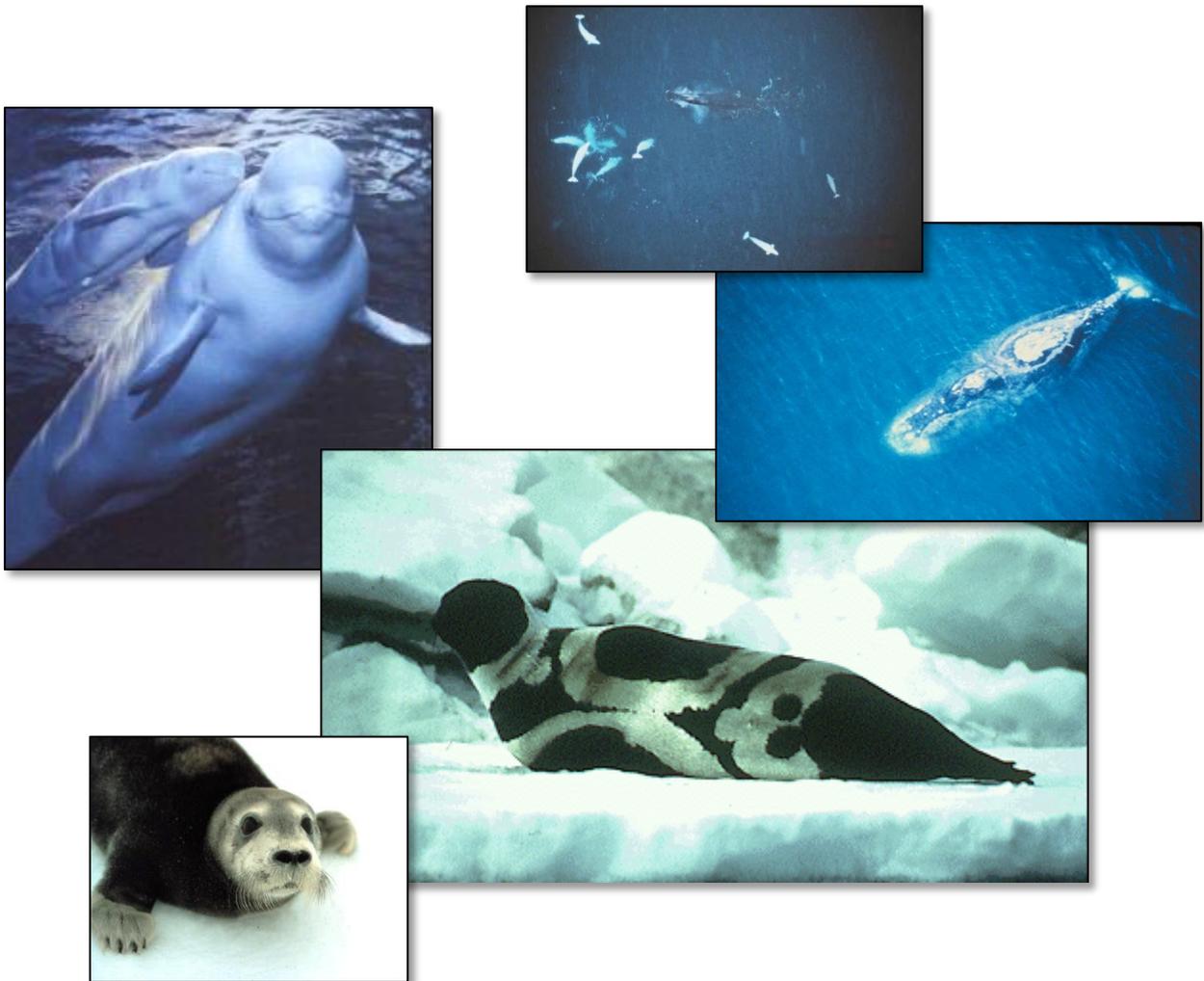


# Effects of Oil and Gas Activities in the Arctic Ocean

## Final Environmental Impact Statement

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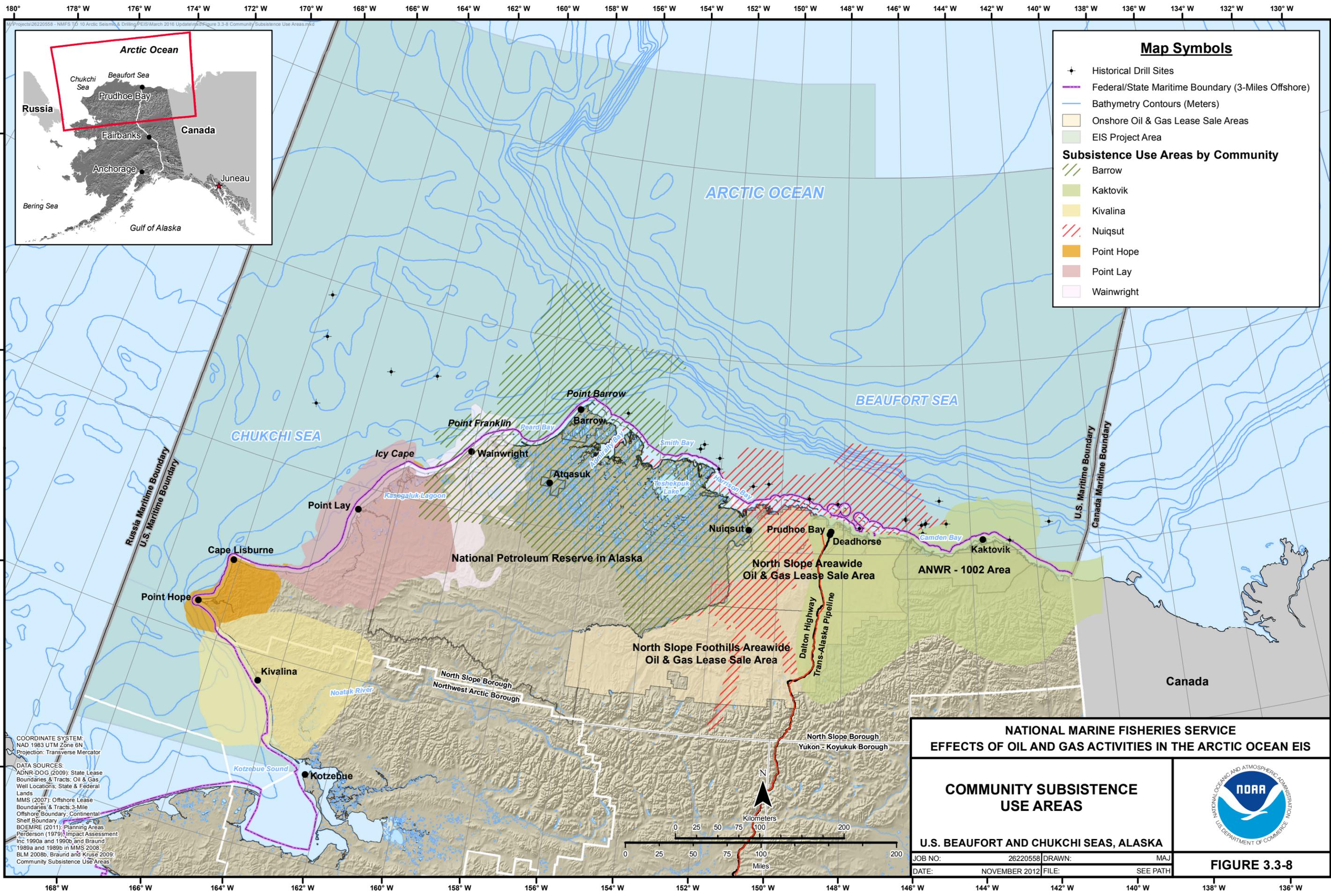
### Volume 3: Figures and Appendices

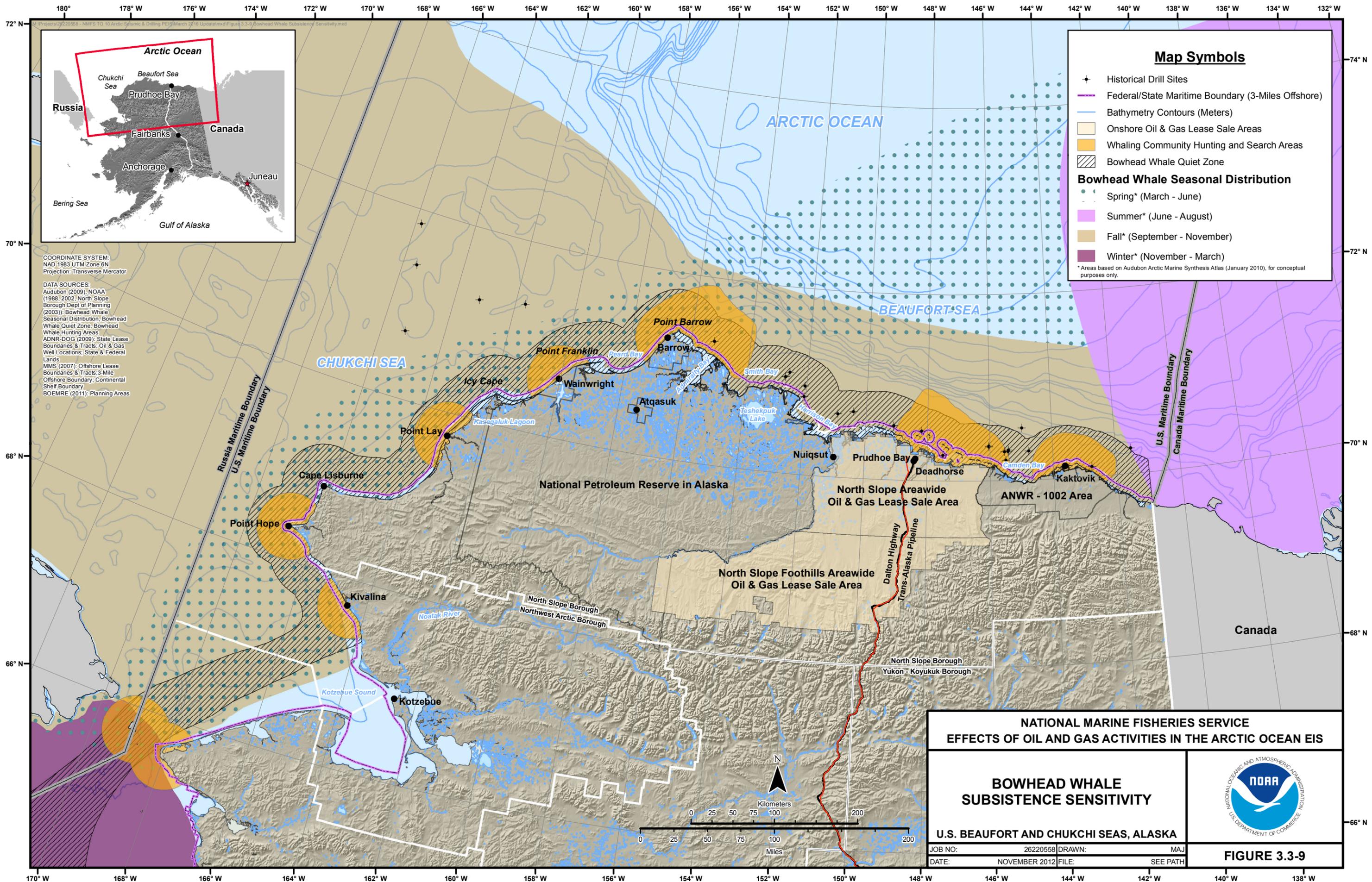


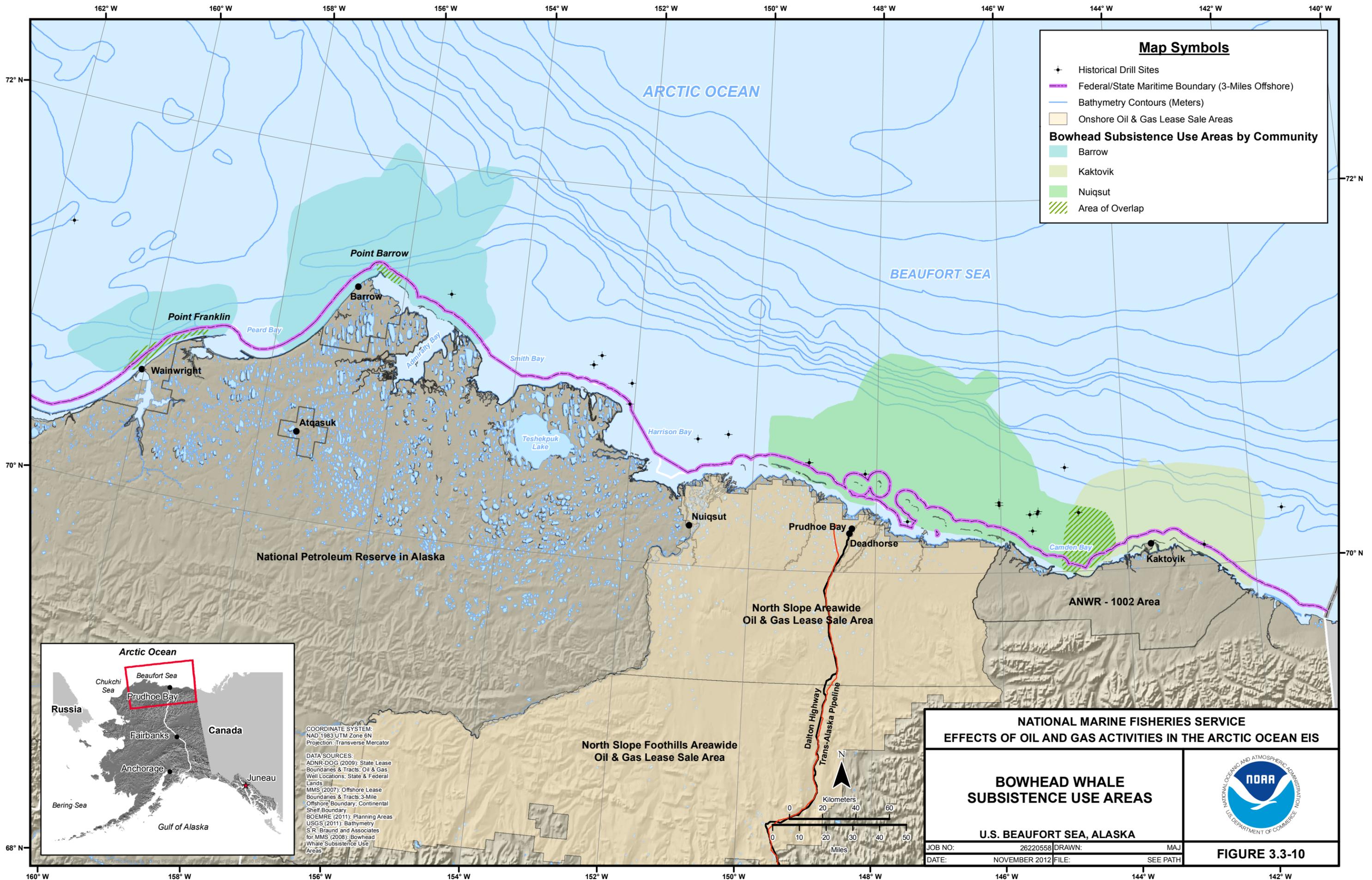
October 2016

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









**Map Symbols**

- ✦ Historical Drill Sites
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Onshore Oil & Gas Lease Sale Areas

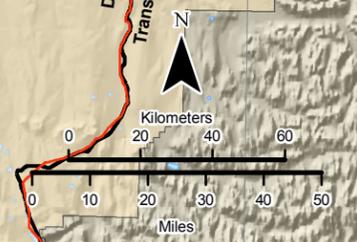
**Bowhead Subsistence Use Areas by Community**

- Barrow
- Kaktovik
- Nuiqsut
- ▨ Area of Overlap



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 (2008): Bowhead Whale Subsistence Use Areas



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

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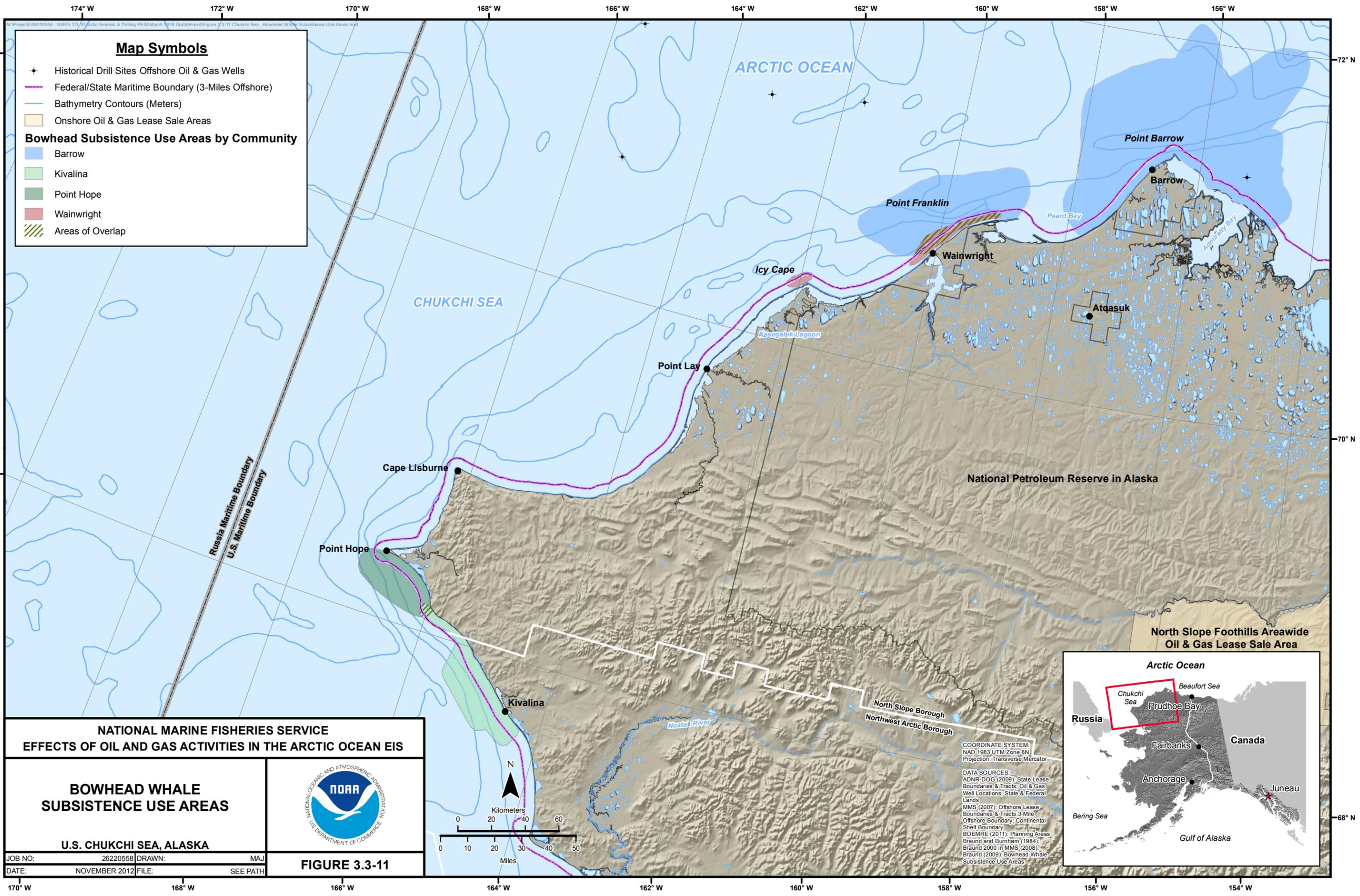
**BOWHEAD WHALE**  
**SUBSISTENCE USE AREAS**

**U.S. BEAUFORT SEA, ALASKA**

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

**FIGURE 3.3-10**





**Map Symbols**

- Historical Drill Sites Offshore Oil & Gas Wells
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Onshore Oil & Gas Lease Sale Areas

**Bowhead Subsistence Use Areas by Community**

- Barrow
- Kivalina
- Point Hope
- Wainwright
- Areas of Overlap

**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

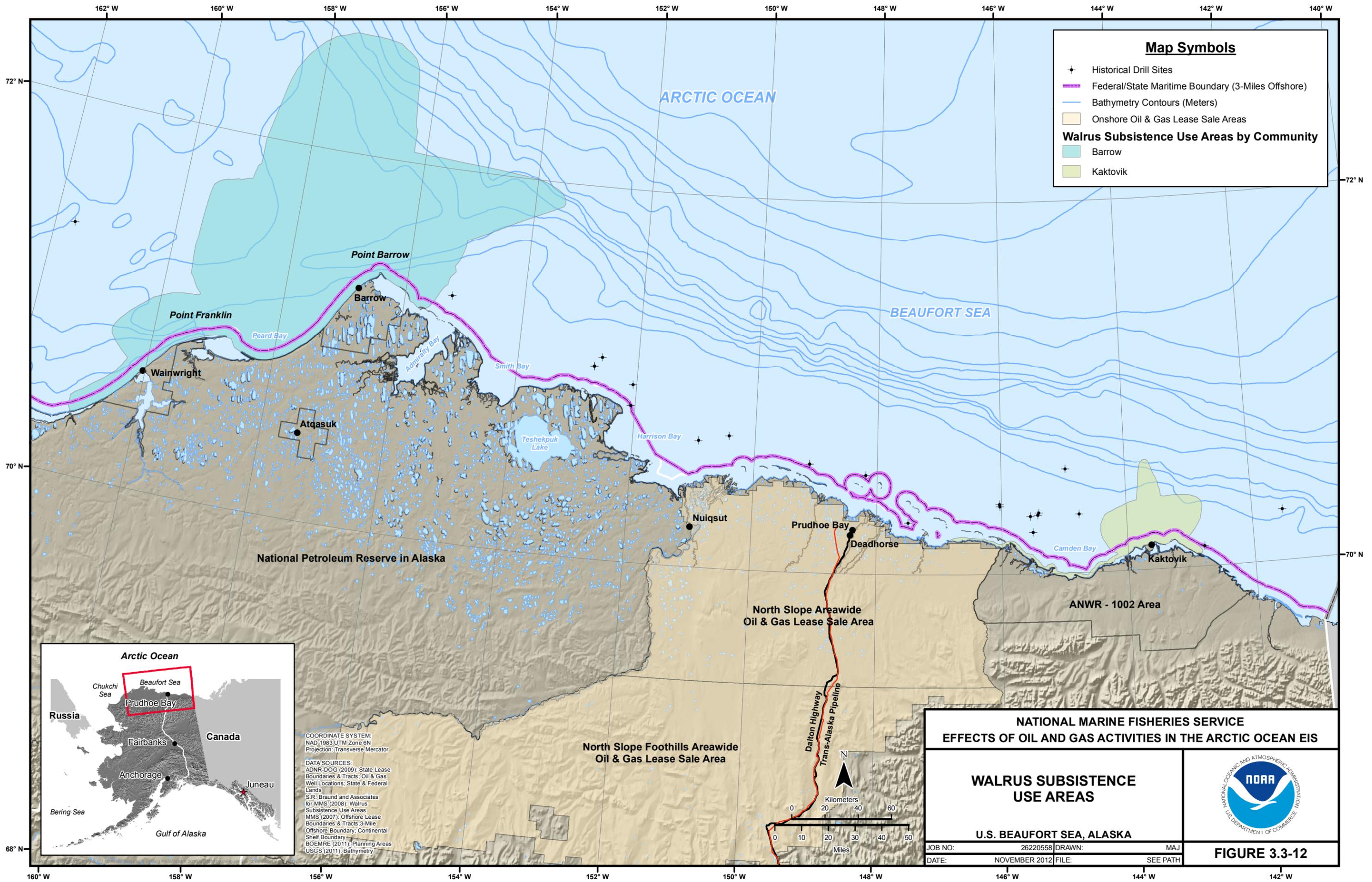
**FIGURE 3.3-11**



COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNOR-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  
 Braund and Burnham (1984); Braund 2000 in MMS (2008); Braund (2009); Bowhead Whale Subsistence Use Areas





**Map Symbols**

- ✦ Historical Drill Sites
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Onshore Oil & Gas Lease Sale Areas

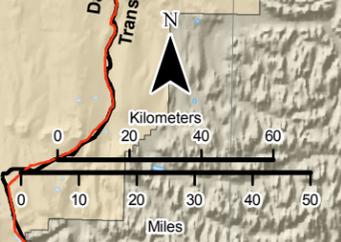
**Walrus Subsistence Use Areas by Community**

- Barrow
- Kaktovik



COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNDR-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



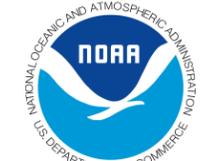
**NATIONAL MARINE FISHERIES SERVICE**  
**EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS**

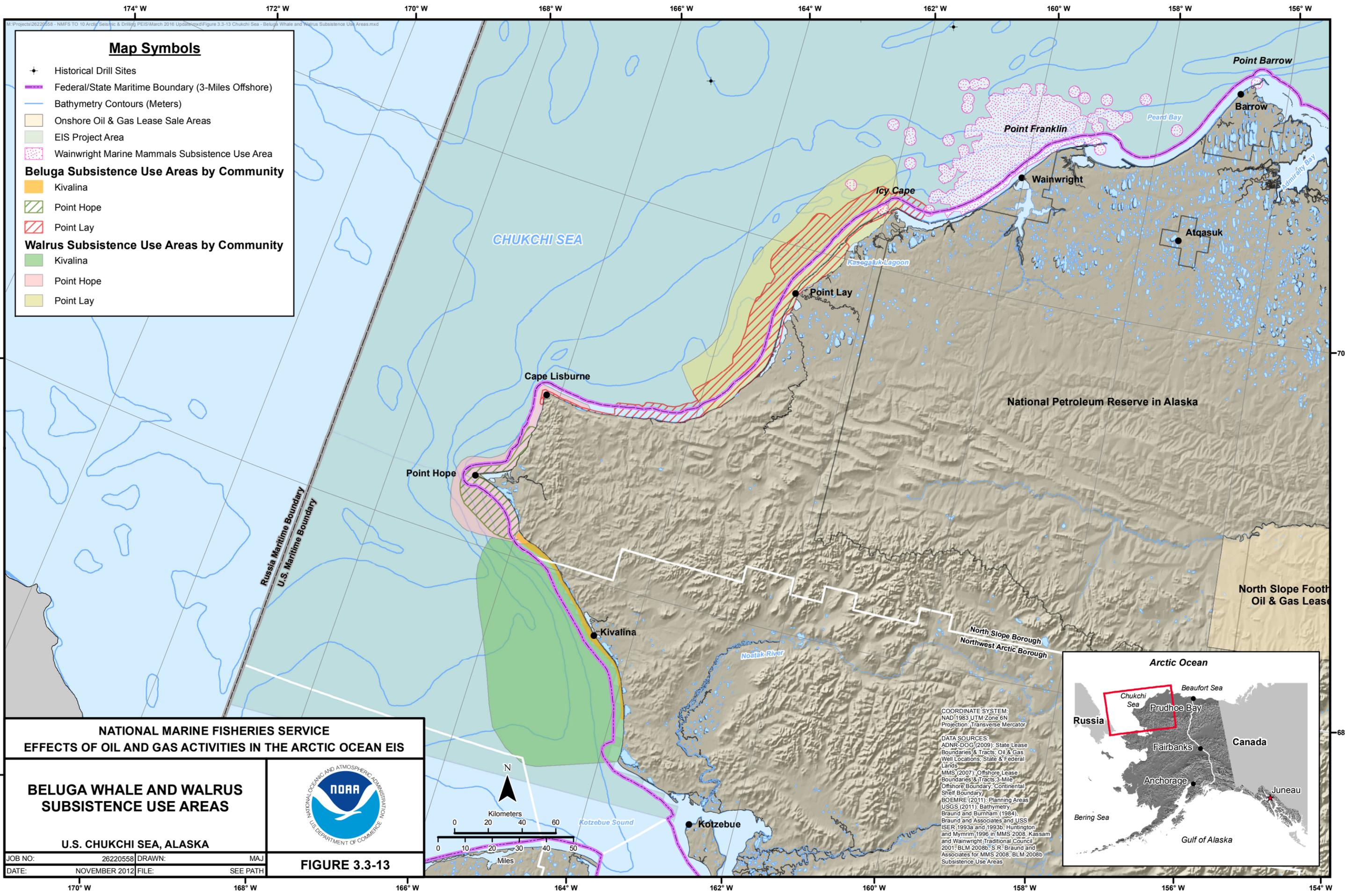
**WALRUS SUBSISTENCE USE AREAS**

**U.S. BEAUFORT SEA, ALASKA**

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

**FIGURE 3.3-12**





**Map Symbols**

- ✦ Historical Drill Sites
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Onshore Oil & Gas Lease Sale Areas
- EIS Project Area
- Wainwright Marine Mammals Subsistence Use Area
- Beluga Subsistence Use Areas by Community**
- Kivalina
- Point Hope
- Point Lay
- Walrus Subsistence Use Areas by Community**
- Kivalina
- Point Hope
- Point Lay

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

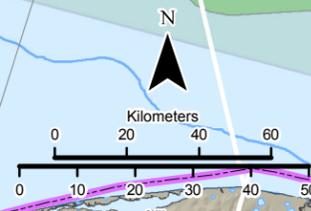
**BELUGA WHALE AND WALRUS**  
**SUBSISTENCE USE AREAS**

**U.S. CHUKCHI SEA, ALASKA**



**FIGURE 3.3-13**

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

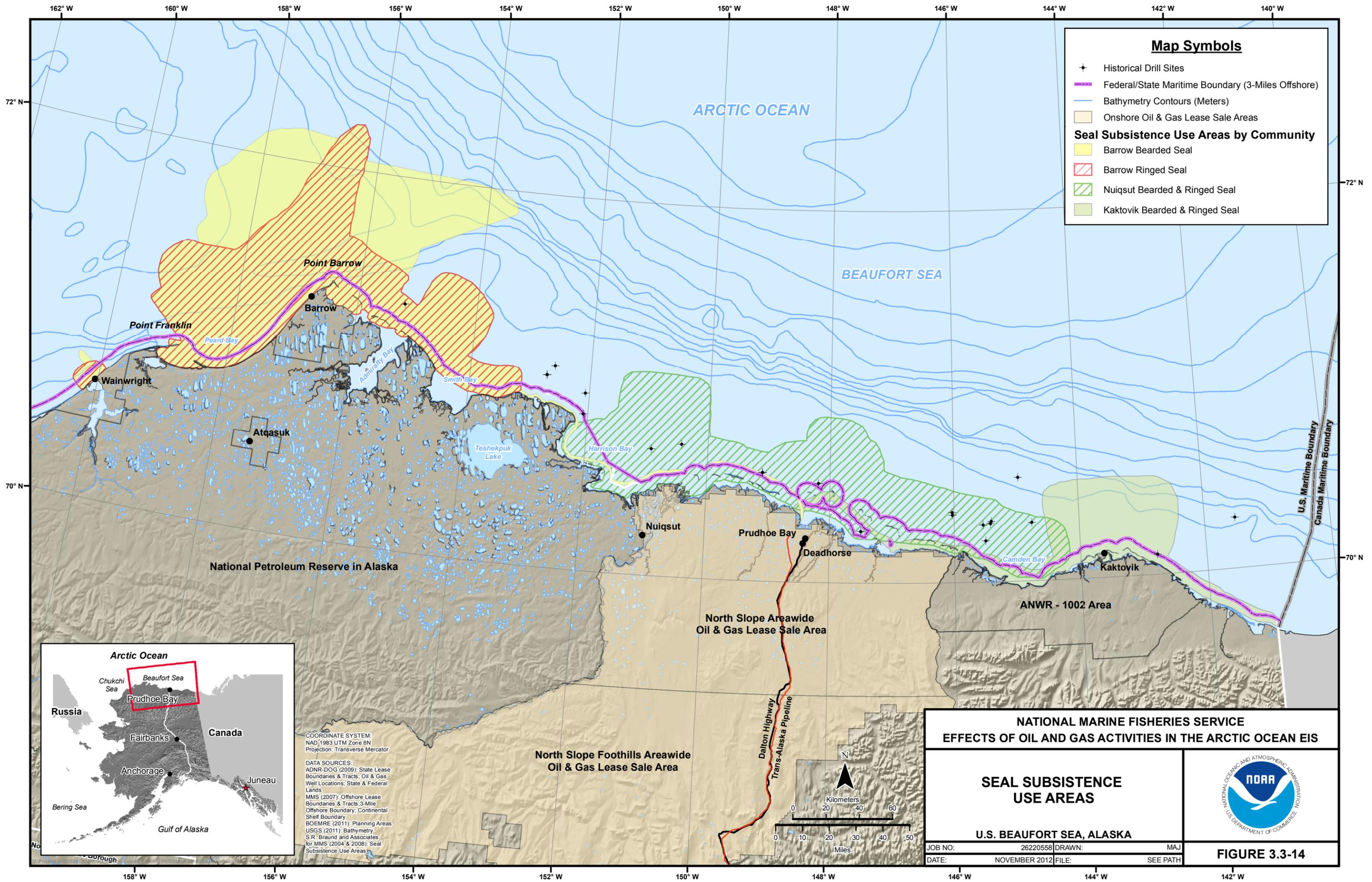


COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNDR-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  
 Braund and Burnham (1984), Braund and Associates and USS ISER 1993a and 1993b, Huntington and Myrim 1996 in MMS 2008, Kassam and Wainwright Traditional Council 2001, BLM 2008b, S.R. Braund and Associates for MMS 2008; BLM 2008b Subsistence Use Areas



170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W



### Map Symbols

- ✦ Historical Drill Sites
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- 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



COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNDR-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

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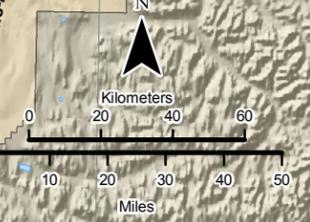
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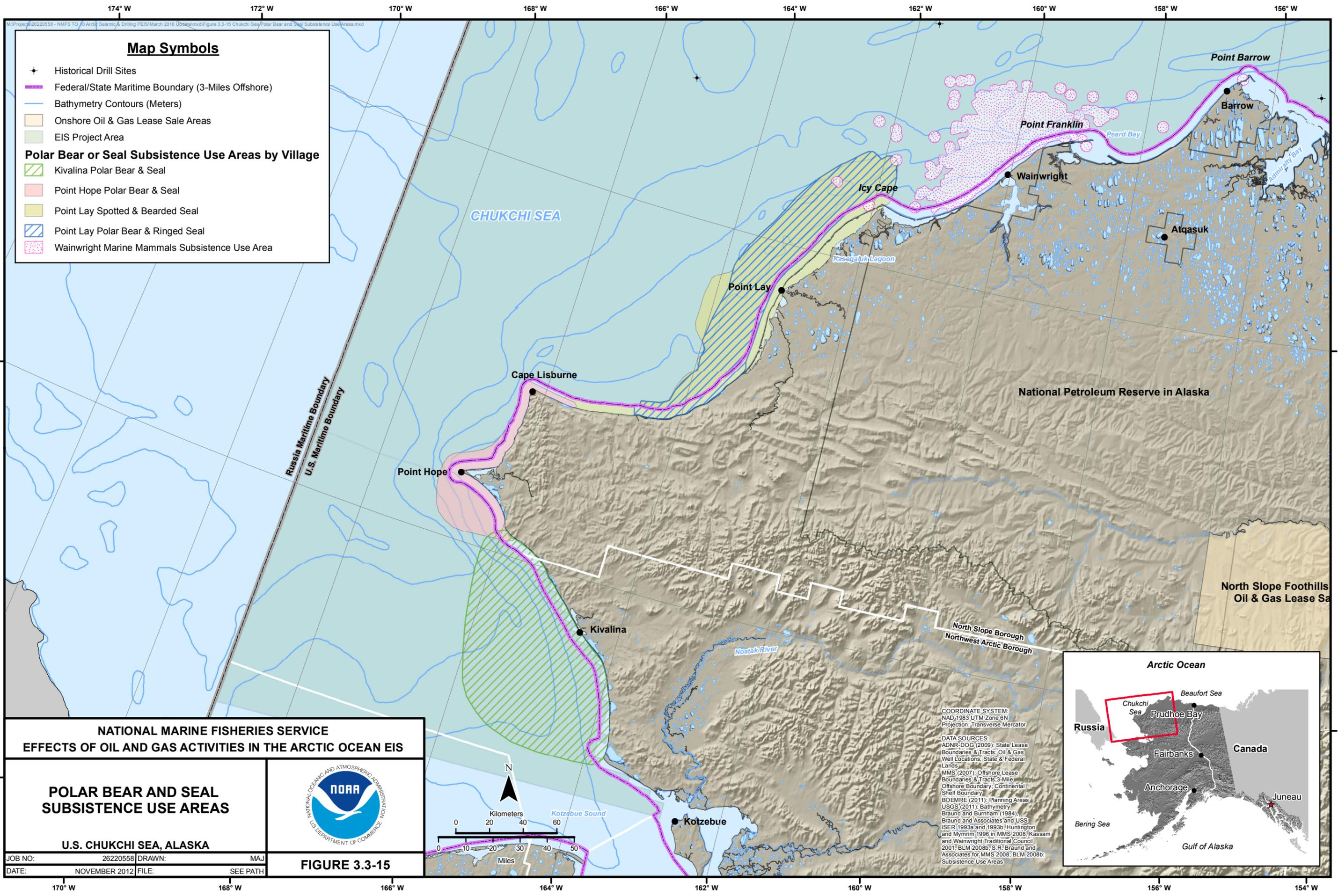
**SEAL SUBSISTENCE USE AREAS**

**U.S. BEAUFORT SEA, ALASKA**

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

**FIGURE 3.3-14**





### Map Symbols

- ✦ Historical Drill Sites
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Onshore Oil & Gas Lease Sale Areas
- EIS Project Area

#### Polar Bear or Seal Subsistence Use Areas by Village

- ▨ Kivalina Polar Bear & Seal
- Point Hope Polar Bear & Seal
- ▨ Point Lay Spotted & Bearded Seal
- ▨ Point Lay Polar Bear & Ringed Seal
- ▨ Wainwright Marine Mammals Subsistence Use Area

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

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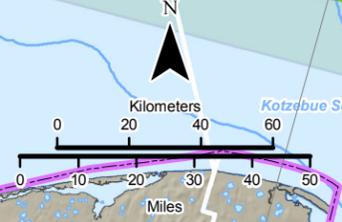
**POLAR BEAR AND SEAL**  
**SUBSISTENCE USE AREAS**

**U.S. CHUKCHI SEA, ALASKA**

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



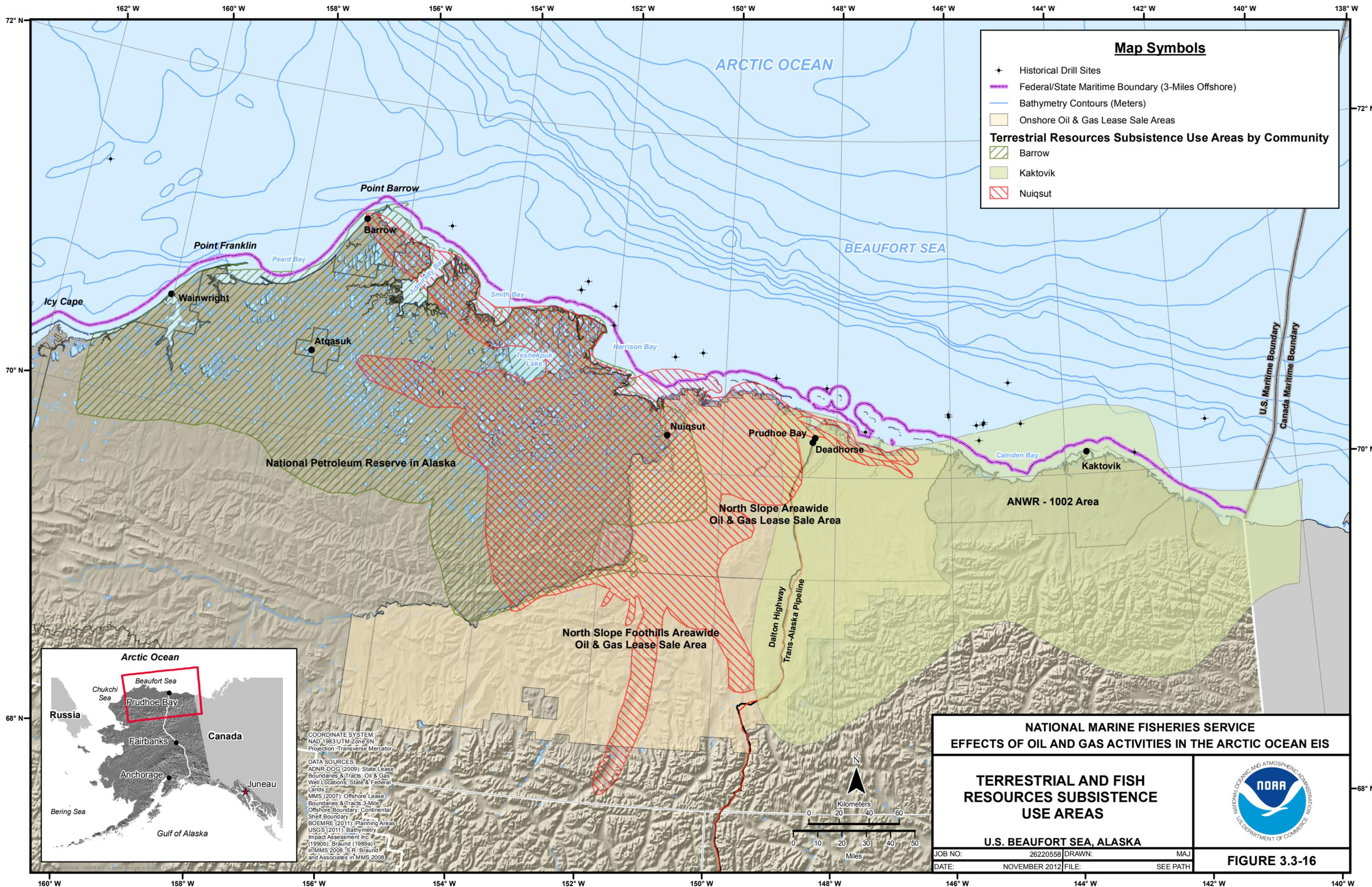
**FIGURE 3.3-15**



**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  
 Braund and Burnham (1984), Braund and Associates and USS ISER, 1993a and 1993b; Huntington and Myrman 1996 in MMS 2008; Kassam and Wainwright Traditional Council 2001; BLM 2008b; S.R. Braund and Associates for MMS 2008; BLM 2008b; Subsistence Use Areas





### Map Symbols

- Historical Drill Sites
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Onshore Oil & Gas Lease Sale Areas

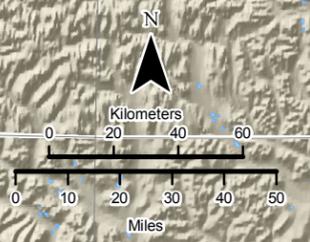
#### Terrestrial Resources Subsistence Use Areas by Community

- Barrow
- Kaktovik
- Nuiqsut



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



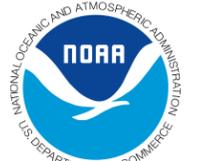
**NATIONAL MARINE FISHERIES SERVICE**  
**EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS**

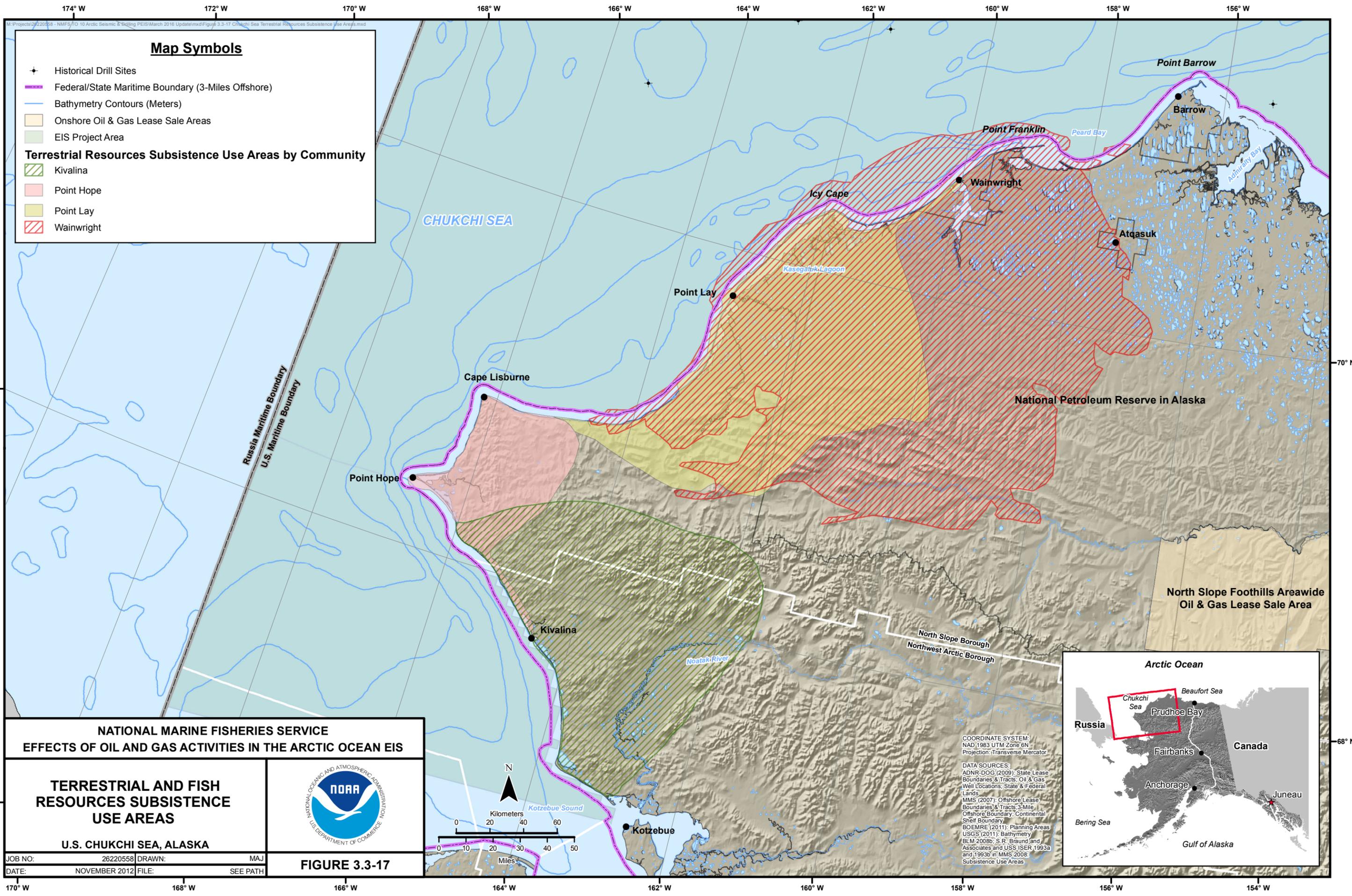
**TERRESTRIAL AND FISH RESOURCES SUBSISTENCE USE AREAS**

**U.S. BEAUFORT SEA, ALASKA**

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

**FIGURE 3.3-16**





**Map Symbols**

- Historical Drill Sites
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Onshore Oil & Gas Lease Sale Areas
- EIS Project Area

**Terrestrial Resources Subsistence Use Areas by Community**

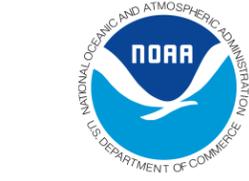
- Kivalina
- Point Hope
- Point Lay
- Wainwright

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

**TERRESTRIAL AND FISH RESOURCES SUBSISTENCE USE AREAS**

**U.S. CHUKCHI SEA, ALASKA**

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



**FIGURE 3.3-17**



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  
 BLM 2008b; S.R. Braund and Associates and USS/ISER 1993a and 1993b in MMS 2008: Subsistence Use Areas





**Figure 3.3-19 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 3.3-20 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 3.3-21 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 3.3-22 Open water off the coast of Barrow, Alaska (Summer).**

Source: URS Corporation



**Figure 3.3-23 Summer in Kotzebue, located on the Chukchi Sea.**

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



**Figure 3.3-24 Vegetation located within the EIS project area.**



**Figure 3.3-25 Oil and Gas Development, Prudhoe Bay.**

Source: URS Corporation



**Figure 3.3-26 Mars Ice Island, Beaufort Sea Alaska.**

Source: Courtesy of BOEM

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



**Figure 3.3-27 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>



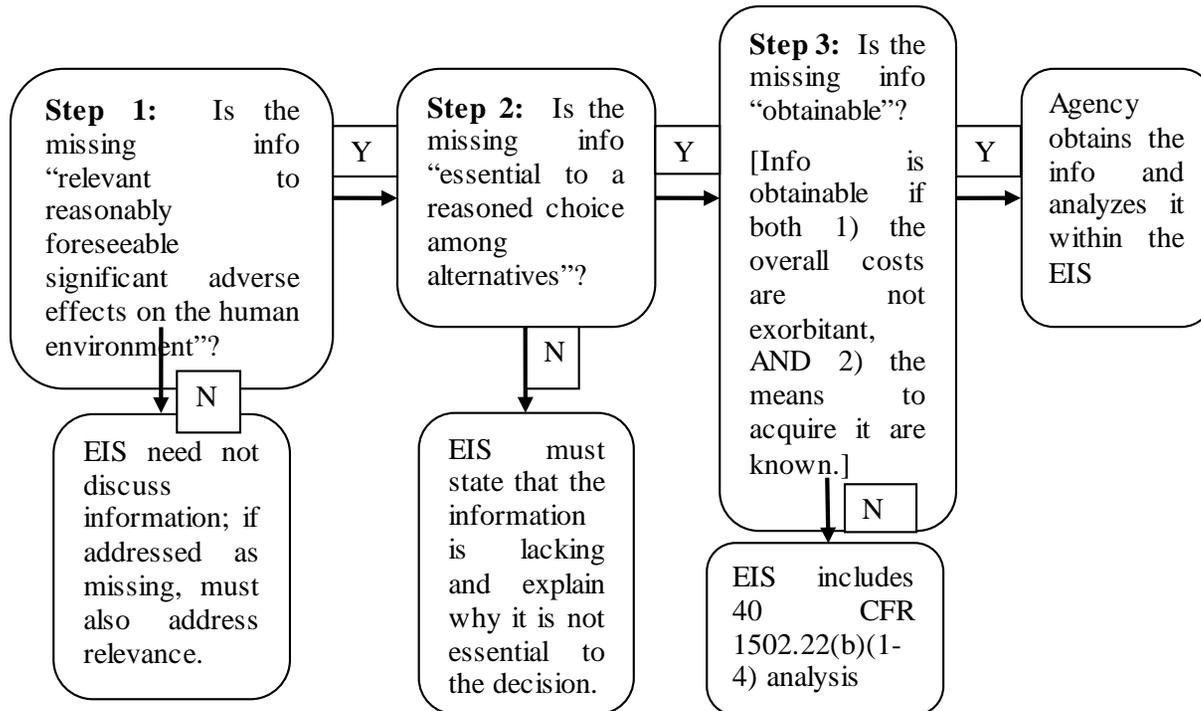
**Figure 3.3-28 Conceptual 3-D Rendering of Proposed Liberty drilling site.**

Source: Hilcorp 2015



## **CHAPTER 4 FIGURES**

**Figure 4.1** This diagram explains the steps utilized in this EIS for evaluating incomplete or unavailable information to comply with CEQ regulations at 40 CFR 1502.22.



**Figure 4.2: Auditory weighting functions for low-frequency (LF), mid-frequency (MF), and high-frequency (HF) cetaceans.**

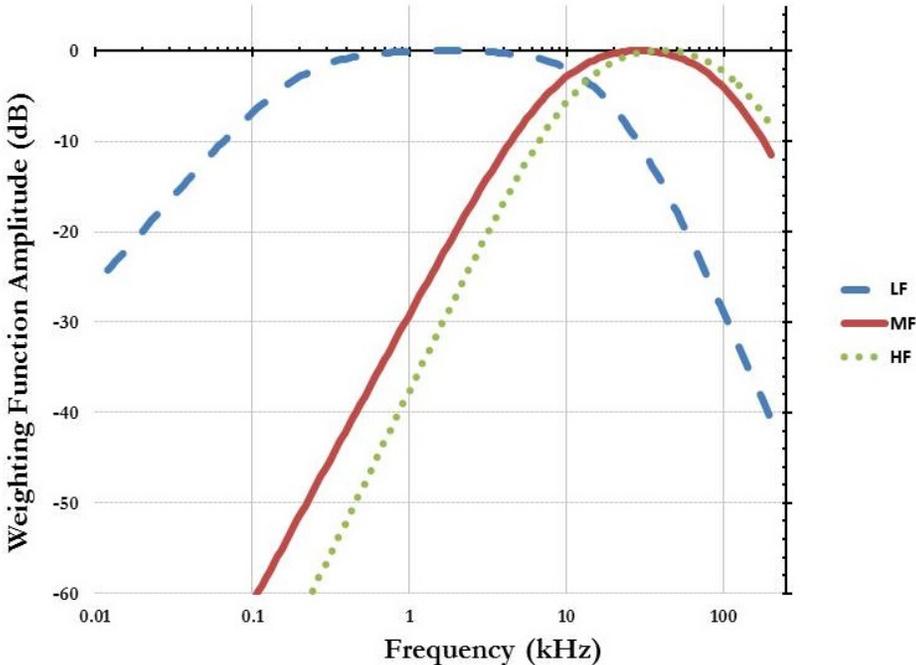
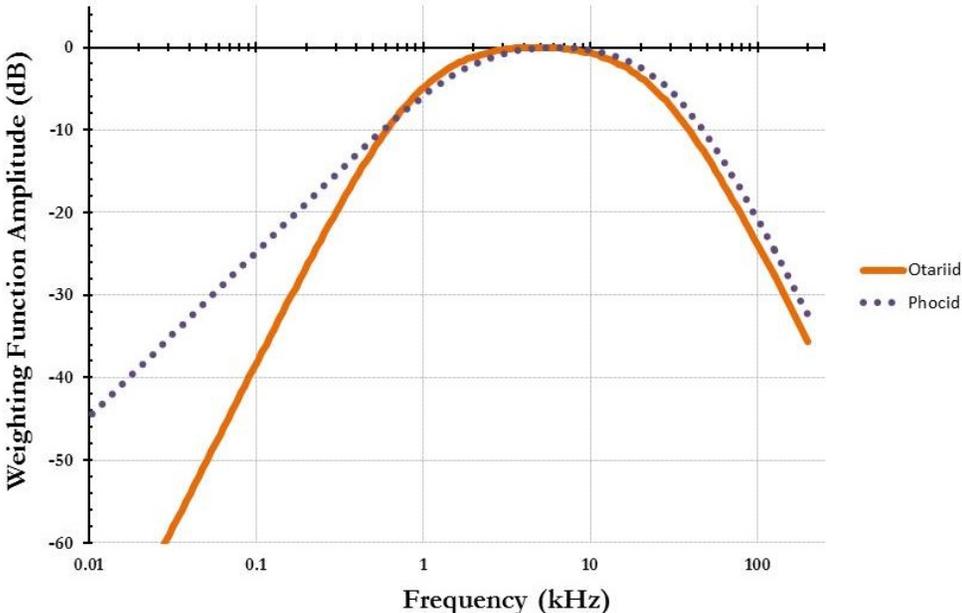
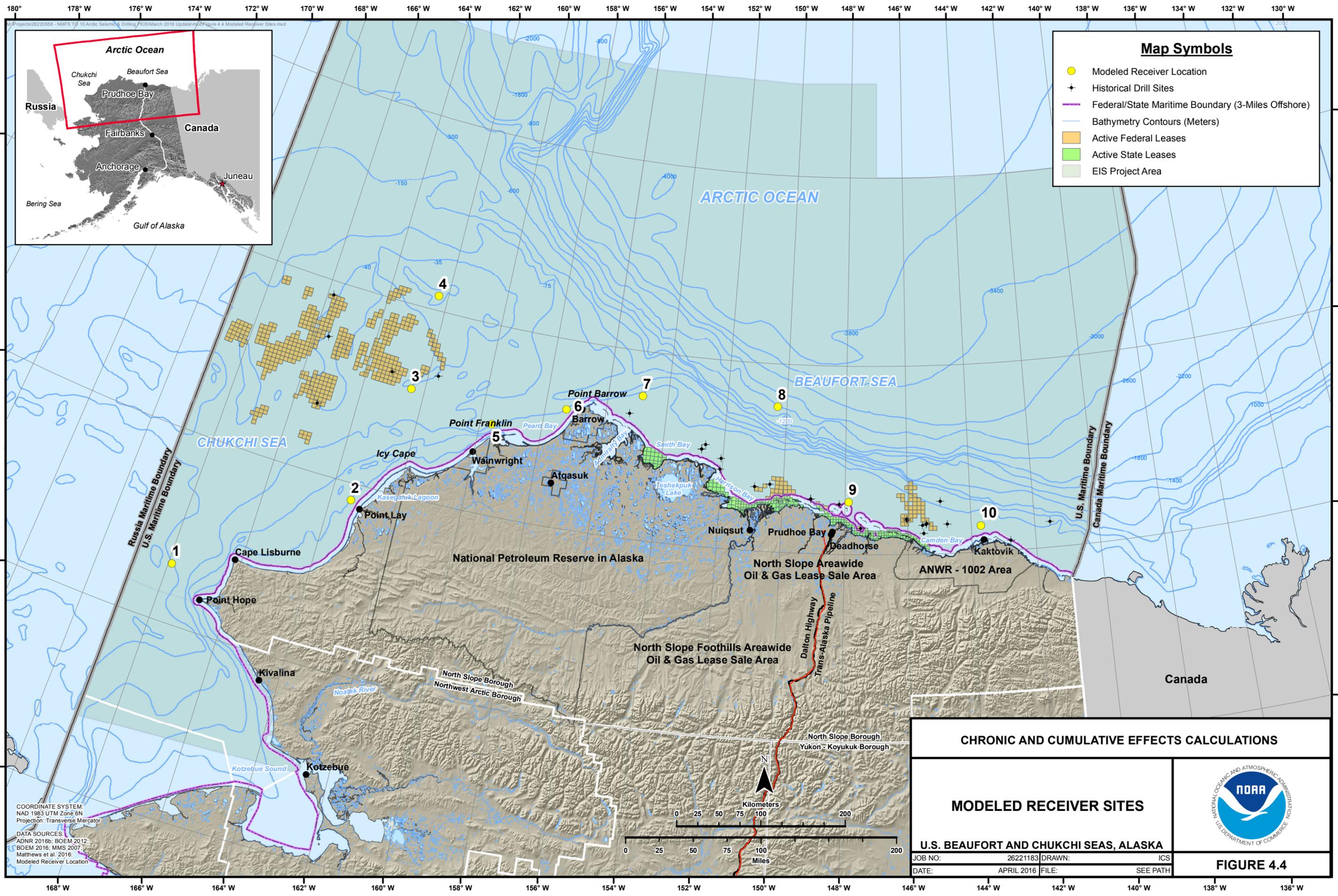


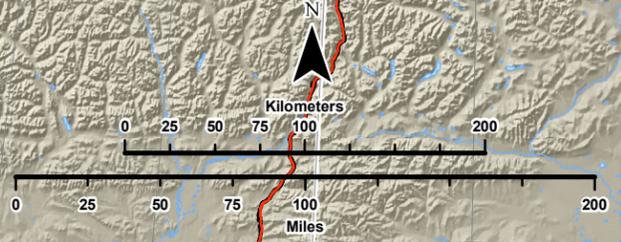
Figure 4.3: Underwater auditory weighting functions for otariid (OW) and phocid (PW) pinnipeds.





COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNR 2016b; BOEM 2012;  
 BOEM 2016; MMS 2007;  
 Matthews et al. 2016;  
 Modeled Receiver Location



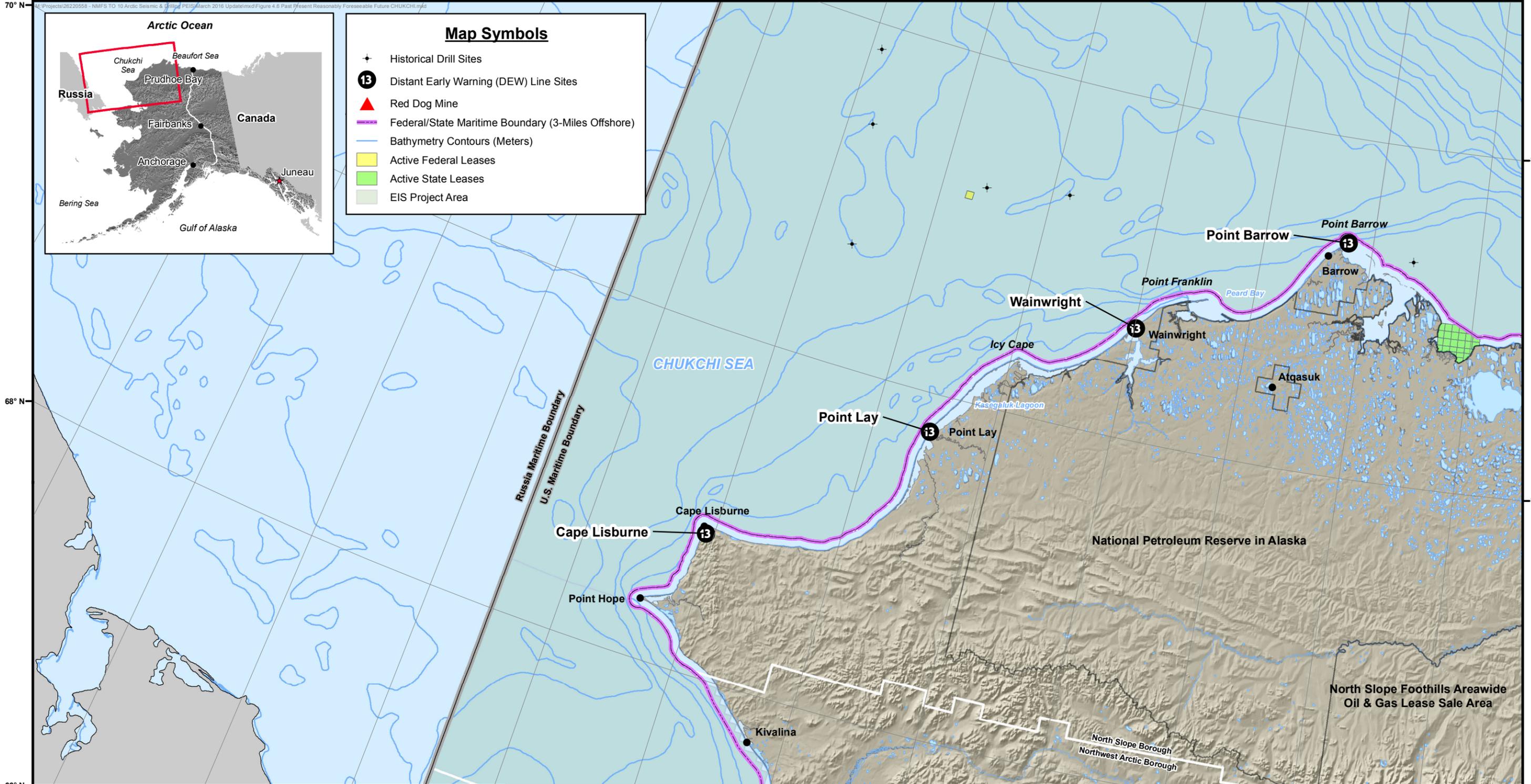


180° 178° W 176° W 174° W 172° W 170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W



### Map Symbols

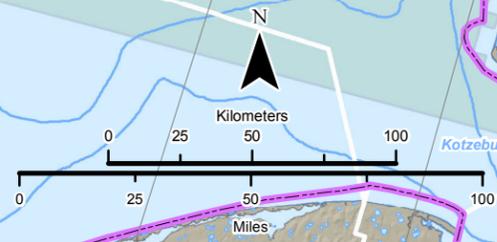
- ✦ Historical Drill Sites
- 13 Distant Early Warning (DEW) Line Sites
- ▲ Red Dog Mine
- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Active Federal Leases
- Active State Leases
- EIS Project Area



**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**

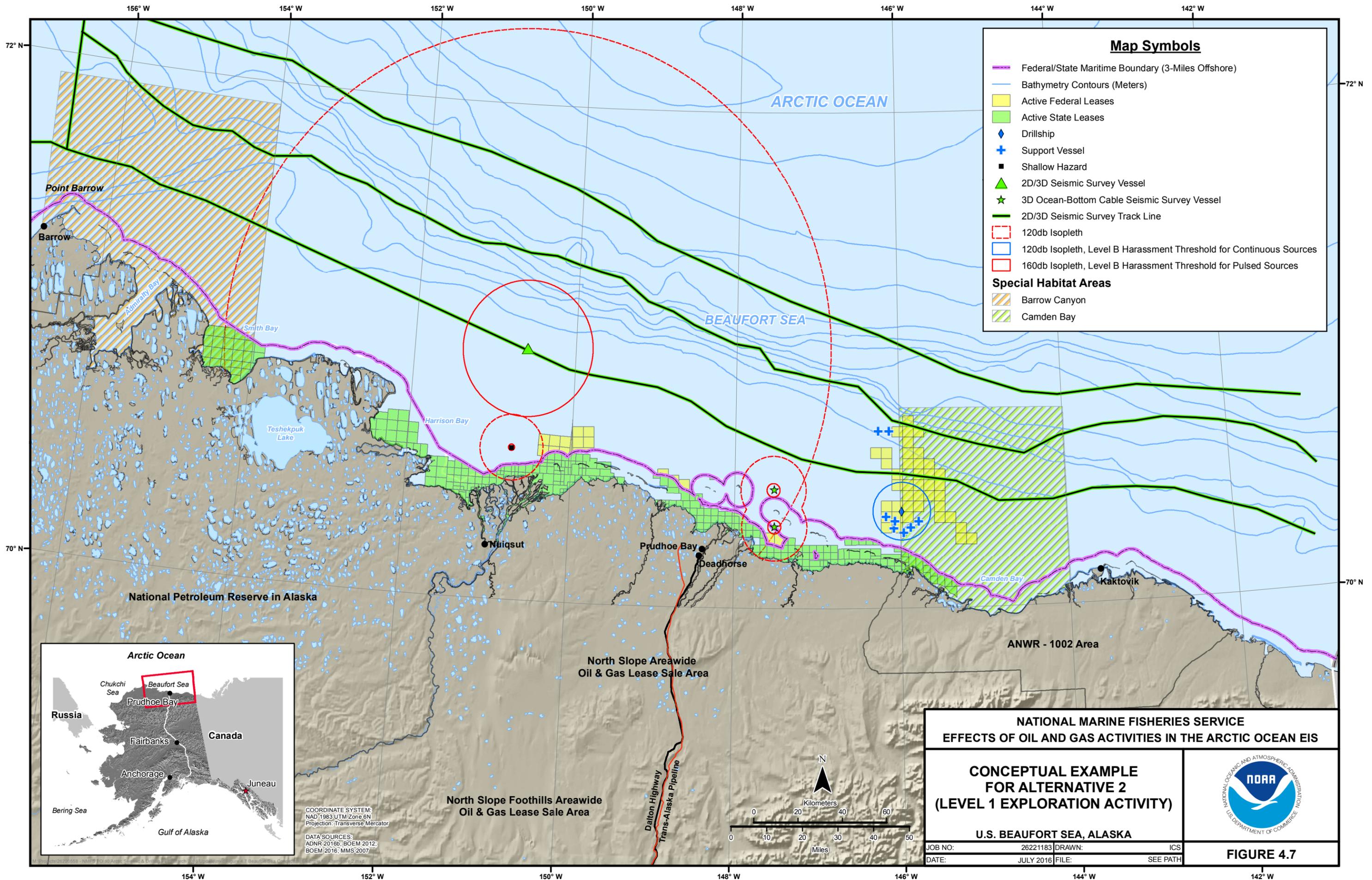


JOB NO: 26221183 DRAWN: ICS  
 DATE: JULY 2016 FILE: SEE PATH

**FIGURE 4.6**

COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator  
 DATA SOURCES:  
 ADNR 2016; BOEM 2012;  
 BOEM 2016; MMS 2007

172° W 170° W 168° W 166° W 164° W 162° W 160° W 158° W 156° W 154° W



### Map Symbols

- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Active Federal Leases
- Active State Leases
- Drillship
- Support Vessel
- Shallow Hazard
- 2D/3D Seismic Survey Vessel
- 3D Ocean-Bottom Cable Seismic Survey Vessel
- 2D/3D Seismic Survey Track Line
- 120db Isoleth
- 120db Isoleth, Level B Harassment Threshold for Continuous Sources
- 160db Isoleth, Level B Harassment Threshold for Pulsed Sources

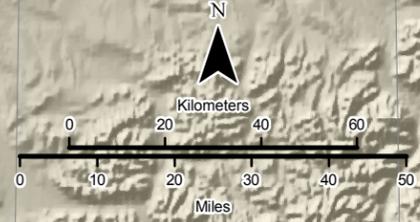
### Special Habitat Areas

- Barrow Canyon
- Camden Bay



COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNIR 2016; BOEM 2012;  
 BOEM 2016; MMS 2007

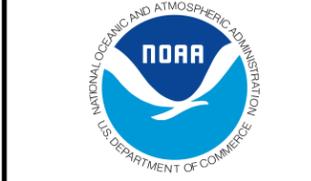


**NATIONAL MARINE FISHERIES SERVICE**  
**EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS**

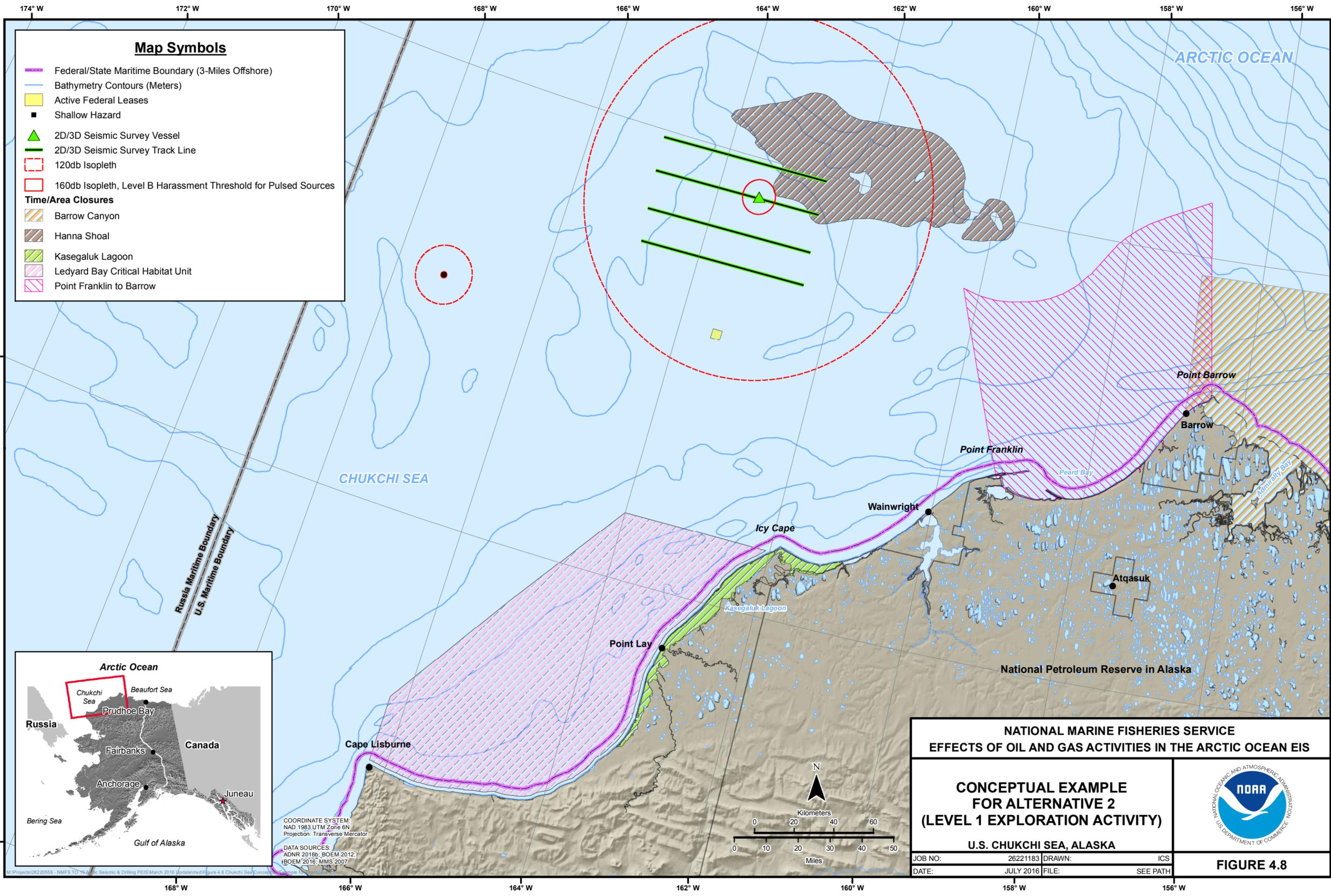
**CONCEPTUAL EXAMPLE  
 FOR ALTERNATIVE 2  
 (LEVEL 1 EXPLORATION ACTIVITY)**

**U.S. BEAUFORT SEA, ALASKA**

JOB NO: 26221183 DRAWN: ICS  
 DATE: JULY 2016 FILE: SEE PATH



**FIGURE 4.7**



### Map Symbols

- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Active Federal Leases
- Shallow Hazard
- ▲ 2D/3D Seismic Survey Vessel
- 2D/3D Seismic Survey Track Line
- 120db Isopleth
- 160db Isopleth, Level B Harassment Threshold for Pulsed Sources

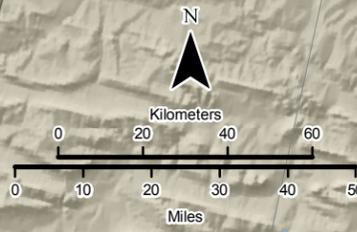
#### Time/Area Closures

- Barrow Canyon
- Hanna Shoal
- Kasegaluk Lagoon
- Ledyard Bay Critical Habitat Unit
- Point Franklin to Barrow



COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNIR 2016b; BOEM 2012;  
 BOEM 2016; MMS 2007

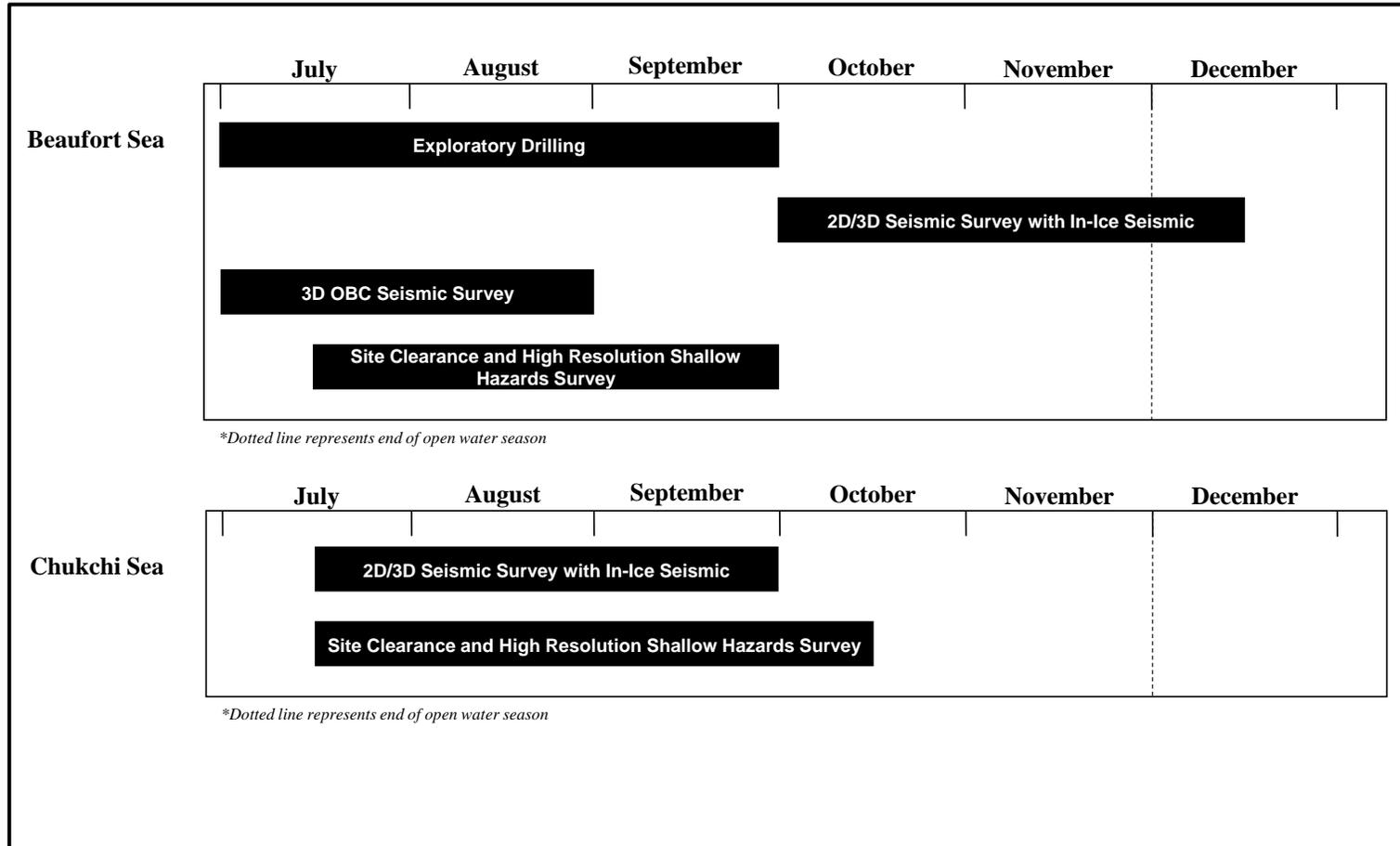


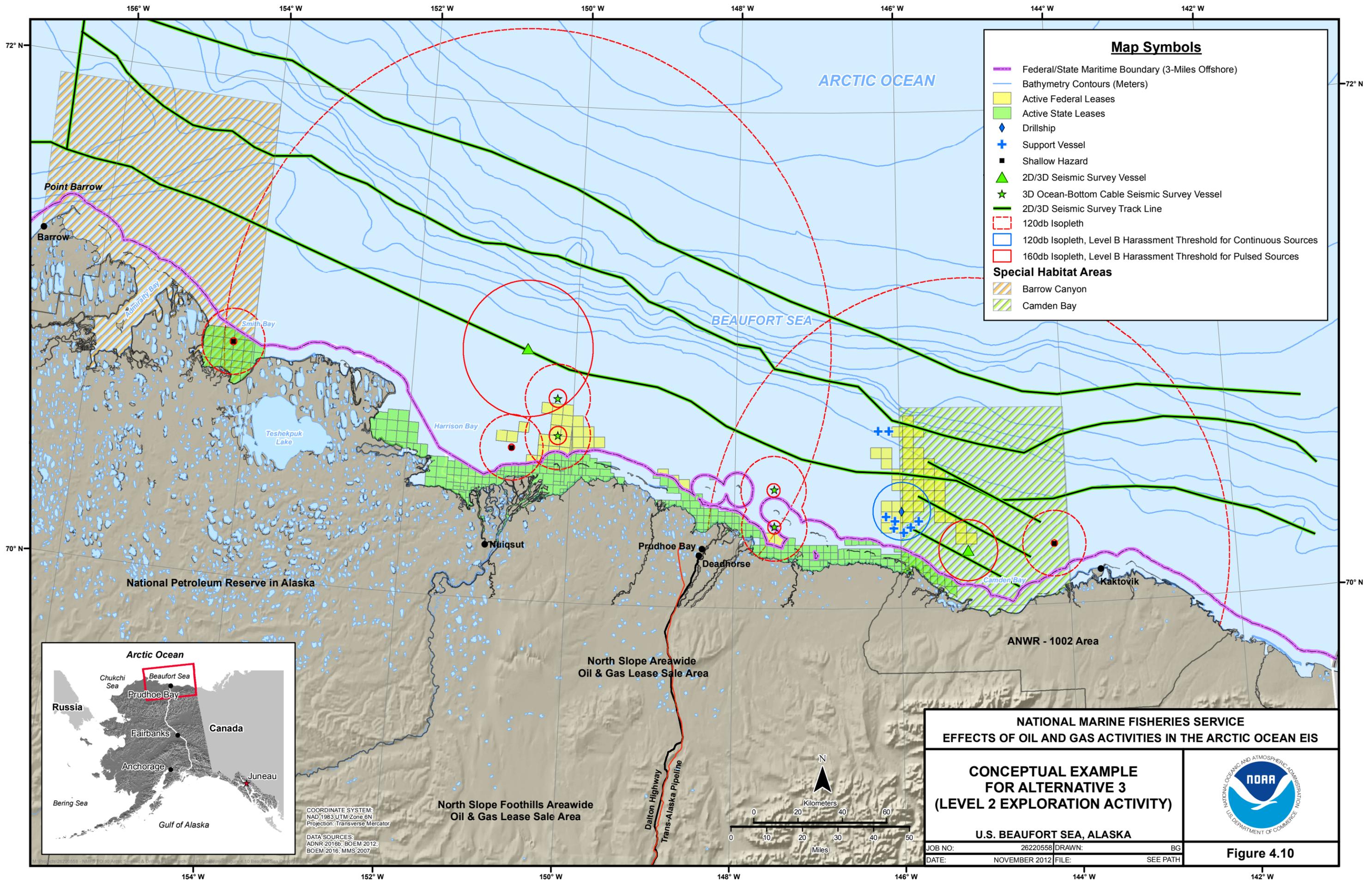
<b>NATIONAL MARINE FISHERIES SERVICE</b>		
<b>EFFECTS OF OIL AND GAS ACTIVITIES IN THE ARCTIC OCEAN EIS</b>		
<b>CONCEPTUAL EXAMPLE FOR ALTERNATIVE 2 (LEVEL 1 EXPLORATION ACTIVITY)</b>		
<b>U.S. CHUKCHI SEA, ALASKA</b>		
JOB NO: 26221183	DRAWN: ICS	
DATE: JULY 2016	FILE: SEE PATH	

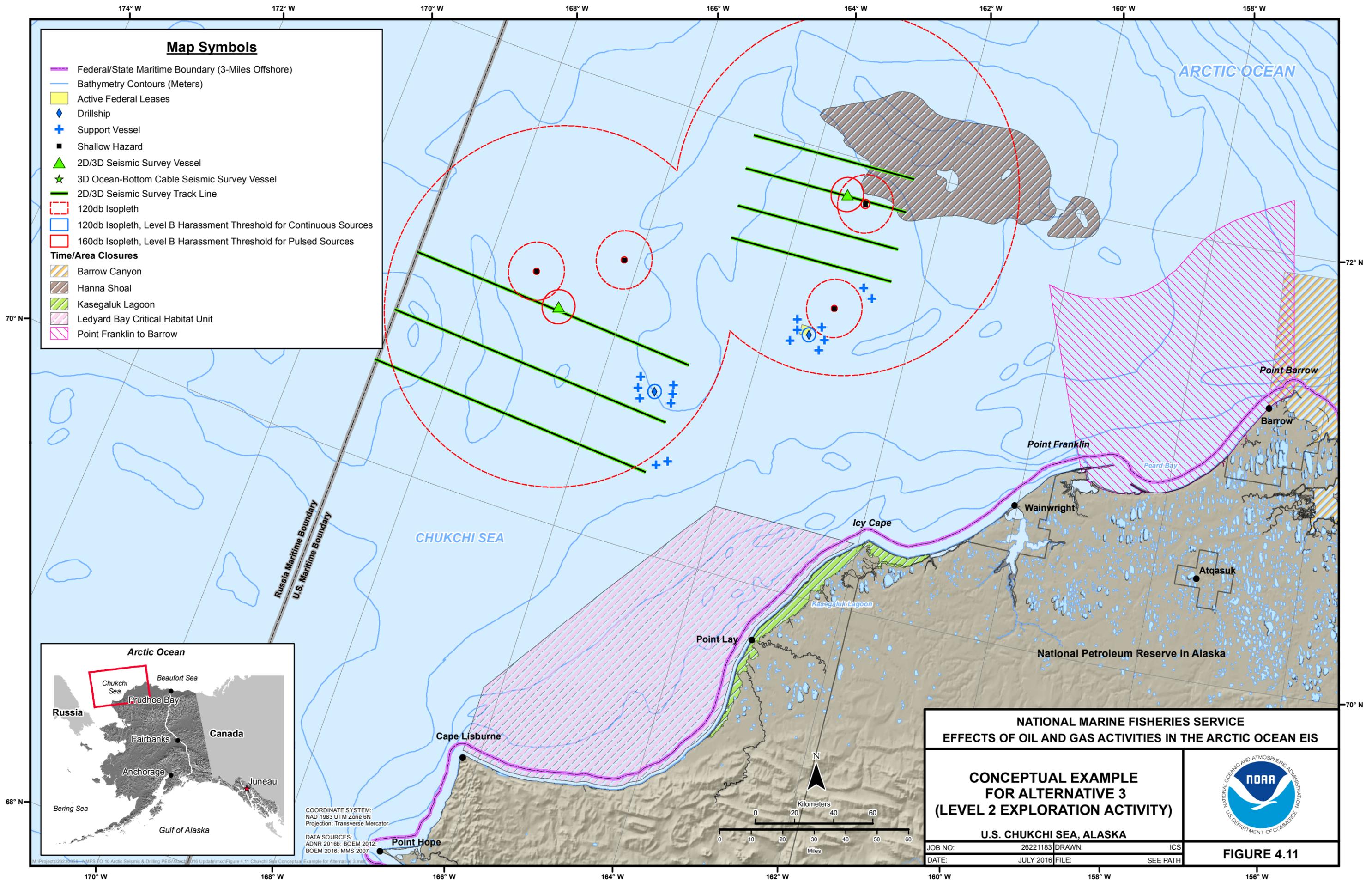


**FIGURE 4.8**

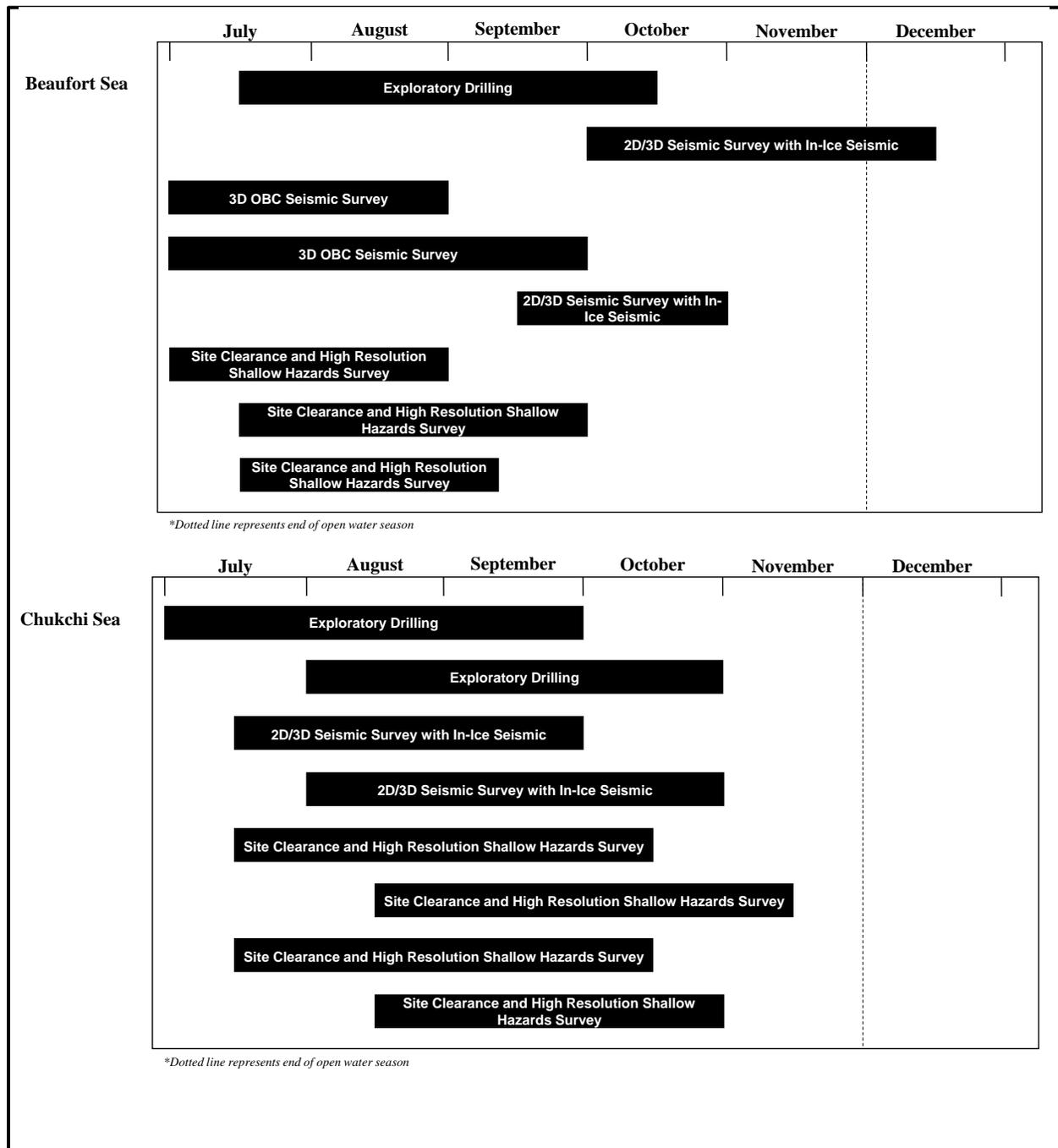
**Figure 4.9 Temporal Conceptual Example under Alternative 2 (Level 1 Exploration Activity)**







**Figure 4.12 Temporal Conceptual Examples under Alternative 3 (Level 2 Exploration Activity)**



**Figure 4.13 Exploration: 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.

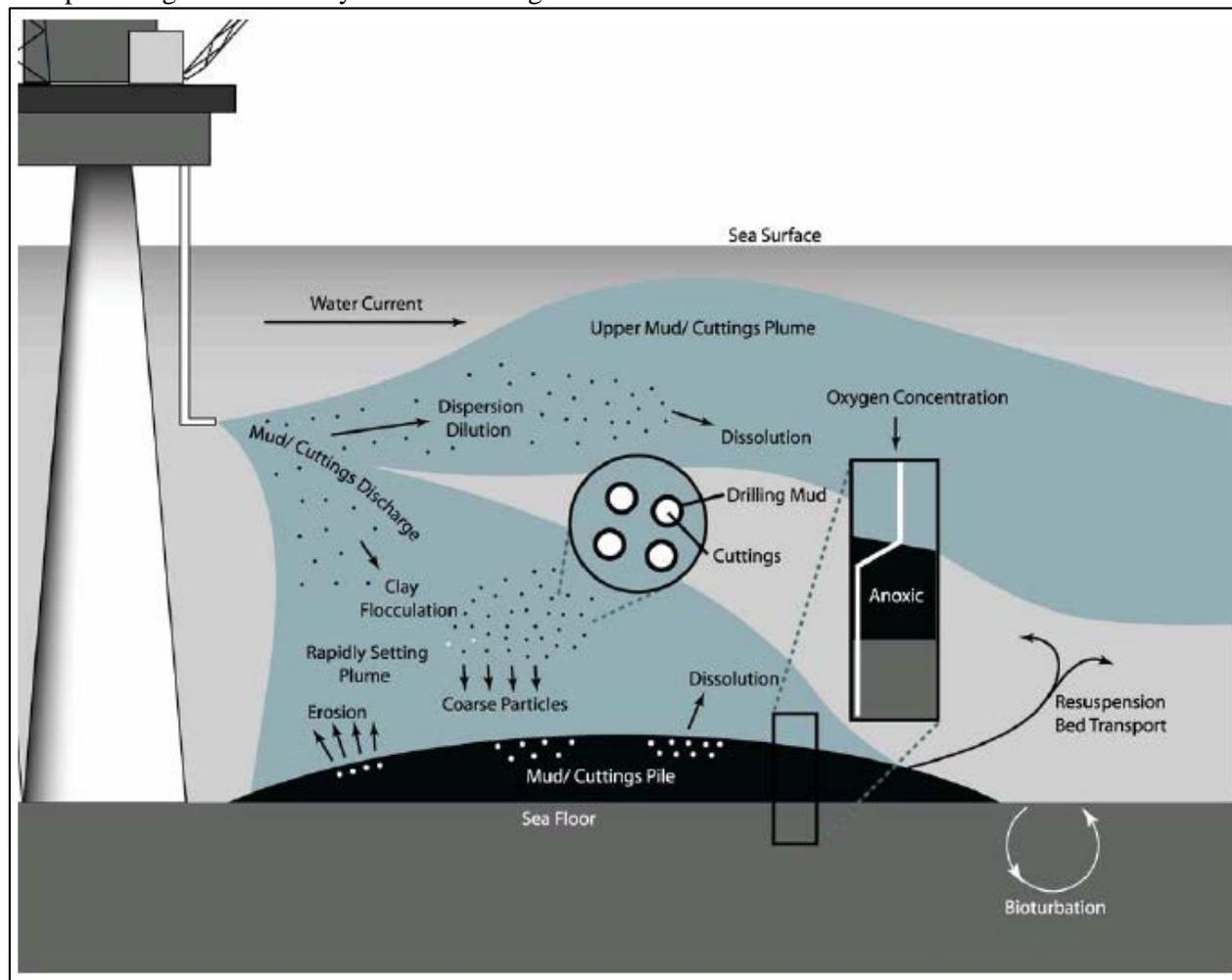
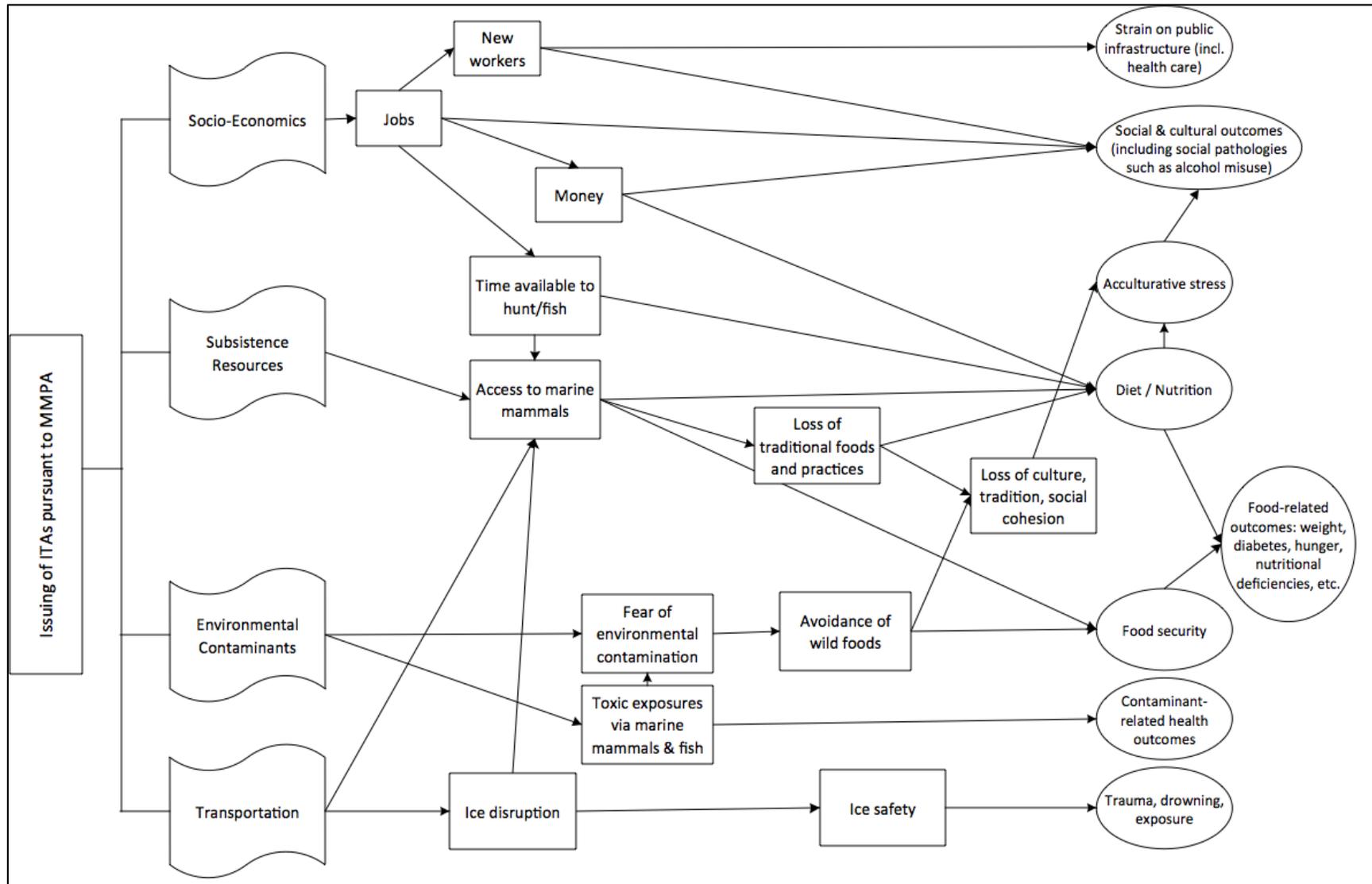
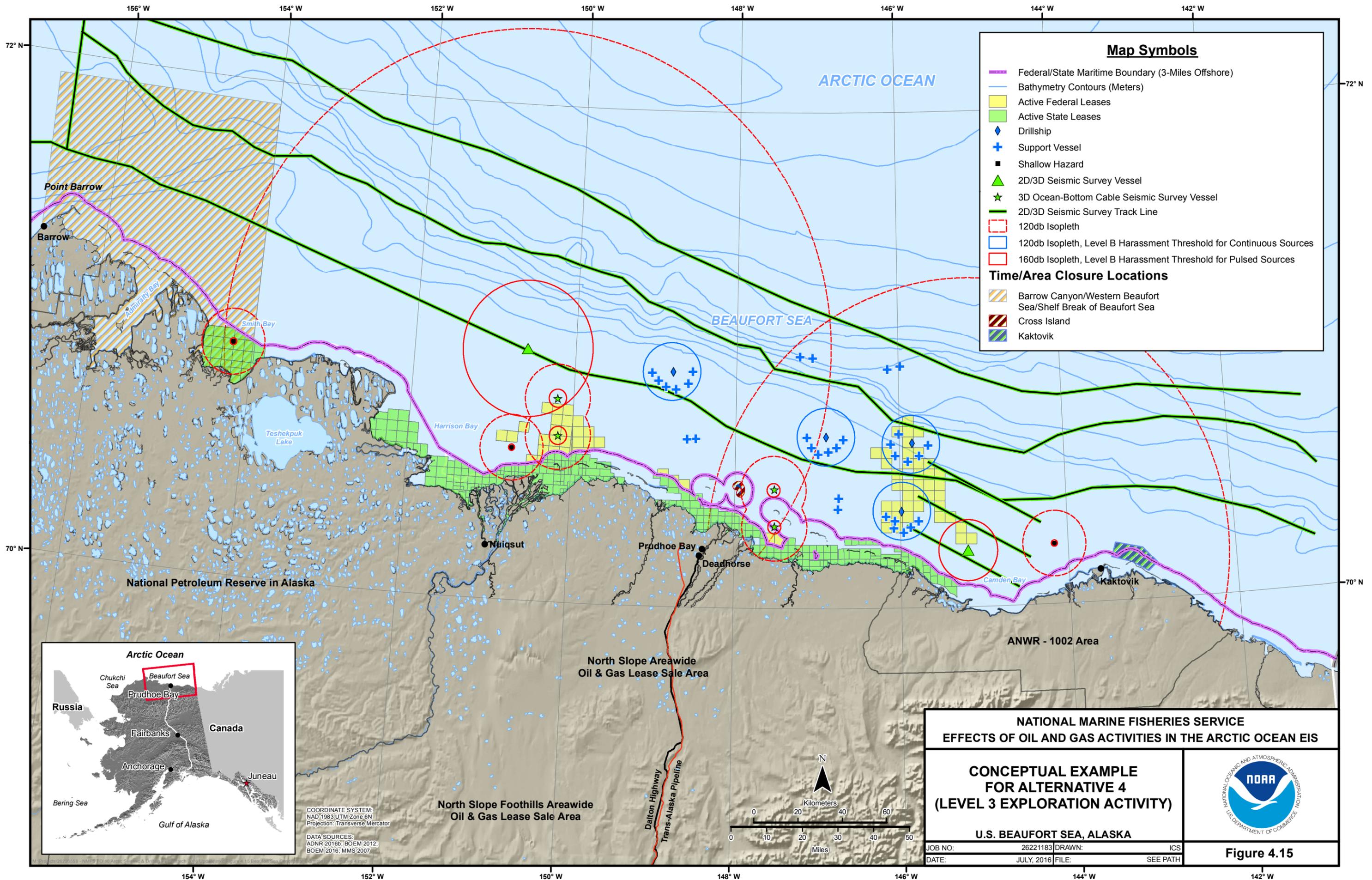


Figure 4.14 Logic framework for potential impacts to human health.



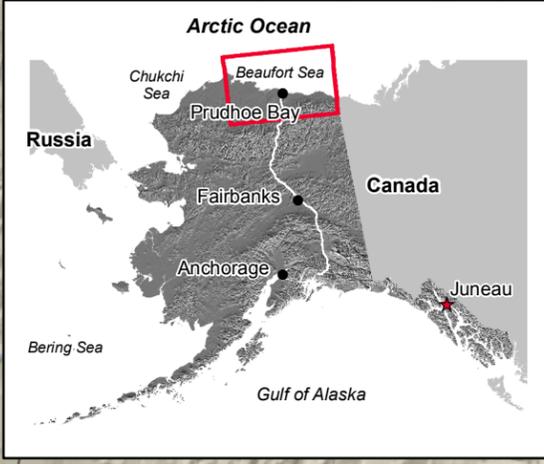


### Map Symbols

- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Active Federal Leases
- Active State Leases
- 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



COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNIR 2016; BOEM 2012;  
 BOEM 2016; MMS 2007

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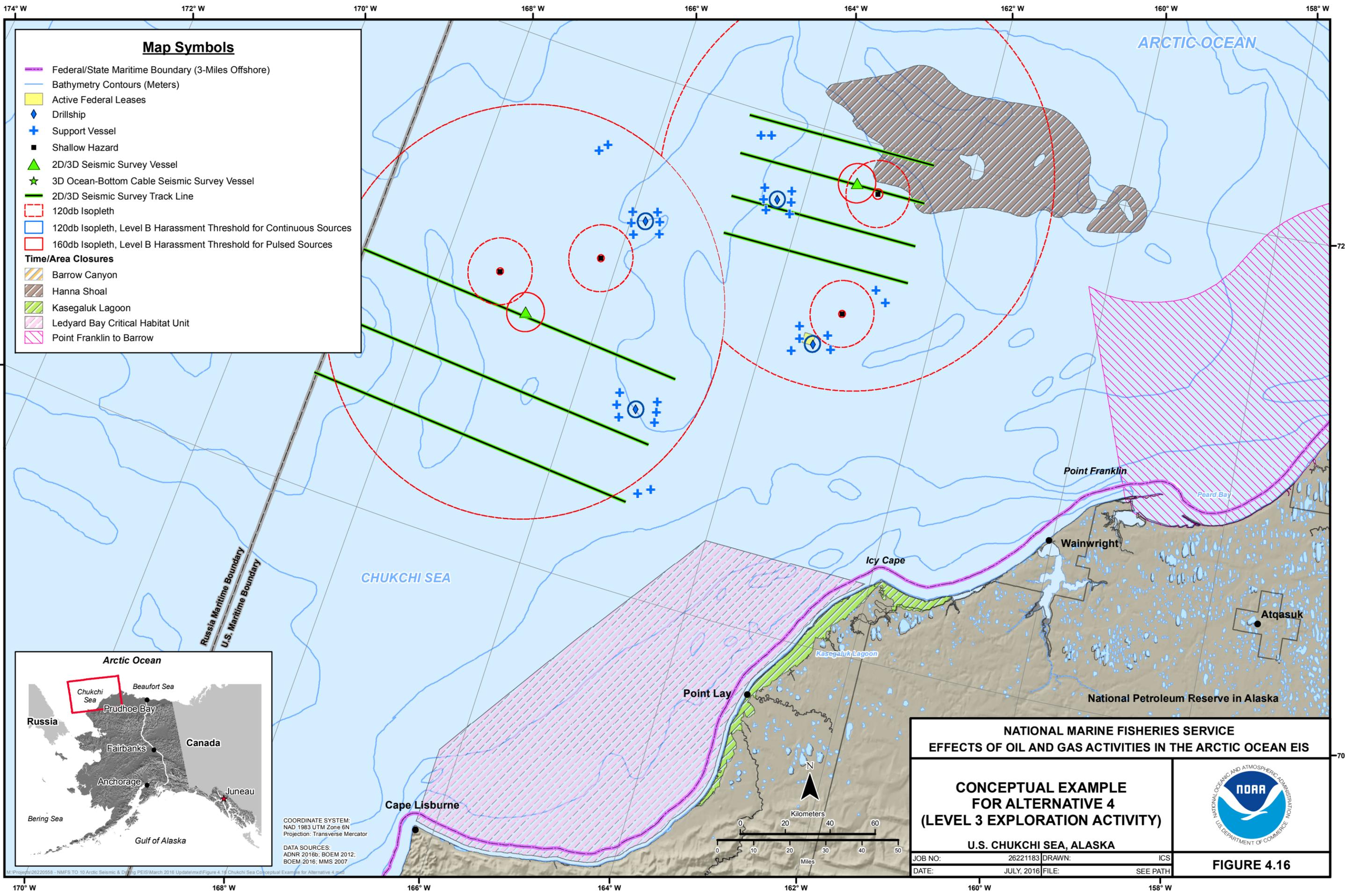
**CONCEPTUAL EXAMPLE**  
**FOR ALTERNATIVE 4**  
**(LEVEL 3 EXPLORATION ACTIVITY)**

**U.S. BEAUFORT SEA, ALASKA**

JOB NO: 26221183 DRAWN: ICS  
 DATE: JULY, 2016 FILE: SEE PATH



**Figure 4.15**

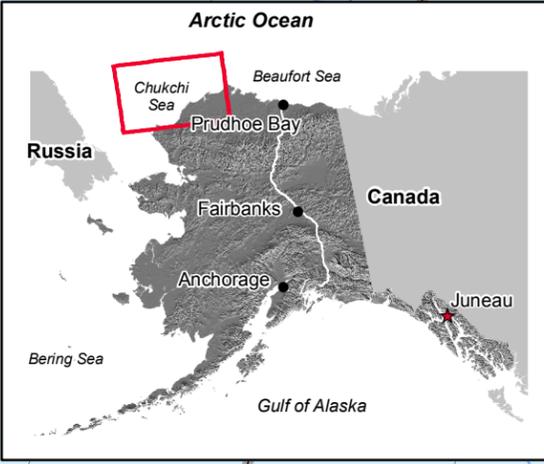


### Map Symbols

- Federal/State Maritime Boundary (3-Miles Offshore)
- Bathymetry Contours (Meters)
- Active Federal Leases
- Drillship
- Support Vessel
- Shallow Hazard
- 2D/3D Seismic Survey Vessel
- 3D Ocean-Bottom Cable Seismic Survey Vessel
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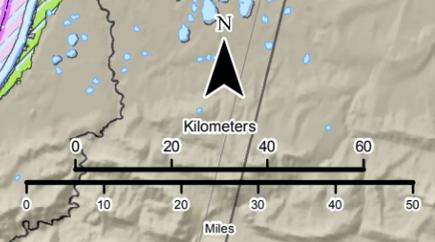
### Time/Area Closures

- Barrow Canyon
- Hanna Shoal
- Kasegaluk Lagoon
- Ledyard Bay Critical Habitat Unit
- Point Franklin to Barrow



COORDINATE SYSTEM:  
 NAD 1983 UTM Zone 6N  
 Projection: Transverse Mercator

DATA SOURCES:  
 ADNIR 2016b; BOEM 2012;  
 BOEM 2016; MMS 2007



**NATIONAL MARINE FISHERIES SERVICE**  
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**CONCEPTUAL EXAMPLE FOR ALTERNATIVE 4 (LEVEL 3 EXPLORATION ACTIVITY)**

**U.S. CHUKCHI SEA, ALASKA**

JOB NO: 26221183 DRAWN: ICS  
 DATE: JULY, 2016 FILE: SEE PATH

**FIGURE 4.16**

**Figure 4.17 Temporal Conceptual Examples under Alternative 4 (Level 3 Exploration Activity)**

