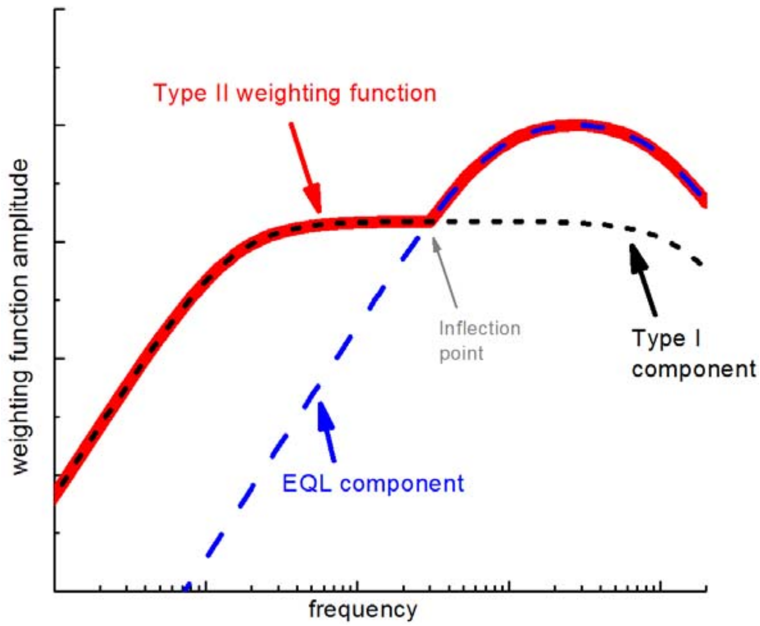

Figure 5. Illustration of the Type II weighting function concept. Below the inflection point frequency, the Type II weighting function matches the shape of the Type I function. Above the inflection point, the Type II function matches the EQL-based weighting function.

The Type II weighting functions are mathematically defined as:

$$W_{II}(f) = \text{maximum}\{G_1(f), G_2(f)\}, \tag{5}$$

where $W_{II}(f)$ is the weighting function amplitude (dB) at the frequency f (Hz),

$$G_1(f) = K_1 + 20\log_{10}\left[\frac{b_1^2 f^2}{(a_1^2 + f^2)(b_1^2 + f^2)}\right], \tag{6}$$

$$G_2(f) = K_2 + 20\log_{10}\left[\frac{b_2^2 f^2}{(a_2^2 + f^2)(b_2^2 + f^2)}\right], \tag{7}$$

the parameters a_1, b_1, and K_1 define the Type I component of the function and a_2, b_2, and K_2 define the EQL component of the function. The specific parameters for the LF, MF, and HF cetaceans are given in Table 4. Note that the values for a_1, b_1 match the parameters a and b for the Type I (and M-weighting) functions and a_2, b_2 match the parameters for the EQL weighting functions. The values for K_2 match the values for K for the EQL weighting function, so the Type II functions also have their peak amplitudes at 0 dB. The values for K_1 are adjusted from the Type I functions so that the MF and HF cetaceans have the inflection point at 3 kHz. For the LF cetaceans, K is adjusted so that the flat portion of the Type I component is 16.5 dB below the peak, identical to the value for the MF cetaceans. This places the inflection point for the LF cetacean function at 267 Hz. The Type II weighting functions are shown graphically in Fig. 6.

Table 4. Marine mammal Type II weighting function parameters for use in Eq. (5).

Functional Hearing Group	K_1 (dB)	a_1 (Hz)	b_1 (Hz)	K_2 (dB)	a_2 (Hz)	b_2 (Hz)	Inflection point (Hz)
LF cetaceans	-16.5	7	22,000	0.9	674	12,130	267
MF cetaceans	-16.5	150	160,000	1.4	7,829	95,520	3,000
HF cetaceans	-19.4	200	180,000	1.4	9,480	108,820	3,000

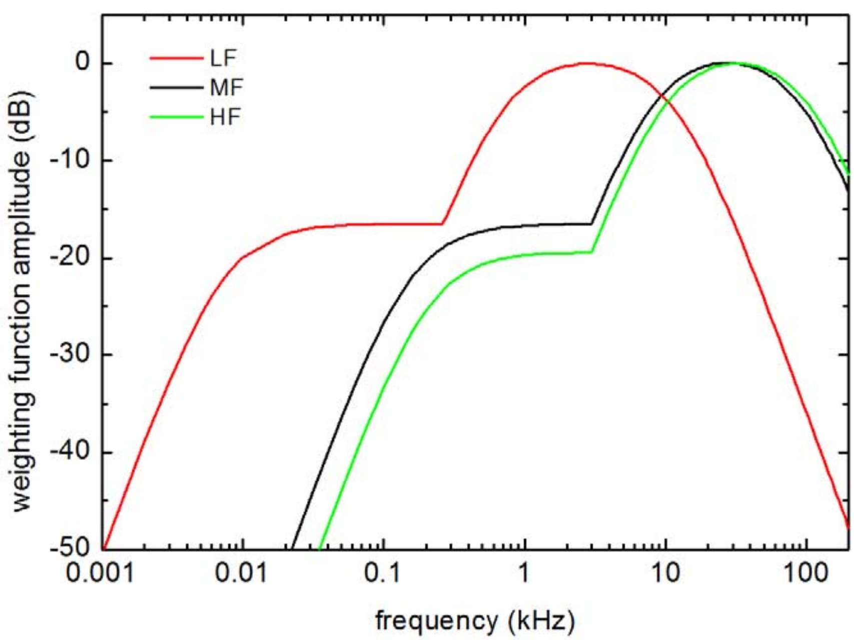

Figure 6. Navy Type II weighting functions for LF, MF, and HF cetaceans.

2.4 CRITERIA AND THRESHOLDS FOR SONARS AND OTHER ACTIVE ACOUSTIC SOURCES

2.4.1 Introduction

Criteria for marine mammals exposed to sonars and other active acoustic sources are divided into physiological effects and behavioral effects. Physiological effects criteria and thresholds are based on temporary and permanent threshold shift (TTS and PTS). Behavioral thresholds are based on observational data documenting the reactions of various marine mammal species to sound. For TTS, PTS, and behavioral responses, criteria and thresholds are provided for each functional hearing group. A summary of the various criteria and thresholds is provided in Appendix C.

2.4.2 Criteria and thresholds for TTS

TTS criteria and thresholds are based on TTS onset values obtained from representative species of MF and HF cetaceans and pinnipeds. The data obtained from MF and HF cetaceans and pinnipeds were then extrapolated to the other functional hearing groups.

Criteria for TTS are based on the sound exposure level (SEL) received by the animal. SEL is used, rather than sound pressure level (SPL), because SEL includes the effect of the exposure duration, which is a key factor is the likelihood that a noise exposure will produce TTS.

The threshold value for TTS for each functional hearing group is defined in terms of the *weighted* SEL. This means that the SEL corresponding to the onset of TTS is “weighted” by the appropriate weighting function. For cetaceans, Type II weighting functions are used for sonars and other active acoustic sources, since the EQL portion of the Type II functions are based on tonal noise exposures most closely related to sonars. For the other functional hearing groups, where Type II weighting functions do not exist, Type I functions are used instead.

For meaningful comparison to the weighted SEL threshold value, the SEL received by an animal must also be weighted by the same function. To determine if a TTS occurs, the frequency content of the SEL is first determined. The appropriate weighting function is then used to weight each frequency band. Then, the total, weighted SEL is calculated by integrating the weighted frequency content. Finally, the weighted exposure is compared to the weighted threshold value for TTS. If the weighted exposure SEL meets or exceeds the weighted SEL threshold value, then TTS is assumed to occur.

2.4.2.1 Low-Frequency Cetaceans

No direct measurements of TTS are available for any LF cetaceans. For this reason, the MF criteria and thresholds are also applied to LF cetaceans; however, exposures and threshold SEL values are weighted using the Type II LF cetacean weighting function rather than the MF cetacean function. This provides higher susceptibility to low frequency sound, consistent with the inferred frequencies of best hearing for LF cetaceans. The resulting (Type II) weighted exposure SEL for LF cetaceans is 178 dB re 1 $\mu Pa^2 \cdot s$.

2.4.2.2 Mid-Frequency Cetaceans

To date, TTS data has been collected for bottlenose dolphins and belugas, two diverse odontocetes. Both species had similar TTS thresholds (Schlundt et al., 2000). Due to the similarity in the known audiograms and TTS thresholds, the TTS thresholds for dolphins and belugas are applied to all MF cetaceans.

A number of studies have shown that an SEL of 195 dB re 1 μPa^2·s is a reasonable threshold for TTS in dolphins and belugas exposed to 3 kHz tones (Finneran, 2005; Finneran et al., 2010; Mooney et al., 2009; Nachtigall et al., 2004; Schlundt *et al.*, 2000). This threshold was also supported by Southall et al. (2007) as the best estimate of onset-TTS for non-impulsive noise exposure in cetaceans. For the MF cetacean Type II weighting function, the weighting function amplitude at 3 kHz is -16.5 dB. This means that the (Type II) weighted exposure SEL for MF cetaceans is 178 dB re 1 μPa^2·s.

2.4.2.3 High-Frequency Cetaceans

At the time the Navy criteria were developed, no direct measurements of TTS were available for any HF cetacean exposed to non-impulsive sound (such as that produced by sonars). TTS thresholds for HF cetaceans were therefore based on data published by Lucke et al. (2009), who measured TTS in a harbor porpoise exposed to impulses produced by a small seismic air gun. The TTS threshold for impulsive noise obtained from the airgun TTS data was adjusted to estimate the TTS threshold for sonars and other active acoustic sources (which are non-impulsive sources) using the method outlined by Southall et al. (2007) (Type II weighted SEL = 146 dB re 1 μPa^2·s). This method relies on the relationship between impulsive and non-impulsive TTS onset values for MF cetaceans, which means that the non-impulsive threshold is 6 dB higher than the impulsive threshold (Southall *et al.*, 2007). For the harbor porpoise, this results in a non-impulsive, (Type II) weighted TTS threshold of 152 dB re 1 μPa^2·s.

Due to the similarities in the known audiograms, the TTS threshold derived for harbor porpoises is used for all HF cetaceans. Newly published TTS data for the Yangtze finless porpoise (Popov et al., 2011) were not directly used to derive threshold values, although this study supports the concept that the HF cetacean thresholds are significantly lower than those for the MF cetaceans. Kastelein et al. (2011) have also presented results of TTS experiments with harbor porpoise, though, at present, these data have not been published.

2.4.2.4 Phocids (in water)

TTS thresholds for phocids exposed to underwater sonars and other active acoustics are based on data reported by Kastak et al. (2005), who provided estimates of the average SEL for onset-TTS for a harbor seal, sea lion, and Northern elephant seal exposed to underwater, octave-band noise centered at 2.5 kHz. The most sensitive of the two phocids was the harbor seal, with a TTS onset threshold of 183 dB re 1 μPa^2·s. For phocids, only a Type I weighting function is used; the weighting function amplitude at 2.5 kHz is 0 dB. This means the (Type I) weighted exposure SEL for harbor seals under water is 183 dB re 1 μPa^2·s.

Due to the similarities in the known audiograms, and the fact that the only other phocid for whom TTS data are available had a higher TTS onset threshold (Northern elephant seal, with

TTS onset 204 dB SEL), the underwater TTS threshold for the harbor seal is used for all phocids seals. Recently, Kastelein et al. (2011) have presented results of TTS experiments with harbor seals exposed to underwater noise, though, at present, these data have not been published.

2.4.2.5 Phocids (in air)

TTS thresholds for phocids exposed to acoustic sources in-air are based on data reported by Kastak et al. (2004), who provided estimates of the average SEL for onset-TTS for a harbor seal, sea lion, and Northern elephant seal exposed to in-air, octave-band noise centered at 2.5 kHz. The most sensitive of the two phocids was the harbor seal, with a TTS onset threshold of 131 dB re (20 µPa)^2·s. For phocids, only a Type I weighting function is used; the weighting function amplitude at 2.5 kHz is 0 dB. This means the (Type I) weighted exposure SEL for harbor seals in air is 131 dB re (20 µPa)^2·s.

Due to the similarities in the known audiograms, and the fact that the only other phocid for whom TTS data are available had a higher TTS onset threshold [northern elephant seal, with TTS onset 163 dB re (20 µPa)^2·s], the in-air TTS threshold for the harbor seal is used for all phocids seals.

2.4.2.6 Otariids and odobenids (in water)

TTS thresholds for otariids exposed to underwater sonars and other active acoustics are based on data reported by Kastak et al. (2005), who provided estimates of the average SEL for onset-TTS for a harbor seal, sea lion, and Northern elephant seal exposed to underwater, octave-band noise centered at 2.5 kHz. The California sea lion TTS onset threshold was 206 dB SEL. For otariids, only a Type I weighting function is used; the weighting function amplitude at 2.5 kHz is 0 dB. This means the (Type I) weighted exposure SEL for California sea lions exposed under water is 206 dB re 1 µPa^2·s.

As the only otariid species for whom TTS data are available, the California sea lion TTS threshold is used for all otariids. No TTS data exist for the walrus; however, underwater audiograms (Kastelein et al., 2002b) for the walrus show a strong similarity to those of other otariids, therefore, the otariid TTS threshold is also used for odobenids.

2.4.2.7 Otariids and odobenids (in air)

TTS thresholds for otariids exposed to acoustic sources in-air are based on data reported by Kastak et al. (2007; 2004), who provided estimates of the average SEL for onset-TTS for a California sea lion exposed to in-air, octave-band noise centered at 2.5 kHz. The California sea lion TTS onset threshold was 154 dB re (20 µPa)^2·s. For otariids, only a Type I weighting function is used; the weighting function amplitude at 2.5 kHz is 0 dB. This means the (Type I) weighted exposure SEL for California sea lions exposed in air is 154 dB re (20 µPa)^2·s.

As the only otariid species for whom TTS data are available, the California sea lion TTS threshold is used for all otariids. No TTS data exist for the walrus; however, underwater audiograms (Kastelein *et al.*, 2002b) for the walrus show a strong similarity to those of other otariids, therefore, the otariid TTS threshold is also used for odobenids.

2.4.2.8 Mustelids

Based on the limited data available for sea otters and the similarities between these species and pinnipeds, the otariid TTS criteria and thresholds are used for mustelids.

2.4.2.9 Ursids

Based on the limited data available for polar bears and the similarities between these species and pinnipeds, the otariid TTS criteria and thresholds are used for polar bears.

2.4.2.10 Sirenians

No TTS data for manatees and dugongs exist; however, because the hearing ranges of phocids and sirenians are roughly equivalent, the phocid TTS threshold (the lowest of any of the pinnipeds), is used for sirenians.

2.4.3 Criteria and thresholds for PTS

In contrast to TTS, which represents a temporary reduction of hearing sensitivity, PTS represents tissue damage that does not recover and leads to a permanent reduced sensitivity to sounds over specific frequency ranges. Since no studies have been designed to intentionally induce PTS in marine mammals, onset-PTS levels for marine mammals must be estimated using available information. TTS data are available for some marine mammal species, and a large amount of TTS and PTS data exist for terrestrial mammals. Differences in auditory structures and sound propagation and interaction with tissues prevent direct application of numerical thresholds for PTS in terrestrial mammals to marine mammals. However, the inner ears of marine and terrestrial mammals are analogous and certain relationships are expected to relate to both groups of mammals. Experiments with marine mammals have revealed similarities between marine and terrestrial mammals with respect to features such as TTS, age-related hearing loss, ototoxic drug-induced hearing loss, masking, and frequency selectivity (e.g., Finneran, 2012; Finneran *et al.*, 2005; Nachtigall et al., 2000). For this reason, relationships between TTS and PTS from human and terrestrial mammal data can be used, along with TTS onset values for marine mammals, to estimate exposures likely to produce PTS in marine mammals (Southall *et al.*, 2007).

A variety of terrestrial and marine mammal data sources indicate that threshold shifts up to 40 to 50 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for threshold shift to prevent PTS (e.g., Kryter et al., 1966; Miller et al., 1963; Ward, 1960; Ward et al., 1958; Ward et al., 1959). A conservative assumption is that 40 dB of TTS is an upper limit for reversibility and that any additional exposure will result in some PTS. This means that 40 dB of TTS essentially defines the onset of PTS. To estimate the exposure necessary to induce 40 dB of TTS (and thus PTS), TTS growth rates from marine and terrestrial mammals are used to estimate the additional exposure required to "grow" TTS from the onset value (6 dB of TTS) to the point of the onset of PTS (40 dB of TTS) — a 34 dB difference.

Data from Ward et al. (1958) reveal a linear relationship between TTS and SEL with growth rates of 1.5 to 1.6 dB TTS per dB increase in SEL. This value for the TTS growth rate is larger than those experimentally measured in a dolphin exposed to 3 and 20 kHz tones (Finneran and Schlundt, 2010), and so appears to be a protective value to use for cetaceans. The additional exposure above onset-TTS that is required to reach PTS is therefore 34 dB divided by 1.6 dB, or approximately 20 dB. For cetaceans, exposure to sonars and other active acoustics sources with an SEL 20 dB above that producing TTS may be assumed to produce a PTS. For example, an onset-TTS threshold of 195 dB re 1 μPa^2·s would have a corresponding onset-PTS threshold of 215 dB re 1 μPa^2·s. This extrapolation process is identical to that recently proposed by Southall et al. (2007).

Kastak et al. (2007) reported a TTS growth rate of 2.5 TTS per dB increase in SEL for a California sea lion. This growth rate results in a 14 dB difference between TTS onset and PTS onset. Since this results in a more protective approach, this value is used for all pinnipeds, not just the otariids. The same 14 dB difference is also used for the functional groups that utilize the same thresholds as the pinnipeds: the odobenids, mustelids, ursids, and sirenians..

2.4.3.1 LF Cetaceans

PTS onset for LF cetaceans is defined as the exposure 20 dB above TTS onset: a (Type II) weighted SEL of 198 dB re 1 μPa^2·s.

2.4.3.2 MF Cetaceans

PTS onset for MF cetaceans is defined as the exposure 20 dB above TTS onset: a (Type II) weighted SEL of 198 dB re 1 μPa^2·s.

2.4.3.3 HF Cetaceans

PTS onset for HF cetaceans is defined as the exposure 20 dB above TTS onset: a (Type II) weighted SEL of 172 dB re 1 μPa^2·s.

2.4.3.4 Phocids (in water)

PTS onset for phocids seals is defined as the exposure 14 dB above TTS onset: a (Type I) weighted SEL of 197 dB re 1 μPa^2·s.

2.4.3.5 Phocids (in air)

PTS onset for phocids seals is defined as the exposure 14 dB above TTS onset: a (Type I) weighted SEL of 145 dB re $(20\ \mu Pa)^2$·s.

2.4.3.6 Otariids and odobenids (in water)

PTS onset for otariids and odobenids is defined as the exposure 14 dB above TTS onset: a (Type I) weighted SEL of 220 dB re 1 μPa^2·s.

2.4.3.7 Otariids and odobenids (in air)

PTS onset for otariids and odobenids is defined as the exposure 14 dB above TTS onset: a (Type I) weighted SEL of 168 dB re $(20\ \mu Pa)^2$·s.

2.4.3.8 Mustelids

Based on the limited data available for sea otters and the similarities between these species and pinnipeds, the otariid PTS criteria and thresholds are used for mustelids: a (Type I) weighted SEL of 220 dB re 1 $\mu Pa^2 \cdot s$ in water and 168 dB re $(20\ \mu Pa)^2 \cdot s$ in-air.

2.4.3.9 Ursids

Based on the limited data available for polar bears and the similarities between these species and pinnipeds, the otariid PTS criteria and thresholds are used for polar bears: a (Type I) weighted SEL of 220 dB re 1 $\mu Pa^2 \cdot s$ in water and 168 dB re $(20\ \mu Pa)^2 \cdot s$ in-air.

2.4.3.10 Sirenians

Because the hearing ranges of the phocids and sirenians are roughly equivalent, the phocid PTS threshold (the lowest of any of the pinnipeds), is used for sirenians: a (Type I) weighted SEL of 197 dB re 1 $\mu Pa^2 \cdot s$.

2.4.4 Criteria and thresholds for behavioral effects

Marine animals are likely to exhibit any of a suite of potential behavioral responses or combinations of behavioral responses upon exposure to sonars and other active acoustic sources. Potential behavioral responses include, but are not limited to, avoiding exposure or continued exposure, behavioral disturbance (including distress or disruption of social or foraging activity), habituation to the sound, becoming sensitized to the sound, or not responding to the sound.

In Navy acoustic impact analyses, two types of criteria/thresholds are utilized to estimate behavioral effects of noise:

(1) In cases where a specific taxonomic group’s behavioral responses to sound have been well documented, a single sound pressure level (SPL) threshold has been provided to predict the number of behavioral disturbances. As an example, for harbor porpoises (but not other HF cetaceans), a behavioral response threshold of 120 dB SPL (no weighting function) is used for sonars and other active acoustic sources because of the demonstrated high behavioral sensitivity of harbor porpoises to these types of sounds.

(2) For all other taxa, the likelihood of behavioral effects is based on a probabilistic function (termed a behavioral response function – BRF), that relates the likelihood (i.e, probability) of a behavioral response to the received SPL. The BRF is used to estimate the percentage of an exposed population that is likely to exhibit altered behaviors or behavioral disturbance at a given exposure SPL. The BRF relies on the assumption that sound poses a negligible risk to marine mammals if they are exposed to SPL below a certain “basement” value. Above the basement exposure SPL, the probability of a response increases with increasing SPL.

Two BRFs are used in Navy acoustic impact analyses: BRF_1 for LF cetaceans and BRF_2 for all other functional hearing groups (i.e., MF and HF cetaceans, pinnipeds, mustelids, ursids, and sirenians). The BRF functions are based on three sources of data: behavioral observations during TTS experiments conducted at the US Navy Marine Mammal Program (Finneran and Schlundt, 2004); reconstruction of sound fields produced by the USS Shoup associated with the behavioral responses of killer whales observed in Haro Strait (Department of the Navy, 2003; Fromm, 2009); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components (Nowacek et al., 2004). For a detailed discussion of the derivation of the BRFs, see Department of the Navy (2008a).

The BRFs are calculated using:

$$R(L) = \frac{1 - \left(\frac{L - B}{K}\right)^{-A}}{1 - \left(\frac{L - B}{K}\right)^{-2A}}, \quad (8)$$

where $R(L)$ is the probability of a response, L is the received SPL, and B and K are parameters that define the shape of the curve. For both BRFs, the "basement" parameter B = 120 dB re 1 μPa and the factor K = 45. For the BRF_1, A = 8; for BRF_2, A = 10. Both functions are illustrated in Fig. 7. Note that the received SPL is weighted using the Type I weighting functions when applying the BRFs.

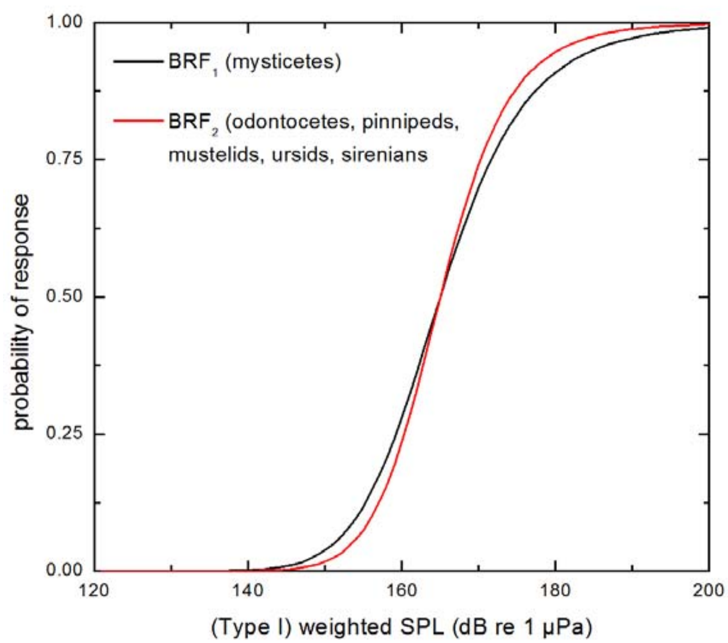

Figure 7. Navy Behavioral response functions (BRFs).

2.4.4.1 LF cetaceans

BRF_1 is used to assess behavioral effects from sonars and other active acoustic sources for all LF cetaceans. The LF cetacean Type I weighting function is used when determining the received SPL to use with the BRF.

2.4.4.2 MF cetaceans

To assess behavioral effects from sonars and other active acoustic sources to all MF cetaceans *except beaked whales*, BRF_2 is used, with the exposure weighted using the Type I weighting function for MF cetaceans.

Data obtained from *Mesoplodon densirostris* suggest greater responsiveness of beaked whales to a variety of sonars and active acoustic sources compared to other species exposed to the same or similar sounds (Tyack et al., 2011). For this reason, an (unweighted) SPL of 140 dB re 1µPa is used for beaked whales as a threshold to predict behavioral disturbance when exposed to sonars or other active acoustic sources.

2.4.4.3 HF cetaceans

To assess behavioral effects from sonars and other active acoustic sources to all HF cetaceans *except harbor porpoises*, BRF_2 is used, with the exposure weighted using the Type I weighting function for HF cetaceans.

For harbor porpoises, the information currently available suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (Kastelein et al., 2005a; Kastelein et al., 2000) and wild harbor porpoises (Johnston, 2002) responded to sound (e.g. acoustic harassment devices, acoustic deterrent devices, or other non-impulsive sound sources) is very low (e.g. an SPL of approximately 120 dB re 1 µPa), although the biological significance of the disturbance is uncertain. Therefore, an (unweighted) SPL of 120 dB re 1µPa is used for harbor porpoises as a threshold to predict behavioral disturbance.

2.4.4.4 Phocids (in water)

To assess behavioral effects from sonars and other active acoustic sources to all phocids in water, BRF_2 is used, with the exposure weighted using the Type I weighting function for phocids.

2.4.4.5 Phocids (in air)

A number of investigators have studied pinniped reactions to rocket launches (Berg et al., 2004; Berg et al., 2002; Berg et al., 2001; Holst et al., 2005; Thorson et al., 2000a; b; Thorson et al., 1999; Thorson et al., 1998). In some cases severe reactions such as stampeding were recorded by pinnipeds exposed to rocket launch noise with SPLs of approximately 110–120 dB re 20 µPa. Distant rocket launches with received SPLs of approximately 60-70 dB re 20 µPa tended to be ignored by hauled-out pinnipeds. Southall et al. (2007) reviewed these studies and recommended an (unweighted) SEL of 100 dB re $(20\ \mu Pa)^2 \cdot s$ as the threshold to predict effects to pinnipeds in air. Despite this threshold being based on reactions to launch noise, not sonars or other active acoustics, Navy uses this threshold as a protective measure for pinnipeds exposed to in-air acoustic sources. Therefore, the behavioral response threshold for phocids exposed to acoustic sources in-air is an (unweighted) SEL of 100 dB re (20 µPa)^2·s.

2.4.4.6 Otariids and odobenids (in water)

To assess behavioral effects from sonars and other active acoustic sources to all otariids and odobenids in water, BRF_2 is used, with the exposure weighted using the Type I weighting function for otariids.

2.4.4.7 Otariids and odobenids (in air)

Similar to phocids seals, the behavioral response threshold for otariids and odobenids exposed to acoustic sources in-air is an (unweighted) SEL of 100 dB re (20 µPa)^2·s.

2.4.4.8 Mustelids

Due to a lack of specific data regarding sea otter reactions to sound, and the phylogenetic and audiometric similarities between these amphibious carnivores and pinnipeds, the pinniped behavioral thresholds are also used to assess the potential behavioral effects to mustelids.

Therefore, to assess behavioral effects from in-water sonars and other active acoustic sources on sea otters, BRF_2 is used, with the exposure weighted using the Type I weighting function for mustelids. For in-air sounds, an (unweighted) SEL of 100 dB re (20 µPa)^2·s is used as a threshold for behavioral reactions in sea otters.

2.4.4.9 Ursids

Due to a lack of specific data regarding polar bear reactions to sound, and the phylogenetic and audiometric similarities between these amphibious carnivores and pinnipeds, the pinniped behavioral thresholds are also used to assess the potential behavioral effects to ursids.

Therefore, to assess behavioral effects from in-water sonars and other active acoustic sources on polar bears, BRF_2 is used, with the exposure weighted using the Type I weighting function for ursids. For in-air sounds, an (unweighted) SEL of 100 dB re (20 µPa)^2·s is used as a threshold for behavioral reactions in polar bears.

2.4.4.10 Sirenians

Due to a lack of specific data regarding sirenian reactions to sound, and the audiometric similarities between these animals and phocid pinnipeds, the phocid behavioral thresholds are also used to assess the potential behavioral effects to sirenians.

Therefore, to assess behavioral effects from in-water sonars and other active acoustic sources on sirenians (manatees and dugongs), BRF_2 is used, with the exposure weighted using the Type I weighting function for sirenians.

2.5 CRITERIA AND THRESHOLDS FOR EXPLOSIVE SOURCES

2.5.1 Introduction

Criteria and thresholds for predicting physical and behavioral effects to marine mammals exposed to underwater explosive detonations were initially developed for the U.S. Navy shock trials of the SEAWOLF submarine (Department of the Navy, 1998) and WINSTON S. CHURCHILL guided missile destroyer (Department of the Navy, 2001). After the SEAWOLF and CHURCHILL shock trials, additional data became available regarding the auditory effects of impulsive sounds, similar to underwater detonations, on marine mammals (e.g., Finneran, 2002). These data were incorporated into the analysis for the shock trial of the MESA VERDE amphibious transport dock ship (Department of the Navy, 2008b). The present US Navy criteria and thresholds for explosive sources follow the a similar approach to that used for the MESA VERDE acoustic impact analysis (Department of the Navy, 2008b).

Similarly to the criteria and thresholds for marine mammals exposed to sonars and other active acoustic sources, criteria and thresholds for explosive sources are divided into physiological effects and behavioral effects. Because of the increased hazardousness of the shock wave associated with underwater detonations, physiological effects not only include auditory effects (PTS and TTS), but also mortality and direct (i.e., non-auditory) tissue damage known as primary blast injury. Criteria and thresholds for physiological effects are presented in order of decreasing severity (i.e., mortality and most serious injuries first). These are followed by criteria and thresholds for PTS, TTS, and behavioral reactions for each functional hearing group. A summary of the various criteria and thresholds is provided in Appendix D.

2.5.2 Mortality and primary (non-auditory) blast injury

A considerable body of laboratory data exist on injuries from impulsive sound exposure, usually from explosive pulses, obtained from tests with a variety of lab animals (mice, rats, dogs, pigs, sheep and other species). Primary blast injuries from explosive detonations are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear). This section describes criteria and thresholds for primary blast injury to non-auditory tissues such as the lungs and gastrointestinal (GI) tract.

2.5.2.1 Mortality

An analysis of potential mortality of submerged terrestrial mammals exposed to small explosive charges has been conducted and used to define Navy thresholds for mortality for marine mammals exposed to underwater detonations (U.S. Navy, 2001; Yelverton, 1981). These analyses found the most common injuries to submerged mammals exposed to underwater detonations to be hemorrhaging in the fine structure of the lungs, and that lung damage is governed by the magnitude of the acoustic impulse (the time integral of the instantaneous sound pressure) of the underwater blast, not the peak pressure or sound exposure level (Richmond et al., 1973; Yelverton, 1981; Yelverton et al., 1973; Yelverton et al., 1975). Therefore, Navy analyses use the value of the acoustic impulse to determine if mortality or slight lung injury occurs. This approach is consistent with other efforts to predict the effects of underwater detonations (Department of the Navy, 1998; 2001; 2008b).

Mortality thresholds resulting from studies of injuries to submerged terrestrial mammals exposed to underwater blasts were based on the occurrence of "extensive lung injury" resulting in "1% Mortality," defined as an exposure where most animals may have moderate blast injuries to the lungs but 99% would survive. The minimum acoustic impulse for predicting the onset of mortality (I_M) is defined as:

$$I_M(M, D) = 91.4 M^{1/3}\left(1 + \frac{D}{10.1}\right)^{1/2}, \tag{9}$$

where M is the animal mass (kg), D is the animal depth (m), and the units of I_M are Pa·s. This equation is based on the Goertner injury model (Goertner, 1982), corrected for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass (Richmond *et al.*, 1973; U.S. Navy, 2001). The impulse required for mortality is assumed to increase proportionally to the square root of the ratio of the combined atmospheric and hydrostatic pressures at a specific depth to the atmospheric pressure at the surface. The critical value is assumed to be delivered during a time period that is the lesser of the positive pressure duration, or 20% of the natural period of the assumed-spherical lung adjusted for the size and depth of the animal. As depth increases, the impulse delivery time decreases (Goertner, 1982).

The impact analyses completed for the SEAWOLF and CHURCHILL shock trials (Department of the Navy, 1998; 2001) and other Navy compliance documents used a single body mass, that of a dolphin calf (12.2 kg), to represent all marine mammals for the derivation of the mortality threshold; however, thresholds based on the mass of a dolphin calf may underestimate mortality in smaller marine mammals and may overestimate mortality in larger marine mammals. Species-specific masses are therefore used for determining mortality thresholds because they most closely represent effects to individual species. Table D-2, in Appendix D, provides a nominal body mass for each species based on newborn individuals, a protective approach since the impulse threshold is lower for smaller masses and only a small percentage of a marine mammal population would consist of newborns (i.e., most would be larger and therefore have a higher threshold for mortality). In some cases, body masses were not available for the listed species and were therefore extrapolated from similar species.

2.5.2.2 Slight lung injury

Thresholds for slight lung injury to marine mammals exposed to underwater blasts were based on the occurrence of "slight lung injury" resulting in "0% Mortality," defined as an exposure where most animals may have slight blast injuries to the lungs but all would survive. The minimum acoustic impulse for predicting the onset of slight lung injury (I_S) is defined as:

$$I_S(M,D) = 39.1 M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}, \qquad (10)$$

where M is the animal mass (kg), D is the animal depth (m), and the units of I_S are Pa·s. This equation is based on the Goertner injury model (Goertner, 1982), corrected for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass (Richmond *et al.*, 1973; U.S. Navy, 2001). The impulse required for a slight lung injury is assumed to increase proportionally to the square root of the ratio of the combined atmospheric and hydrostatic pressures at a specific depth to the atmospheric pressure at the surface. As with the mortality thresholds, species-specific masses (see Table D-2, in Appendix D) are used for determining thresholds for slight lung injury.

In-air mortality and slight lung injury criteria and thresholds for pinnipeds (i.e., otariids, phocids, and odobenids) were not developed. Navy explosive training and testing activities do not normally coincide with pinniped, polar bear, or sea otter terrestrial habitat and therefore exposure to explosive energy on land that could cause mortality and slight lung injury is unlikely.

2.5.2.3 GI tract injury

Slight injury to the GI tract appears to be better correlated with the peak sound pressure of the shock wave rather than the acoustic impulse and is independent of the animal's size and mass (Goertner, 1982). Slight contusions to the GI tract were reported during small charge tests (Richmond *et al.*, 1973), when the (unweighted) peak SPL was 237 dB re 1µPa, therefore an unweighted peak SPL of 237 dB re 1 µPa is used as a threshold for slight injury to the GI tract for all marine mammals exposed to underwater explosions.

In-air GI tract injury criteria and thresholds for pinnipeds (i.e., otariids, phocids, and odobenids) were not developed. Navy explosive training and testing activities do not normally coincide with pinniped, polar bear, or sea otter terrestrial habitat and therefore exposure to explosive energy on land that could cause GI tract injury is unlikely.

2.5.3 Auditory Effects (TTS and PTS)

Navy environmental analyses for auditory effects (TTS and PTS) from underwater detonations follow the approach proposed by Southall et al. (2007) and used in the MESA VERDE acoustic impact analysis (Department of the Navy, 2008b), where a weighted SEL threshold is used in conjunction with an unweighted peak SPL threshold. The threshold producing the greater range for effect is then used because it is the more protective of the dual thresholds. In most cases, a total weighted SEL is more conservative than the largest SEL in any single 1/3-octave band, which was used for some earlier ship shock trials (e.g., Department of the Navy, 2001). Type II weighting functions for each functional hearing group are used, when available, to determine the auditory effects of explosions. If a Type II weighting function is not available for a functional hearing group, the Type I function for the group is used.

SEL and peak SPL thresholds for TTS are based on TTS data from impulsive sound exposures when available. If impulsive TTS data are not available, but TTS data from non-impulsive exposures are available, the onset of TTS is estimated from the TTS onset for non-impulsive sound and the relationship between impulse and non-impulse TTS observed in dolphins and belugas. For those species for whom no TTS data exist, TTS onset thresholds are based on the most closely related species for whom TTS data exist.

Since marine mammal PTS data from impulsive noise exposures do not exist, onset-PTS levels for these animals are estimated by adding 15 dB to the SEL-based TTS threshold and adding 6 dB to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function (i.e., Type II when available, otherwise Type I) for each functional hearing group is applied when using the SEL-based thresholds to predict PTS. The peak SPL thresholds are not weighted.

The specific thresholds for TTS and PTS for each marine mammal functional hearing group are detailed below and summarized in Appendix D.

2.5.3.1 LF Cetaceans

No TTS data are available for LF cetaceans, so the MF cetacean TTS onset values are used for LF cetaceans as well. The dual TTS thresholds for LF cetaceans therefore consist of a (Type II) weighted SEL of 172 dB re 1 $\mu Pa^2 \cdot s$ and a peak SPL of 224 dB re 1 μPa.

The PTS thresholds for LF cetaceans consist of a total (Type II) weighted SEL of 187 dB re 1 $\mu Pa^2 \cdot s$ and a peak SPL of 230 dB re 1 μPa.

2.5.3.2 MF Cetaceans

The TTS onset thresholds for MF cetaceans are based on TTS data from a beluga exposed to an underwater impulse produced from a seismic watergun (Finneran et al., 2002). These thresholds were also recommended by Southall et al. (2007). The numeric thresholds for MF cetaceans consist of a (Type II) weighted SEL of 172 dB re 1 $\mu Pa^2 \cdot s$ and a peak SPL of 224 dB re 1 μPa.

The PTS thresholds for MF cetaceans consist of a total (Type II) weighted SEL of 187 dB re 1 $\mu Pa^2 \cdot s$ and a peak SPL of 230 dB re 1 μPa.

2.5.3.3 HF Cetaceans

The TTS onset thresholds for HF cetaceans are based on TTS data from a harbor porpoise exposed to an underwater impulse produced from a seismic airgun (Lucke *et al.*, 2009). The numeric thresholds for HF cetaceans consist of a (Type II) weighted SEL of 146 dB re 1 $\mu Pa^2 \cdot s$ and a peak SPL of 195 dB re 1 μPa are used for HF cetaceans.

The PTS thresholds for HF cetaceans consist of a (Type II) weighted SEL of 161 dB re 1 $\mu Pa^2 \cdot s$ and a peak SPL of 201 dB re 1 μPa.

2.5.3.4 Phocids (in water)

Criteria for predicting TTS in phocid seals exposed to underwater pulses were based on underwater TTS data from a harbor seal exposed to octave band noise (Kastak *et al.*, 2005) and the extrapolation procedures described by Southall et al. (2007). The resulting TTS threshold values are: a (Type I) weighted SEL of 177 dB re 1 µPa^2·s and a peak SPL of 212 dB re 1 µPa.

The PTS thresholds for phocid seals exposed to underwater explosives consist of a total (Type I) weighted SEL of 192 dB re 1 µPa^2·s and a peak SPL of 218 dB re 1 µPa.

2.5.3.5 Phocids (in air)

The only known data regarding TTS in pinnipeds exposed to in-air impulse noise are from an unpublished report [Bowles et al. (unpublished data), as cited by Southall et al. (2007)] of TTS in harbor seals exposed to simulated sonic booms. The report cites onset-TTS at a peak SPL of 143 dB re 20 µPa or 129 dB re (20 µPa)^2·s. Southall et al. 2007 also reported that Bowles tested other pinnipeds whose TTS thresholds were higher, but actual numeric thresholds were not reported. Based on the only available TTS data for pinnipeds exposed to in-air impulsive noise, TTS thresholds for phocid seals exposed to in-air blasts consist of a (Type I) weighted SEL of 129 dB re (20 µPa)^2·s and a peak SPL of 143 dB re 20 µPa.

The PTS thresholds for phocid seals exposed to in-air explosives consist of a (Type I) weighted SEL of 144 dB re (20 µPa)^2·s and a peak SPL of 149 dB re 20 µPa.

2.5.3.6 Otariids and odobenids (in water)

Criteria for predicting TTS in otariids and odobenids exposed to underwater pulses were based on underwater TTS data from a California sea lion exposed to octave band noise (Kastak *et al.*, 2005) and the extrapolation procedures described by Southall et al. (2007). The resulting threshold values are: a (Type I) weighted SEL of 200 dB re 1 µPa^2·s and a peak SPL of 212 dB re 1 µPa.

The PTS thresholds for otariids and odobenids exposed to underwater explosives consist of a (Type I) weighted SEL of 215 dB re 1 µPa^2·s and a peak SPL of 218 dB re 1 µPa.

2.5.3.7 Otariids and odobenids (in air)

Based on the only available TTS data for pinnipeds exposed to in-air impulsive noise [Bowles et al., as cited by Southall et al. (2007)], TTS thresholds for otariids and odobenids exposed to in-air blasts consist of a (Type I) weighted SEL of 129 dB re (20 µPa)^2·s and a peak SPL of 143 dB re 20 µPa.

The PTS thresholds for otariids and odobenids exposed to in-air explosives consist of a (Type I) weighted SEL of 144 dB re (20 µPa)^2·s and a peak SPL of 149 dB re 20 µPa.

2.5.3.8 Mustelids

The explosive TTS and PTS thresholds for otariids are also used for sea otters because of the close taxonomic relationships and the similarities between audiograms. Therefore, for underwater exposures, the TTS threshold values for explosives consist of a (Type I) weighted

SEL of 200 dB re 1 μPa^2·s and a peak SPL of 212 dB re 1 μPa. For in-air exposures, a (Type I) weighted SEL of 129 dB re (20 μPa)^2·s and a peak SPL of 143 dB re 20 μPa are used.

The PTS threshold values for mustelids exposed to underwater explosives consist of a (Type I) weighted SEL of 215 dB re 1 μPa^2·s and a peak SPL of 218 dB re 1 μPa. For in-air exposures, mustelid PTS thresholds consist of a (Type I) weighted SEL of 144 dB re (20 μPa)^2·s and a peak SPL of 149 dB re 20 μPa.

2.5.3.9 Ursids

The explosive TTS and PTS thresholds for otariids are also used for polar bears because of the close taxonomic relationships and the similarities between audiograms. Therefore, for underwater exposures, the TTS threshold values for explosives consist of a (Type I) weighted SEL of 200 dB re 1 μPa^2·s and a peak SPL of 212 dB re 1 μPa. For in-air exposures, a (Type I) weighted SEL of 129 dB re (20 μPa)^2·s and a peak SPL of 143 dB re 20 μPa are used.

Similarly, the PTS threshold values for ursids exposed to underwater explosives consist of a (Type I) weighted SEL of 215 dB re 1 μPa^2·s and a peak SPL of 218 dB re 1 μPa. For in-air exposures, ursid PTS thresholds consist of a (Type I) weighted SEL of 144 dB re (20 μPa)^2·s and a peak SPL of 149 dB re 20 μPa.

2.5.3.10 Sirenians

The explosive TTS and PTS thresholds for phocid seals are also used for sirenians because of the similarities between the hearing ranges of phocids and manatees/dugongs. Therefore, for underwater exposures, the TTS threshold values for explosives consist of a (Type I) weighted SEL of 177 dB re 1 μPa^2·s and a peak SPL of 212 dB re 1 μPa.

The PTS thresholds for sirenians exposed to underwater explosives consist of a total (Type I) weighted SEL of 192 dB re 1 μPa^2·s and a peak SPL of 218 dB re 1 μPa.

2.5.4 Behavioral Effects

For single detonations, behavioral disturbance is likely to be limited to a short-lived startle reaction; therefore, Navy does not use any unique behavioral disturbance thresholds for marine mammals exposed to single explosive events.

For multiple, successive detonations (i.e., detonations happening at the same location within a 24-hour period), the threshold for behavioral disturbance is set 5 dB below the SEL-based TTS threshold, unless there are species or group specific data indicating that a lower threshold should be used. This is based on observations of behavioral reactions in captive dolphins and belugas occurring at exposure levels ~ 5 dB below those causing TTS after exposure to pure tones (Finneran and Schlundt, 2004; Schlundt *et al.*, 2000). The appropriate frequency weighting function (i.e., Type II when available, otherwise Type I) for each functional hearing group is applied when using the SEL-based disturbance thresholds.

The specific behavioral disturbance thresholds for the marine mammal functional hearing groups are detailed below and summarized in Appendix D.

2.5.4.1 LF Cetaceans

Specific data are lacking on the levels of sound that may illicit a behavioral reaction in LF cetaceans. Therefore, the disturbance threshold for LF cetaceans exposed to multiple, successive detonations is the TTS SEL-based threshold minus 5 dB: a (Type II) weighted SEL of 167 dB re 1 $\mu Pa^2 \cdot s$.

2.5.4.2 MF Cetaceans

The disturbance threshold for MF cetaceans exposed to multiple, successive detonations is a (Type II) weighted SEL of 167 dB re 1 $\mu Pa^2 \cdot s$, based on observations of behavioral reactions in captive dolphins and belugas occurring at exposure levels ~ 5 dB below those causing TTS after exposure to pure tones (Finneran and Schlundt, 2004; Schlundt *et al.*, 2000).

2.5.4.3 HF Cetaceans

Specific data are lacking on the levels of sound that may illicit a behavioral reaction in HF cetaceans. Therefore, the disturbance threshold for HF cetaceans exposed to multiple, successive detonations is the TTS SEL-based threshold minus 5 dB: a (Type II) weighted SEL of 141 dB re 1 $\mu Pa^2 \cdot s$.

2.5.4.4 Phocids (in water)

Specific data are lacking on the levels of sound that may illicit a behavioral reaction in phocid seals. Therefore, the disturbance threshold for phocids exposed to multiple, successive detonations is the TTS SEL-based threshold minus 5 dB: a (Type I) weighted SEL of 172 dB re 1 $\mu Pa^2 \cdot s$.

2.5.4.5 Phocids (in air)

As described in Section 2.4.4.5, a (Type I) weighted SEL of 100 dB re $(20\ \mu Pa)^2 \cdot s$ as the behavioral disturbance threshold for phocids exposed to multiple, successive, in-air blasts.

2.5.4.6 Otariids/odobenids (in water)

As with the phocids, the Navy the disturbance threshold for otariids and odobenids exposed to multiple, successive underwater detonations is the TTS SEL-based threshold minus 5 dB: a (Type I) weighted SEL of 195 dB re 1 $\mu Pa^2 \cdot s$.

2.5.4.7 Otariids/odobenids (in air)

As with the phocids, the Navy thresholds for otariids/odobenids exposed to multiple, successive explosive detonations in-air follows the Southall et al. (2007) recommendations: a (Type I) weighted SEL of 100 dB re $(20\ \mu Pa)^2 \cdot s$.

2.5.4.8 Mustelids

Specific data are lacking on the levels of sound that may illicit a behavioral reaction in sea otters. In light of the close taxonomic relationships and the similarities between the audiograms of otariids and mustelids, the behavioral disturbance thresholds for otariids exposed to multiple detonations are also used for sea otters. Therefore, the Navy the disturbance threshold for mustelids exposed to multiple, successive underwater detonations is a (Type I) weighted SEL of 195 dB re 1 $\mu Pa^2 \cdot s$.

For in-air exposures, the disturbance thresholds for mustelids exposed to multiple, successive explosive detonations consists of a (Type I) weighted SEL of 100 dB re (20 µPa)^2·s.

2.5.4.9 Ursids

Specific data are lacking on the levels of sound that may illicit a behavioral reaction in polar bears. In light of the close taxonomic relationships and the similarities between the audiograms of otariids and ursids, the behavioral disturbance thresholds for otariids are also used for polar bears. Therefore, the Navy the disturbance threshold for ursids exposed to multiple, successive underwater detonations is a (Type I) weighted SEL of 195 dB re 1 μPa^2·s.

For in-air exposures, the disturbance thresholds for ursids exposed to multiple, successive explosive detonations consists of a (Type I) weighted SEL of 100 dB re (20 µPa)^2·s.

2.5.4.10 Sirenians

The behavioral disturbance thresholds for phocid seals exposed to multiple, successive detonations are also used for sirenians because of the similarities between the hearing ranges of phocids and manatees/dugongs. Therefore, the disturbance threshold for sirenians exposed to multiple, successive detonations consists of a (Type I) weighted SEL of 172 dB re 1 μPa^2·s.

3 CRITERIA AND THRESHOLDS FOR SEA TURTLES

3.1 INTRODUCTION

The criteria and thresholds for sea turtles are similar to those proposed by Southall et al. (2007) for marine mammals: All sea turtles are placed into a single functional hearing group, and an auditory weighting function is used to emphasize frequencies where sensitivity to noise is high and de-emphasize frequencies where sensitivity is low. Individual criteria and thresholds are defined for sonars and other active acoustic sources and explosives.

3.2 FUNCTIONAL HEARING GROUP

To facilitate the acoustic and explosive effects analyses, animals are divided into functional hearing groups, and the same criteria and thresholds used for all species within a group. Several studies using green, loggerhead, and Kemp’s ridley turtles suggest sea turtles are most sensitive to low-frequency sounds (Bartol and Ketten, 2006; Bartol et al., 1999; Lenhardt, 1994; Ridgway et al., 1969). Although hearing sensitivity varies slightly by species and age class, because of the similarities across the available data, all sea turtles are placed into a single functional hearing group.

3.3 AUDITORY WEIGHTING FUNCTION

Auditory weighting functions are used to emphasize frequencies where sensitivity to noise is high and to de-emphasize frequencies where sensitivity is low. The weighted noise levels at each frequency are then combined to generate a single, weighted exposure value. This technique allows the use of a single, weighted threshold value, regardless of the noise frequency.

For humans, weighting functions are based on subjective loudness data. Analogous data for dolphins was used to derive the Type II weighting functions for MF cetaceans, and by extrapolation, for the other cetaceans. For the other marine mammal functional groups, only Type I weighting functions, based on functional hearing limits, are used. Since there are no equal loudness data for sea turtles and the differences between turtles and cetaceans preclude extrapolation to derive a Type II function for turtles, only a Type I weighting function is used for sea turtles.

The sea turtle weighting function amplitude is calculated using Eq. (4). The parameters for the weighting function are provided in Table 5; these are based on the functional hearing range for sea turtles of approximately 100 Hz to 1 kHz, with an upper frequency limit of 2 kHz (Bartol and Ketten, 2006; Bartol *et al.*, 1999; Lenhardt, 1994; Ridgway *et al.*, 1969). Figure 8 shows the sea turtle weighting function. The sea turtle (Type I) weighting function is used with all sea turtle SEL-based thresholds.

Table 5. Parameters for the Navy sea turtle (Type I) weighting function.

Functional Hearing Group	*K*	*a* (Hz)	*b* (Hz)
Sea turtles	0	10	2,000

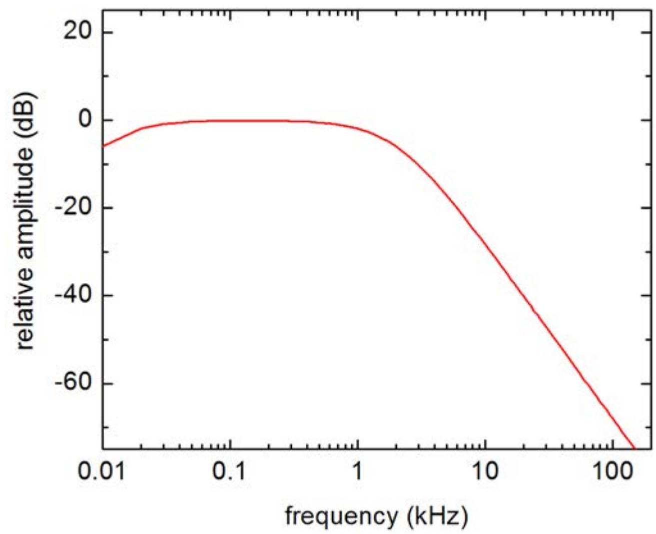

Figure 8. Auditory weighting function for sea turtles.

3.4 CRITERIA AND THRESHOLDS FOR SONARS AND OTHER ACTIVE ACOUSTIC SOURCES

3.4.1 Introduction

Criteria for sea turtles exposed to sonars and other active acoustic sources are divided into physiological effects and behavioral effects. Physiological effects criteria and thresholds are based on temporary and permanent threshold shift (TTS and PTS). Behavioral thresholds are based on experimental and observational data documenting the reactions of sea turtles to sound. A summary of the various criteria/thresholds and the sea turtle weighting function is provided in Appendix C.

3.4.2 Criteria and thresholds for TTS

To date, no known data are available on potential hearing impairments (i.e., TTS and PTS) in aquatic turtles. Sea turtles, based on their auditory anatomy (Bartol and Musick, 2003; Lenhardt et al., 1985; Wartzok and Ketten, 1999; Wever, 1978; Wyneken, 2001), are believed to have lower absolute sensitivity (i.e., higher thresholds) compared to cetaceans. Because of this, and the lack of data specific to sea turtles, previous Navy environmental analyses (e.g., Department of the Navy, 1998; 2001; 2008b), used the cetacean TTS threshold to define the sea turtle threshold. Since sea turtles have best sensitivity at low frequencies, similar to the LF cetaceans, the LF cetacean TTS threshold is applied to sea turtles. Therefore, the TTS threshold for sea turtles exposed to sonars and other active acoustic sources is a (Type I) weighted SEL of 178 dB re 1 $\mu Pa^2 \cdot s$.

3.4.3 Criteria and thresholds for PTS

As with the marine mammals, the PTS threshold for sea turtles exposed to sonars and other active acoustic sources is estimated as being 20 dB above the TTS threshold. This results in a PTS threshold consisting of a (Type I) weighted SEL of 198 dB re 1 $\mu Pa^2 \cdot s$.

3.4.4 Criteria and thresholds for behavioral effects

Potential behavioral changes could include a startle reaction, avoiding the sound source, increased swimming speed, increased surfacing time, and decreased foraging. No known studies have examined the reactions of sea turtles to sonars or other active acoustic sources. However, several studies have investigated the behavioral responses of sea turtles to impulsive sounds produced by seismic airguns. O'Hara and Wilcox (1990) reported that loggerhead turtles kept in a 300 × 45 m enclosure in a 10 m deep canal maintained a standoff range of 30 m from three small airguns fired simultaneously at 15-s internals (O'Hara and Wilcox, 1990). Although O'Hara and Wilcox did not report the actual received sound levels, McCauley et al. (2000) have estimated the received SPL for avoidance to be 175–176 dB re 1 μPa.

Moein et al. (1994) investigated the use of airguns to repel juvenile loggerhead sea turtles from hopper dredges. The results from all turtles tested (11 individuals, six trials each) indicated avoidance was seen during the first presentation of the air gun exposure at a mean range of 24 m; however, details of the airgun, its operational pressure, deployment depth, and the sound levels received by the turtles throughout the cage were not provided.

McCauley et al. (2000) measured behavioral responses in captive green and loggerhead turtles exposed to airgun impulses. The results showed that above a received SPL of 166 dB re 1 μPa the turtles noticeably increased their swimming activity compared to non airgun operation periods. Above 175 dB re 1 μPa, behavior became more erratic possibly indicating the turtles were in an agitated state (McCauley *et al.*, 2000). The authors noted that the point at which the turtles showed the more erratic behavior would be expected to approximately equal the point at which avoidance would occur for unrestrained turtles (McCauley *et al.*, 2000).

Cumulatively, these studies indicate that behavioral disturbance may occur in sea turtles exposed to impulsive noise with SPLs greater than 166 dB re 1 μPa and that more erratic behavior and avoidance may begin at SPLs of 175–179 dB re 1 μPa, with 175 dB re 1 μPa more likely to be the point at which avoidance may occur in unrestrained turtles (McCauley *et al.*, 2000). Navy effects analyses use the lower range of SPLs that caused avoidance as the behavioral disturbance threshold for sea turtles: a (Type I) weighted SPL of 175 dB re 1 μPa.

3.5 CRITERIA AND THRESHOLDS FOR EXPLOSIVE SOURCES

3.5.1 Introduction

Similarly to the marine mammal criteria and thresholds for sonars and other active acoustic exposures, criteria and thresholds for explosive sources are divided into physiological effects and behavioral effects. Because of the increased hazardousness of the shock wave associated with underwater detonations, physiological effects not only include auditory effects (PTS and TTS), but also mortality and direct (i.e., non-auditory) tissue damage known as primary blast injury. Criteria and thresholds for physiological effects are presented in order of decreasing severity (i.e., mortality and most serious injuries first). These are followed by criteria and thresholds for PTS, TTS, and behavioral reactions. A summary of the various criteria and thresholds is provided in Appendix D.

3.5.2 Mortality and primary (non-auditory) blast injury

Very little information exists regarding the impacts of underwater detonations on sea turtles. Impacts to sea turtles from explosive removal operations have ranged from non-injurious effects (e.g., acoustic annoyance, mild tactile detection or physical discomfort) to varying levels of injury (i.e., non-lethal and lethal injuries). Often, effects of explosive events on turtles must be inferred from documented effects to other vertebrates with lungs or other-gas containing organs, such as mammals and fish (Viada et al., 2008). As with marine mammals, primary blast injury almost exclusively affects the gas-containing organs: the lung and the ear. For this reason, the general principles of the Goertner injury model are applicable; however, since it is not known what degree of protection from a shock wave is provided by a turtle's shell, application of the Goertner injury model is believed to be protective (Viada *et al.*, 2008). Therefore, Eqs. (9) and (10) are used to calculate the mortality and slight lung injury thresholds, respectively, for sea turtles exposed to underwater detonations. Sea turtle body masses for use in Eqs. (9) and (10) are provided in Table D-2, in Appendix D. Since sea turtle hatchlings can weigh less than 0.5% of their adult mass, juvenile masses are used to avoid greatly over-estimating the potential effects of detonations.

Although the lungs and auditory system are considered to be the most likely site of injury to sea turtles exposed to underwater detonations, as a protective measure, the GI tract injury threshold used for marine mammals is also applied to sea turtles: an (unweighted) SPL of 237 dB re 1 μPa.

3.5.3 Auditory Effects (TTS and PTS)

No data exist to correlate the sensitivity of the sea turtle tympanum and middle and inner ear to trauma associated with the shock waves associated with underwater explosions (Viada *et al.*, 2008). Thus, similar to the turtle sonar and other active acoustic thresholds, sea turtle thresholds for TTS and PTS after exposure to underwater detonations are identical to the values for LF cetaceans.

Therefore, the dual TTS thresholds for sea turtles consist of a (Type I) weighted SEL of 172 dB re 1 $\mu Pa^2 \cdot s$ and a peak SPL of 224 dB re 1 μPa.

The PTS thresholds for sea turtles consist of a (Type I) weighted SEL of 187 dB re 1 μPa^2·s and a peak SPL of 230 dB re 1 μPa.

3.5.4 Behavioral Effects

As discussed in Section 3.4.4, several authors have investigated the behavioral responses of sea turtles to impulsive sounds produced by airguns (McCauley et al., 2000; Moein et al., 1994; O'Hara and Wilcox, 1990). Cumulatively, these studies indicate that a behavioral reaction to a sound may occur with SPLs greater than 166 dB re 1 μPa, and that more erratic behavior and avoidance, which may be indicative of a behavioral disturbance in wild animals, may occur at SPLs of 175–179 dB re 1 μPa. McCauley et al. determined that these SPLs would result in an SEL 11.4–14.6 dB lower than the SPL. For an SPL of 175 dB re 1 μPa, the comparable SEL would therefore be 163.6–160.4 dB re 1 μPa^2·s.

For Navy environmental documents, the sea turtle behavioral disturbance threshold after exposure to multiple, successive underwater impulses therefore consists of a (Type I) weighted SEL of 160 dB re 1 μPa^2·s.

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APPENDIX A. FUNCTIONAL HEARING GROUPS

Table A-1. Functional hearing groups used in Navy acoustic impact analyses.

Functional Hearing Group	Description
LF cetaceans	Suborder Mysticeti (baleen whales)
MF cetaceans	Family Ziphiidae (beaked whales) Family Physeteridae (Sperm whale) Family Monodontidae (Irrawaddy dolphin, beluga, narwhal) Subfamily Delphininae (white-beaked/white-sided/ Risso's/bottlenose/spotted/spinner/striped/common dolphins) Subfamily Steninae (rough-toothed/humpback dolphins) Subfamily Globicephalinae (melon-headed whales, false/pygmy killer whale, killer whale, pilot whales) Subfamily Lissodelphinae (right whale dolphins)
HF cetaceans	Family Phocoenidae (porpoises) Family Platanistidae (Indus/Ganges river dolphins) Family Iniidae (Amazon river dolphins) Family Pontoporiidae (Baiji/ La Plata river dolphins) Family Kogiidae (Pygmy/dwarf sperm whales) Subfamily Cephalorhynchinae (Commersen's, Black, Heaviside's, Hector's dolphins)
Phocids	Family Phocidae (earless seals)
Otariids and Odobenids	Family Otaridae (fur seals/sea lions) Family Odobenidae (walrus)
Mustelids	Family Mustelidae (sea otters)
Ursids	Family Ursidae (polar bears)
Sirenians	Order Sirenia (mantees/dugongs)
Sea turtles	Family Cheloniidae (loggerhead, green, hawksbill, Kemp's ridley, olive ridley, flatback sea turtle) Family Dermochelyidae (leatherback sea turtle)

APPENDIX B. AUDITORY WEIGHTING FUNCTIONS

B.1 TYPE I WEIGHTING FUNCTIONS

$$W_I(f) = K + 20\log_{10}\left[\frac{b^2 f^2}{(a^2 + f^2)(b^2 + f^2)}\right] \tag{B-1}$$

$W_I(f)$	weighting function amplitude (dB)
f	sound frequency (Hz)
a	lower cutoff frequency (Table B-1)
b	upper cutoff frequency (Table B-1)
K	gain (Table B-1)

Table B-1. Parameters for the Navy Type I weighting functions.

Functional Hearing Group	*K* (dB)	*a* (Hz)	*b* (Hz)
LF cetaceans	0	7	22,000
MF cetaceans	0	150	160,000
HF cetaceans	0	200	180,000
Phocids (in water), Sirenians	0	75	75,000
Phocids (in air)	0	75	30,000
Otariids, Odobenids, Mustelids, Ursids (in water)	0	100	40,000
Otariids, Odobenids, Mustelids, Ursids (in air)	0	100	30,000
Sea turtles	0	10	2,000

B.2 TYPE II WEIGHTING FUNCTIONS

$$W_{II}(f) = \text{maximum}\{G_1(f), G_2(f)\}, \tag{B-2}$$

$W_{II}(f)$ weighting function amplitude (dB)

f sound frequency (Hz)

$$G_1(f) = K_1 + 20\log_{10}\left[\frac{b_1^2 f^2}{(a_1^2 + f^2)(b_1^2 + f^2)}\right] \tag{B-3}$$

$G_1(f)$ amplitude of Type I function component (dB)

a_1 Type I component lower cutoff frequency (Table B-2)

b_1 Type I component upper cutoff frequency (Table B-2)

K_1 Type I component gain (Table B-2)

$$G_2(f) = K_2 + 20\log_{10}\left[\frac{b_2^2 f^2}{(a_2^2 + f^2)(b_2^2 + f^2)}\right] \tag{B-4}$$

$G_2(f)$ amplitude of EQL function component (dB)

a_2 EQL component lower cutoff frequency (Table B-2)

b_2 EQL component upper cutoff frequency (Table B-2)

K_2 EQL component gain (Table B-2)

Table B-2. Parameters for the Navy (cetacean) Type II weighting functions.

Functional Hearing Group	K_1 (dB)	a_1 (Hz)	b_1 (Hz)	K_2 (dB)	a_2 (Hz)	b_2 (Hz)	Inflection point (Hz)
LF cetaceans	-16.5	7	22,000	0.9	674	12,130	267
MF cetaceans	-16.5	150	160,000	1.4	7,829	95,520	3,000
HF cetaceans	-19.4	200	180,000	1.4	9,480	108,820	3,000

APPENDIX C. CRITERIA AND THRESHOLDS FOR SONARS AND OTHER ACTIVE ACOUSTIC SOURCES

Table C-1. Navy criteria and thresholds for marine mammals and sea turtles exposed to sonars and other active acoustic sources

Functional Hearing Group or Species	PTS Threshold (all weighted SEL)	TTS Threshold (all weighted SEL)	Behavioral Threshold
LF Cetaceans	(Type II) SEL: 198 dB re 1 μPa^2·s	(Type II) SEL: 178 dB re 1 μPa^2·s	(Type I) SPL: BRF_1
MF Cetaceans (*except beaked whales*)	(Type II) SEL: 198 dB re 1 μPa^2·s	(Type II) SEL: 178 dB re 1 μPa^2·s	(Type I) SPL: BRF_2
Beaked whales	(Type II) SEL: 198 dB re 1 μPa^2·s	(Type II) SEL: 178 dB re 1 μPa^2·s	(unweighted) SPL: 140 dB re 1 μPa
HF Cetaceans (*except harbor porpoises*)	(Type II) SEL: 172 dB re 1 μPa^2·s	(Type II) SEL: 152 dB re 1 μPa^2·s	(Type I) SPL: BRF_2
Harbor porpoises	(Type II) SEL: 172 dB re 1 μPa^2·s	(Type II) SEL: 152 dB re 1 μPa^2·s	(unweighted) SPL: 120 dB re 1 μPa
Phocids Sirenians (in water)	(Type I) SEL: 197 dB re 1 μPa^2·s	(Type I) SEL: 183 dB re 1 μPa^2·s	(Type I) SPL: BRF_2
Phocids (in air)	(Type I) SEL: 145 dB re (20 μPa)^2·s	(Type I) SEL: 131 dB re (20 μPa)^2·s	(unweighted) SEL: 100 dB re (20 μPa)^2·s
Otariids Odobenids Mustelids Ursids (in water)	(Type I) SEL: 220 dB re 1 μPa^2·s	(Type I) SEL: 206 dB re 1 μPa^2·s	(Type I) SPL: BRF_2
Otariids Odobenids Mustelids Ursids (in air)	(Type I) SEL: 168 dB re (20 μPa)^2·s	(Type I) SEL: 154 dB re (20 μPa)^2·s	(unweighted) SEL: 100 dB re (20 μPa)^2·s
Sea Turtles	(Type I) SEL: 198 dB re 1 μPa^2·s	(Type I) SEL: 178 dB re 1 μPa^2·s	(Type I) SPL: 175 dB re 1 μPa

APPENDIX D. CRITERIA AND THRESHOLDS FOR EXPLOSIVES

Table D-1. Navy criteria and thresholds for marine mammals and sea turtles exposed to explosive detonations.

Functional Hearing Group or Species	Mortality	Slight Lung Injury	GI tract injury	PTS Threshold	TTS Threshold	Behavioral Threshold
LF Cetaceans	Modified Goertner model, Eq. (D-1) Mass from Table D-2	Modified Goertner model, Eq. (D-2) Mass from Table D-2	(unweighted) SPL: 237 dB re 1 µPa	(Type II) SEL: 187 dB re 1 µPa^2·s (unweighted) peak SPL: 230 dB re 1 µPa	(Type II) SEL: 172 dB re 1 µPa^2·s (unweighted) peak SPL: 224 dB re 1 µPa	(Type II) SEL: 167 dB re 1 µPa^2·s
MF Cetaceans	Modified Goertner model, Eq. (D-1) Mass from Table D-2	Modified Goertner model, Eq. (D-2) Mass from Table D-2	(unweighted) SPL: 237 dB re 1 µPa	(Type II) SEL: 187 dB re 1 µPa^2·s (unweighted) peak SPL: 230 dB re 1 µPa	(Type II) SEL: 172 dB re 1 µPa^2·s (unweighted) peak SPL: 224 dB re 1 µPa	(Type II) SEL: 167 dB re 1 µPa^2·s
HF Cetaceans	Modified Goertner model, Eq. (D-1) Mass from Table D-2	Modified Goertner model, Eq. (D-2) Mass from Table D-2	(unweighted) SPL: 237 dB re 1 µPa	(Type II) SEL: 161 dB re 1 µPa^2·s (unweighted) peak SPL: 201 dB re 1 µPa	(Type II) SEL: 146 dB re 1 µPa^2·s (unweighted) peak SPL: 195 dB re 1 µPa	(Type II) SEL: 141 dB re 1 µPa^2·s
Phocids Sirenians (in water)	Modified Goertner model, Eq. (D-1) Mass from Table D-2	Modified Goertner model, Eq. (D-2) Mass from Table D-2	(unweighted) SPL: 237 dB re 1 µPa	(Type I) SEL: 192 dB re 1 µPa^2·s (unweighted) peak SPL: 218 dB re 1 µPa	(Type I) SEL: 177 dB re 1 µPa^2·s (unweighted) peak SPL: 212 dB re 1 µPa	(Type I) SEL: 172 dB re 1 µPa^2·s

Functional Hearing Group or Species	Mortality	Slight Lung Injury	GI tract injury	PTS Threshold	TTS Threshold	Behavioral Threshold
Phocids (in air)	See Note 1	See Note 1	See Note 1	(Type I) SEL: 144 dB re (20 µPa)^2·s (unweighted) peak SPL: 149 dB re 20 µPa	(Type I) SEL: 129 dB re (20 µPa)^2·s (unweighted) peak SPL: 143 dB re 20 µPa	(Type I) SEL: 100 dB re (20 µPa)^2·s
Otariids Odobenids Mustelids Ursids (in water)	Modified Goertner model, Eq. (D-1) Mass from Table D-2	Modified Goertner model, Eq. (D-2) Mass from Table D-2	(unweighted) SPL: 237 dB re 1 µPa	(Type I) SEL: 215 dB re 1 µPa^2·s (unweighted) peak SPL: 218 dB re 1 µPa	(Type I) SEL: 200 dB re 1 µPa^2·s (unweighted) peak SPL: 212 dB re 1 µPa	(Type I) SEL: 195 dB re 1 µPa^2·s
Otariids Odobenids Mustelids Ursids (in air)	See Note 1	See Note 1	See Note 1	(Type I) SEL: 144 dB re (20 µPa)^2·s (unweighted) peak SPL: 149 dB re 20 µPa	(Type I) SEL: 129 dB re (20 µPa)^2·s (unweighted) peak SPL: 143 dB re 20 µPa	(Type I) SEL: 100 dB re (20 µPa)^2·s
Sea Turtles	Modified Goertner model, Eq. (D-1) Mass from Table D-2	Modified Goertner model, Eq. (D-2) Mass from Table D-2	(unweighted) SPL: 237 dB re 1 µPa	(Type I) SEL: 187 dB re 1 µPa^2·s (unweighted) peak SPL: 230 dB re 1 µPa	(Type I) SEL: 172 dB re 1 µPa^2·s (unweighted) peak SPL: 224 dB re 1 µPa	(Type I) SEL: 160 dB re 1 µPa^2·s

1 - In-air GI tract injury, slight lung injury, and mortality criteria and thresholds for pinnipeds (i.e., otariids, phocids, and odobenids) were not developed. Navy explosive training and testing activities do not normally coincide with pinniped, polar bear, or sea otter terrestrial habitat and therefore exposure to explosive energy on land that could cause these injuries is unlikely.

$$I_M(M,D) = 91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2} \quad \text{(D-1)}$$

$I_M(M,D)$ mortality threshold, expressed in terms of acoustic impulse (Pa·s)

M Animal mass (Table D-1)

D Water depth (m)

$$I_S(M,D) = 39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2} \quad \text{(D-2)}$$

$I_S(M,D)$ slight lung injury threshold, expressed in terms of acoustic impulse (Pa·s)

M Animal mass (Table D-1)

D Water depth (m)

Table D-2. Representative animal masses for use in Eqs. (D-1) and (D-2).

Species Name	Common Name	Newborn Calf / Pup Mass (kg)	Reference
Cetaceans			
Family Balaenidae			
Eubalaena glacialis	North Atlantic right whale	910	Reeves et al. (2002)
Eubalaena japonica	North Pacific right whale	910	Reeves et al. (2002)
Family Balaenopteridae			
Balaenoptera acutorostrata	Minke whale	200	Mann et al. (2000)
Balaenoptera borealis	Sei whale	650	Gambell (1985)
Balaenoptera edeni	Bryde's whale	680	Reeves et al. (2002)
Balaenoptera musculus	Blue whale	2,000	Reidenberg and Laitman (2002)
Balaenoptera physalus	Fin whale	1,750	Reidenberg and Laitman (2002)
Megaptera novaeangliae	Humpback whale	680	Reeves et al. (2002)
Family Delphinidae			
Delphinus capensis	Long-beaked common dolphin	7	Surrogate: striped dolphin
Delphinus delphis	Short-beaked common dolphin	7	Surrogate: striped dolphin
Feresa attenuata	Pygmy killer whale	7	Surrogate: striped dolphin
Globicephala macrorhynchus	Short-finned pilot whale	37	Reeves et al. (2002)
Globicephala melas	Long-finned pilot whale	70	Reidenberg and Laitman (2002)
Grampus griseus	Risso's dolphin	47	Nachtigall et al. (2005)
Lagenodelphis hosei	Fraser's dolphin	19	Reeves et al. (2002)
Lagenorhynchus acutus	Atlantic white-sided dolphin	20	Reeves et al. (2002)
Lagenorhynchus albirostris	White-beaked dolphin	40	Reidenberg and Laitman (2002)
Lagenorhynchus obliquidens	Pacific white-sided dolphin	12	Heise (1997)
Lissodelphis borealis	Northern right whale dolphin	15	Surrogate: bottlenose dolphin/melon-headed whale
Orcinus orca	Killer whale	160	Reeves et al. (2002)
Peponocephala electra	Melon-headed whale	15	Reeves et al. (2002)
Pseudorca crassidens	False killer whale	80	Mann et al. (2000)
Stenella attenuata	Pantropical spotted dolphin	7	Surrogate: striped dolphin
Stenella clymene	Clymene dolphin	7	Surrogate: striped dolphin
Stenella coeruleoalba	Striped dolphin	7	Reeves et al. (2002)
Stenella frontalis	Atlantic spotted dolphin	7	Surrogate: striped dolphin
Stenella longirostris	Spinner dolphin	7	Surrogate: striped dolphin
Steno bredanensis	Rough-toothed dolphin	14	Surrogate: humpbacked dolphin
Tursiops aduncus	Indo-Pacific bottlenose dolphin	9	Reeves et al. (2002)
Tursiops truncatus	Common bottlenose dolphin	14	Reeves et al. (2002)
Family Eschrisctiidae			

Species Name	Common Name	Newborn Calf / Pup Mass (kg)	Reference
Eschrichtius robustus	Gray whale	500	Reidenberg and Laitman (2002)
Family Kogiidae			
Kogia breviceps	Pygmy sperm whale	23	Reeves et al. (2002)
Kogia sima	Dwarf sperm whale	14	Plön (2004)
Family Monodontidae			
Delphinapterus leucas	Beluga whale	80	Reeves et al. (2002) and Reidenberg and Laitman (2002)
Monodon monoceros	Narwhal	80	Reeves et al. (2002)
Family Phocoenidae			
Phocoenoides dalli	Dall's Porpoise	6	Ferrero and Walker (1999)
Phocoena phocoena	Harbor porpoise	5	Reeves et al. (2002) and Reidenberg and Laitman (2002)
Family Physeteridae			
Physeter macrocephalus	Sperm whale	1000	Reeves et al. (2002) and Reidenberg and Laitman (2002)
Family Ziphiidae			
Berardius arnouxii	Arnoux's beaked whale	250	Surrogate: Cuvier's beaked whale
Berardius berardii	Baird's beaked whale	250	Surrogate: Cuvier's beaked whale
Hyperoodon ampullatus	Northern bottlenose whale	250	Surrogate: Cuvier's beaked whale
Indopacetus pacificus	Longman's beaked whale	228	Dalebout et al (2003)
Mesoplodon bidens	Sowerby's beaked whale	170	Reeves et al. (2002)
Mesoplodon carlhubbsi	Hubb's beaked whale	170	Surrogate: Sowerby's beaked whale
Mesoplodon densirostris	Blainville's beaked whale	60	Reeves et al. (2002) and Reidenberg and Laitman (2002)
Mesoplodon europaeus	Gervais' beaked whale	49	Reidenberg and Laitman (2002)
Mesoplodon ginkgodens	Ginkgo-toothed beaked whale	170	Surrogate: Sowerby's beaked whale
Meosplodon hectori	Hector's beaked whale	60	Surrogate: Blainville's beaked whale
Mesoplodon layardii	Strap-toothed whale	136	Surrogate: True's beaked whale
Mesoplodon mirus	True's beaked whale	136	Reidenberg and Laitman (2002)
Mesoplodon perrini	Perrin's beaked whale	60	Surrogate: Blainville's beaked whale
Mesoplodon peruvianus	Pygmy beaked whale	49	Surrogate: Gervais' beaked whale
Mesoplodon stejnegeri	Stejneger's beaked whale	60	Surrogate: Blainville's beaked whale

Species Name	Common Name	Newborn Calf / Pup Mass (kg)	Reference
Tasmacetus shepherdi	Shepherd's beaked whale	250	Surrogate: Cuvier's beaked whale
Ziphius cavirostris	Cuvier's beaked whale	250	Reeves et al. (2002)
Carnivores			
Family Mustelidae			
Enhydra lutris	Sea otter	2	Reeves et al. (2002)
Family Phocidae			
Cystophora cristata	Hooded seal	11	Reeves et al. (2002)
Erignathus barbatus	Bearded seal	29	Lydersen et al. (2002)
Halichoerus grypus	Gray seal	13	Iverson et al. (1993)
Histriophoca fasciata	Ribbon seal	9	Reeves et al. (2002)
Mirounga angustirostris	Northern elephant seal	22	Le Boeuf et al. (1972)
Monachus schauinslandi	Hawaiian monk seal	10	Wirtz (1968)
Pagophilus groenlandicus	Harp seal	7	Reeves et al. (2002)
Phoca vitulina	Harbor seal	7	Ellis et al. (2000)
Pusa hispida	Ringed seal	4	Reeves et al. (2002)
Family Otariidae			
Arctocephalus townsendi	Guadalupe fur seal	2	Reeves et al. (2002)
Callorhinus ursinus	Northern fur seal	4	Reeves et al. (2002)
Eumetopias jubatus	Steller sea lion	16	Reeves et al. (2002)
Zalophus californianus	California sea lion	6	Reeves et al. (2002)
Family Ursidae			
*Ursinus maritimus**	Polar bear	10	DeMaster and Stirling (1981)
Sirenians			
Family Dugonginae			
Dugong dugong	Dugong	25	Reeves et al. (2002)
Family Trichechidae			
Trichechus manatus	West Indian manatee	27	Caldwell and Caldwell (1985)
Sea Turtles			
Family Cheloniidae			
Caretta caretta	Loggerhead turtle	8.7	Southwood, Higgins et al. (2007)
Chelonia mydas	Green turtle	8.7	Wood and Wood (1993)
Eretmochelys imbricata	Hawksbill turtle	7.4	Okuyama, Shimizu et al. (2010)
Lepidochelys kempii	Kemp's ridley turtle	6.25	McVey and Wibbels (1984) and Caillouet, Koi et al. (1986)
Lepidochelys olivacea	Olive ridley turtle	7.15	Rajagopalan (1984)
Family Dermochelyidae			
Dermochelys coriacea	Leatherback turtle	35.18	Jones (2009)

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