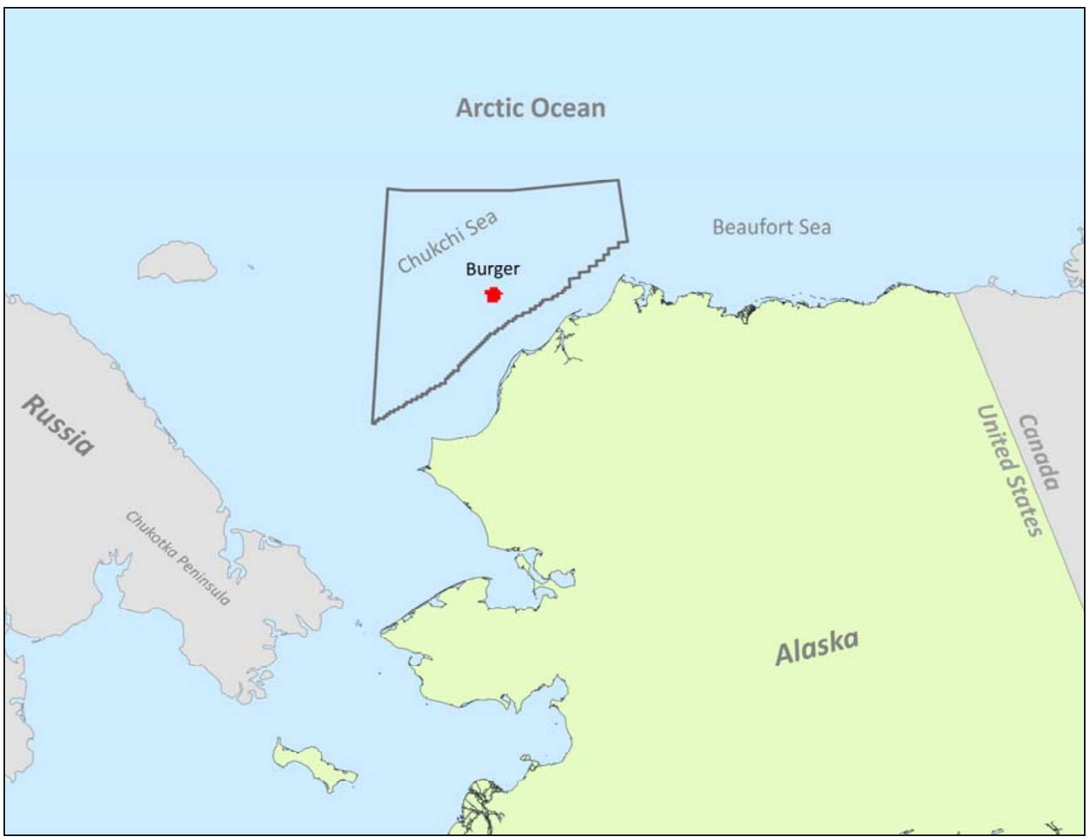
Alaska Outer Continental Shelf

OCS EIS/EA
BOEM 2011-061

# Chukchi Sea Planning Area

Shell Gulf of Mexico, Inc.
Shell Revised Chukchi Sea Exploration Plan
Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915
Chukchi Lease Sale 193

# Environmental Assessment




**U.S. Department of the Interior**
**Bureau of Ocean Energy Management**
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December 2011

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**Prepared by:**
Office of Environment
Alaska OCS Region

**U.S. Department of the Interior**
**Bureau of Ocean Energy Management**
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# Acronyms and Abbreviations

AAAQS ..........................Alaska Ambient Air Quality Standards
AAC ..............................Alaska Administrative Code
ACIA .............................Arctic Climate Impact Assessment
ACP ...............................Arctic Coastal Plain
ADEC ............................Alaska Department of Environmental Conservation
ADF&G .........................Alaska Department of Fish and Game
ADNR............................Alaska Department of Natural Resources
AEWC ...........................Alaska Eskimo Whaling Commission
AFMP ............................Arctic Fishery Management Plan
AI/AN............................American Indian and Alaskan Native populations
ANS ...............................aquatic nuisance species
ANWR...........................Arctic National Wildlife Refuge
API ................................American Petroleum Institute
APD ...............................Application for Permit to Drill
AQCP ............................Alaska State Air Quality Control Plan
AQCR............................air quality control regions
ARBO............................Arctic Region Biological Opinion
ASRC ............................Arctic Slope Regional Corporation
ASWG ...........................Alaska Shorebird Working Group
atm .................................atmosphere (of pressure)
BACT ............................Best Available Control Technology
bbls ................................barrels
bbls/d .............................barrels per day
Bcf .................................billion cubic feet
Bcfg ...............................billion cubic feet of gas
BCB ...............................Bering-Chukchi-Beaufort Seas stock of bowhead whales
BE..................................Biological Evaluation
BLM ..............................Bureau of Land Management
BO .................................Biological Opinion
BOEM ...........................Bureau of Ocean Energy Management
BOEMRE ......................Bureau of Ocean Energy Management, Regulation and Enforcement
BOP ...............................blowout preventer (system)
B.P. ................................Before Present
BPXA ............................British Petroleum Exploration (Alaska)
CAA ..............................Clean Air Act or Conflict Avoidance Agreement
CAH ..............................Central Arctic (caribou) Herd
CBD...............................Center for Biological Diversity
CBS ...............................Chukchi/Bering Seas stock of polar bears
CEQ ...............................Council on Environmental Quality
CER ...............................Categorical Exclusion Review
CFCs..............................chlorofluorocarbons
CFR ...............................Code of Federal Regulations
CI ...................................confidence interval
CIAP ..............................Coastal Impact Assistance Program
CIP .................................Capital Improvement Program
CO .................................carbon monoxide
COA ..............................Corresponding Onshore Area
COMIDA.......................Chukchi Offshore Monitoring in Drilling Area
cp ...................................centipoise (measure of viscosity)
CWA..............................Clean Water Act
CZMA ...........................Coastal Zone Management Act
CZMP ............................Coastal Zone Management Program (or Plan)
DEW .............................Distant Early Warning (system)

DO ................................ dissolved oxygen
DPP............................... Development and Production Plan
Draft EIS....................... Draft Environmental Impact Statement
Draft SEIS .................... Draft Supplemental Environmental Impact Statement
EA................................ Environmental Assessment
EEZ............................... Exclusive Economic Zone
EFH .............................. Essential Fish Habitat
EIS ................................ Environmental Impact Statement
EJ ................................. Environmental Justice
EO................................. Executive Order
EP ................................. Exploration Plan
ERA .............................. Environmental Resource Area
ESA .............................. Endangered Species Act
FEIS.............................. Final Environmental Impact Statement
Final SEIS..................... Final Supplemental Environmental Impact Statement
FMP .............................. Fishery Management Plan
FONSI .......................... Finding of No Significant Impact
FR ................................. Federal Register
FWS.............................. Fish and Wildlife Service
G&G ............................. geological and geophysical
Hz ................................. Hertz
IHA............................... Incidental Harassment Authorization
IPCC ............................. Intergovernmental Panel on Climate Change
IWC .............................. International Whaling Commission
ITA ............................... Incidental Take Authorization
ITL................................ Information to Lessees (Clauses)
LA................................. Launch Area
LNG.............................. liquefied natural gas
LOA.............................. Letter of Authorization
LS ................................. Land Segment
MAI .............................. Maximum Allowable Increase
Mbbls............................ thousand barrels
MBTA .......................... Migratory Bird Treaty Act
Mcf ............................... thousand cubic feet
MLC ............................. mud line cellar
MMbbls ........................ million barrels
MMC ............................ Marine Mammal Commission
MMcf............................ million cubic feet
MMPA.......................... Marine Mammal Protection Act
MMS............................. Minerals Management Service
NAAQS ........................ National Ambient Air Quality Standards
NEPA............................ National Environmental Policy Act
NPFMC ........................ North Pacific Fisheries Management Council
NHPA ........................... National Historic Preservation Act
NMFS ........................... National Marine Fisheries Service
NMML.......................... National Marine Mammal Laboratory
$NO_x$ ............................... nitrogen oxides
$NO_2$ .............................. nitrogen dioxide
NOA ............................. Nearest Onshore Area
NOAA .......................... National Oceanographic and Atmospheric Administration
NOI............................... Notice of Intent
NPDES ......................... National Pollutant Discharge Elimination System
NRC.............................. National Research Council
NSB .............................. North Slope Borough
NSIDC.......................... National Snow and Ice Data Center
NTL .............................. Notice to Lessees

$O_3$ .................................. ozone
OCS ............................... Outer Continental Shelf
OCS Lands Act.............. Outer Continental Shelf Lands Act
ODPCP .......................... Oil Discharge Prevention and Contingency Plan
OSRA ............................ Oil Spill Risk Analysis
OSRP ............................. Oil Spill Response Plan
PEA ............................... Programmatic Environmental Assessment
PM ................................. particulate matter
$PM_{10}$ .............................. particulate matter equal to or less than 10 micrometers in diameter
$PM_{2.5}$ .............................. particulate matter equal to or less than 2.5 micrometers in diameter
PSD................................ Prevention of Significant Deterioration
ROD .............................. Record of Decision
RPM's............................ Reasonably Prudent Measures
RUSALCA .................... Russian-American Long-term Census of the Arctic
Lease Sale 193............... Chukchi Sea OCS Lease Sale 193
SBS................................ southern Beaufort Sea stock of polar bears
SEIS............................... Supplemental Environmental Impact Statement
SHPO............................. State Historic Preservation Act
SIP ................................. State Implementation Plan
$SO_x$ ................................ sulfur oxides
$SO_2$ ................................ sulfur dioxide
$SO_4$ ................................ sulfate
TOC ............................... total organic carbon
TTS................................ temporary threshold shift
TAPS ............................. Trans-Alaska Pipeline System
ULSD ............................ ultra-low sulfur diesel
USC. .............................. United States Code
USDOC ......................... U.S. Department of Commerce
USDOI........................... U.S. Department of the Interior
USEPA .......................... U.S. Environmental Protection Agency
VLOS ............................ very large oil spill
VOC .............................. volatile organic compounds
WAH ............................. Western Arctic (caribou) Herd
WCD.............................. Worst Case Discharge
ZVSP ............................. Zero-offset Vertical Seismic Profile

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# SECTION 1. Purpose and Need

## 1.1 Purpose of the Proposed Action

Shell Gulf of Mexico Inc. (Shell) provided to the Bureau of Ocean Energy Management (BOEM) a Revised Exploration Plan (EP)—*Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea, Alaska* (2012 Shell Revised Chukchi Sea EP or Revised EP)—in October 2011 (Shell 2011a). The 2012 Shell Revised Chukchi Sea EP, which proposes exploratory drilling to evaluate the oil and gas resource potential of six of the company's Outer Continental Shelf (OCS) leases in the U.S. Chukchi Sea, was deemed submitted by BOEM on November 16, 2011.

The purpose of Shell's proposed action is to evaluate the oil and gas resource potential of six leases (OCS-Y-2280, OCS-Y-2267, OCS-Y-2321, OCS-Y-2294, OCS-Y-2278, and OCS-Y-2324) within a prospect known as "Burger" (Figure 1). The need for this action is established by BOEM's responsibility under the Outer Continental Shelf Lands Act (OCSLA) to make OCS lands available for expeditious and orderly development, subject to environmental safeguards, in a manner which is consistent with the maintenance of competition and other national needs.

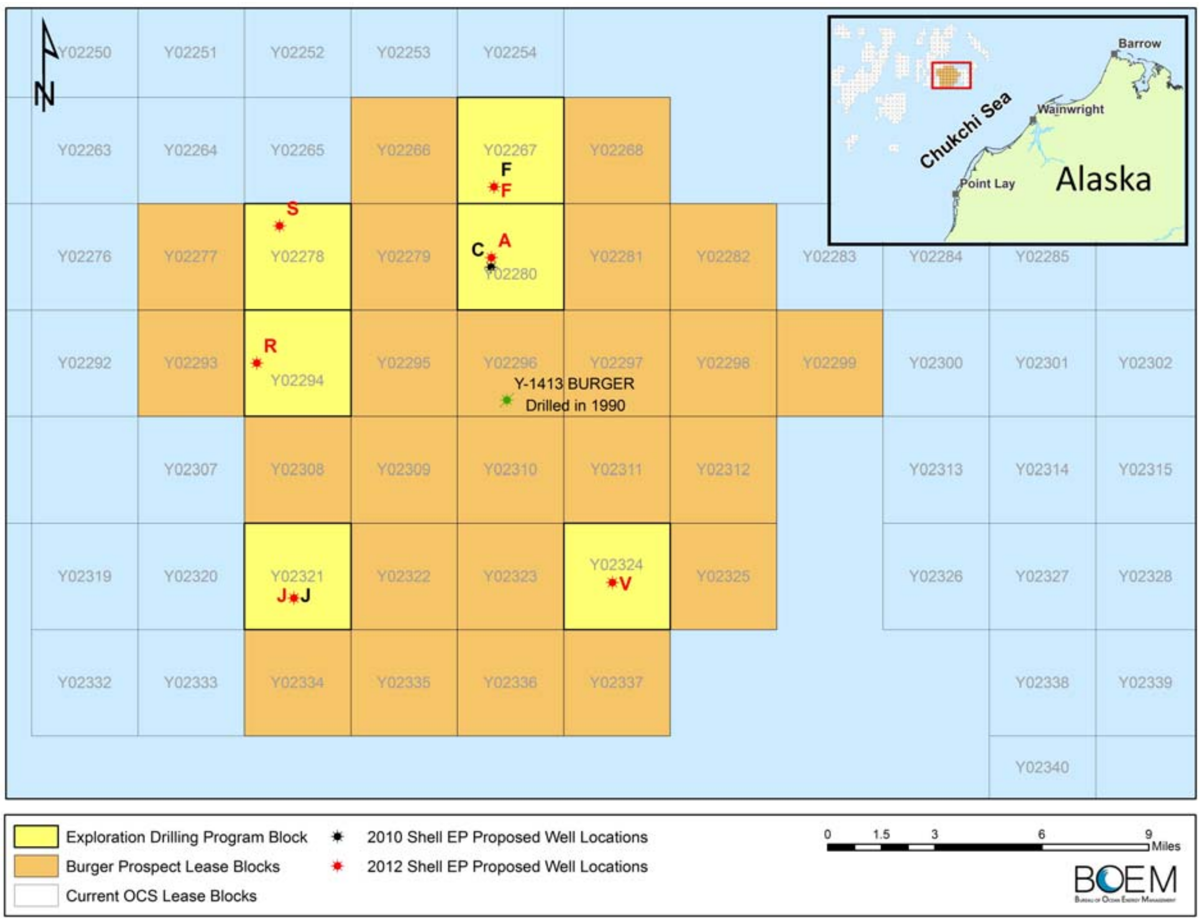


**Figure 1. Location of Shell's proposed exploratory drilling in the Chukchi Sea.**

BOEM has prepared this Environmental Assessment (EA) to assist with agency planning and decision making, in accordance with the following:

- The National Environmental Policy Act (NEPA)
- Council on Environmental Quality (CEQ) regulations at 40 CFR 1501.3(b) and 1508.9

- Department of the Interior (DOI) regulations at 43 CFR Part 46, and
- DOI policy in Section 516 of the Department of the Interior Manual (DM) Chapter 15 (516 DM 15).

## 1.2 Background

Shell acquired the Burger leases through Chukchi Sea OCS Lease Sale 193 (Lease Sale 193), held in February 2008. Under OCS leasing regulations at 30 CFR 556 and operating regulations at 30 CFR 250.180, a lease expires at the end of its primary lease term unless the lessee is conducting operations on the lease. Shell's leases have a primary term of ten years (30 CFR 556.37).

The 2012 Shell Revised Chukchi Sea EP makes changes to an initial Chukchi Sea Exploration Plan (initial EP; Shell, 2009) that was dated May 2009 and deemed submitted by BOEM on October 20, 2009 (see Table 1 for a direct comparison of the two EPs). After completing a technical and environmental review of the initial EP and supporting documents, MMS (now BOEM) issued (on December 7, 2009) an EA (USDOI, MMS, 2009a) and a Finding of No Significant Impact (FONSI)(USDOI, MMS, 2009b). The EA and FONSI are incorporated by reference into this document. The initial EP was approved with conditions on December 7, 2009.

**Table 1. Comparison of Shell's initial EP (submitted in 2009) and the 2012 Shell Revised Chukchi Sea EP.**

| Parameter | Initial Chukchi Sea EP | 2012 Shell Revised Chukchi Sea EP |
|---|---|---|
| **Drilling Seasons** | One season (July-October 2010) | Multiple seasons (July-October) commencing in 2012 |
| **Wells** | Up to three wells | Six wells |
| **Drilling Unit** | Drillship M/V *Frontier Discoverer* | Drillship M/V *Noble Discoverer* (same drillship) |
| **Prospects** | Burger, Southwest Shoebill, Crackerjack | Burger |
| **Potential Drill Sites** | 5 total - Burger C, F, J; Shoebill C; Crackerjack C | 6 total – Burger A, F, J, R, S, V |
| **Shorebase** | Marine support from Wainwright, air support from Barrow | Marine support (and possibly air support) from Wainwright, air support from Barrow |
| **Vertical Seismic Profile** | None | One at each well |
| **Drilling Waste** | Water based muds and cuttings discharged | Water based muds and cuttings discharged |
| **Primary Support Fleet** | Anchor handler, ice management vessel, offshore supply vessel, shallow water landing craft | Anchor handler, ice management vessel, 2 offshore supply vessels, shallow water landing craft |
| **Oil Spill Response** | Oil Spill Response (OSR) vessel, OSR barge, Oil Storage Tanker (OST) | OSR vessel, OSR barge, OST, capping stack and containment system (additional barge, tug, and anchor handler) |

Shell submitted their 2012 Shell Revised Chukchi Sea EP under BOEM operating regulations at 30 CFR 550 Subpart B. Shell proposes to drill up to six exploration wells on six leases, all of which are located on the Burger Prospect. Exploration activities would commence as soon as the 2012 open-water drilling season and would continue in subsequent open-water seasons until completion of the six-well plan. Shell would conduct its drilling operations using the ice-strengthened drillship M/V *Noble Discoverer* (*Discoverer*).

In support of the 2012 Shell Revised Chukchi Sea EP, Shell submitted the following:

- An environmental impact analysis (EIA) as Appendix F of the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a).
- Oil Discharge Prevention and Contingency Plan (ODPCP)(Shell, 2011b) for the drilling program

- Environmental information and reports
- Site-specific geohazards survey data and assessment
- A Plan of Cooperation (POC) addendum to reduce potential conflicts with subsistence activities (Shell, 2011a: Appendix H)
- A description of Shell's Cultural Awareness and Environmental Awareness Programs
- Other mitigation measures, and
- Other information as required by BOEM regulations and lease stipulations

BOEM has completed a technical and environmental review of the 2012 Shell Revised Chukchi Sea EP and supporting information to ensure the proposed activities would be conducted in a manner that is consistent with protection of the human, marine, and coastal environments.

## 1.3 Previous Applicable Analyses

NEPA requires Federal agencies to conduct an environmental review of certain Federal actions at each stage of the OCSLA process. The appropriate level of NEPA review depends on the OCSLA stage (516 DM 15), the scope of the proposed activities, and the agency's findings on the potential effects of the proposed activities. BOEM has completed numerous NEPA reviews of Chukchi Sea OCS activities. Recent NEPA reviews relevant to the proposed action analyzed here include the following:

- Final Supplemental Environmental Impact Statement – Chukchi Sea Planning Area Oil and Gas Lease Sale 193 in the Chukchi Sea, Alaska (OCS EIS/EA BOEMRE 2011-041)
- Environmental Assessment – Shell Gulf of Mexico, Inc., 2010 Exploration Drilling Program, Burger, Crackerjack, and SW Shoebill Prospects, Chukchi Sea Outer Continental Shelf, Alaska, and Finding of No Significant Impact (OCS EIS/EA MMS 2009-061)
- Draft Environmental Impact Statement – Beaufort and Chukchi Sea Planning Areas Oil and Gas Lease Sales 209, 212, 217, and 221 (OCS EIS/EA MMS 2008-0055)
- Final Environmental Impact Statement – Chukchi Sea Planning Area Oil and Gas Lease Sale 193 and Seismic Surveying Activities in the Chukchi Sea (OCS EIS/EA MMS 2007-026)
- Final Environmental Impact Statement – Outer Continental Shelf Oil & Gas Leasing Program: 2007-2012 (OCS EIS/EA MMS 2007-003)
- Final Environmental Impact Statement – Outer Continental Shelf Oil and Gas Leasing Program: 2002-2007 (OCS EIS/EA MMS 2002-2006)

These documents are available on the BOEM Alaska Region website at http://www.alaska.boemre.gov/ref/eis_ea.htm. Relevant sections of these documents are summarized and incorporated by reference into this EA. This EA tiers from the Lease Sale 193 Final EIS (USDOI, MMS, 2007a) and the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011).

This EA also summarizes and incorporates by reference relevant information and analysis from the following documents:

- Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea, Alaska (2012 Shell Revised Chukchi Sea EP)(USDOI, BOEMRE, 2011)
- October 10, 2011 Biological Evaluation (BE) to NMFS (USDOI, BOEM, 2011)
- September 30, 2011 BE to US Fish and Wildlife Service (FWS)(USDOI, BOEMRE, 2011b)

- Letter of Authorization (LOA) and Incidental Harassment Authorization (IHA) Applications
- Biological Opinion for Beaufort and Chukchi Sea Program Area Lease Sales and associated Seismic Surveys and Exploratory Drilling (USDOI, FWS, 2009).
- Biological Opinion for Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska; and Authorizations of Small Takes Under the Marine Mammal Protection Act (NMFS, 2008).
- Biological Opinion for Oil and Gas Leasing, Exploration Activities, in the U.S. Beaufort and Chukchi Seas, Alaska, Arctic Regional Biological Opinion (NMFS, 2006)

## 1.4 Statutory Framework

Shell's proposed exploration drilling activities are subject to an established regulatory framework that includes Federal and State regulations. Some, but not all, of the statutory framework governing oil and gas exploration on the OCS are listed below. A more detailed treatment of these requirements and how they relate to the proposed action is provided in Appendix F.

- OCSLA
- BOEM and Bureau of Safety and Environmental Enforcement (BSEE) Regulations
- Endangered Species Act
- Marine Mammal Protection Act
- Coastal Zone Management Act
- Clean Air Act
- Clean Water Act
- Oil Pollution Act of 1990
- National Historic Preservation Act
- National Invasive Species Act
- Magnuson-Stevens Fishery Conservation and Management Act

# SECTION 2. Proposed Action and Alternatives

## 2.1 Summary of Alternatives

### 2.1.1 Alternative 1 – No Action

Under Alternative 1 – No Action, BOEM would not approve Shell's proposed exploration drilling activities. This alternative would delay or preclude Shell from evaluating potential hydrocarbon resources of certain lease blocks acquired under Chukchi Sea Lease Sale 193. This alternative would also delay or avoid potential environmental impacts associated with the Proposed Action.

### 2.1.2 Alternative 2 – Proposed Action

Under Alternative 2 – Proposed Action, BOEM would approve, with conditions, Shell's proposal to drill six exploration wells within the Burger Prospect. Activities could occur on six leases acquired in Chukchi Sea Lease Sale 193. These leases are OCS-Y-2280, OCS-Y-2267, OCS-Y-2321, OCS-Y-2294, OCS-Y-2278, and OCS-Y-2324 (Figure 1). Shell proposes to commence drilling the wells during the open-water-season (July through October) of 2012 and would continue during subsequent open water seasons. Shell would conduct drilling operations from the *Discoverer*, to be supported by additional vessels for ice management, anchor handling, crew transport and supplies, and spill response.

### 2.1.3 Alternative 3 – One Well per Season

Under Alternative 3 – One Well per Season, BOEM would approve, with conditions, the Proposed Action, but would limit exploration drilling to one well (drilled to total depth) per season. Multiple mud line cellars and "spuds" (a type of partial well where an initial casing is set) may be drilled in a given season, but Shell could only access the hydrocarbon-bearing zone or zones of one well per year. As a result, this alternative could spread the positive impacts, negative impacts, and risks associated with oil and gas exploration activities across additional open-water seasons.

## 2.2 Other Alternatives Considered But Not Analyzed

During development of the Environmental Assessment (EA), the following concepts were considered as potential alternatives, but were not carried forward for full analysis.

### 2.2.1 Alternative Technologies

An alternative considered but not further analyzed is the use of alternative technologies to explore the oil and gas potential of the six leases identified for potential exploration. BOEM is unaware of any alternate techniques that would serve the purpose of the Proposed Action.

### 2.2.2 Adaptive Seasonal Restrictions

BOEM also considered creating adaptive seasonal restrictions to determine the end of each year's drilling season. Ice, weather, and other important environmental conditions vary from one drilling season to the next. Utilizing real-time measurements of ice, weather, and other environmental conditions, combined with advanced hindcasting and forecasting techniques, it may be possible to make more informed, yearly determinations on how long drilling operations could safely proceed. Adaptive seasonal restrictions could effectively shorten or lengthen a given drilling season, depending on actual conditions.

This concept is not carried forward for full analysis as an alternative within this EA. The 2012 Shell Revised Chukchi Sea EP states that exploratory activities will cease by October 31st of each year. This independent limitation renders moot the advantages of potentially extending the drilling season should ice conditions prove favorable. Meanwhile, BOEM and BSEE already possess continuing authority over all exploratory activities on the OCS (see Appendix F). If ice or other environmental conditions rendered continued exploration unsafe, BOEM and BSEE would use their existing authority to order Shell to cease exploratory activities prior to October 31st. Thus, mechanisms already exist to protect human safety and the environment in the event of unfavorable conditions.

### 2.2.3 Reduced Discharge

Stakeholders have also expressed concern that several waste streams associated with the proposed exploration activities—drilling fluids, drillings muds, and drilling cuttings—could lead to water quality impacts and bioaccumulation (particularly within animals harvested during subsistence activities). To address these concerns, stakeholders suggested that BOEM restrict the amount and type of wastes to be discharged, and offered Shell's reduced discharge plan for exploration drilling in the Beaufort Sea as a model for what BOEM should require as a condition of approval for the 2012 Shell Revised Chukchi Sea EP.

Potential effects associated with the discharge of drilling fluids, drilling muds, and drilling cuttings are analyzed in relevant portions of this EA, particularly sections analyzing potential impacts to water quality, fish and their habitat, lower trophic levels, and marine mammals. These analyses find that any effects on water quality, lower trophic levels, and fish and their habitat would be localized and minor. Any impacts to marine mammals would be negligible. No threats to subsistence resources or public health were identified.

Due to the low level of impacts associated with these discharges, a reduced discharge alternative is not carried forward for full analysis within this EA.

### 2.2.4 Alternative Drilling Plan

While commenting on a preliminary draft version of this EA, NMFS raised the possibility of an alternative drilling plan whereby BOEM would allow several wells to be partially drilled during one season, and then drilled to completion at an earlier time the following year. NMFS suggested that this plan would provide the following benefits: reducing the risk of a spill late in the season; providing additional time for any spill response; consolidating the necessary ZVSP into a single season; allowing ZVSP to occur much earlier in the season; and completing drilling operations earlier in the season to offset that operation from the fall migration of bowhead whales.

The suggested alternative drilling plan is not carried forward for full analysis as an alternative within the EA. This determination was based on consideration of the following:

- The EA analyses identified no substantive impacts associated with conducting ZVSP in consecutive years.
- The suggested alternative would require anchoring at each drill site twice, increasing the potential effects to benthic organisms.
- The suggested alternative would also require duplicate transits between drill sites, increasing overall transit time, transit related emissions, and anchor-handling-related emissions.
- The results from any one completed well would be used by Shell to determine whether a subsequent exploration well should be drilled, and if so, which well and whether any adjustments to the proposed location would be necessary. The suggested alternative would eliminate using the new well information to support decisions on subsequent wells and possibly result in the drilling of unnecessary wells.
- It is operationally preferable to permanently abandon a well if at all possible rather than temporarily abandon a well.

## 2.3 Proposed Mitigation Measure

This section presents a potential mitigation measure that, if implemented, would further address risks associated with late season drilling by assuring a greater opportunity for spill response and cleanup. This mitigation measure may be applied to either Alternative 2 or 3. If adopted, approval of the Revised EP could be conditioned on adherence to the restrictions described below.

Avoiding oil spills has always been, and will continue to be, the cornerstone of BOEM's regulatory program. This measure, however, is focused on mitigating the environmental impacts in the unlikely event of a large oil spill. It is a risk management tool that could be implemented as a condition of approval of the Revised EP. As such, this proposed mitigation measure could further guard against the types of adverse impacts analyzed in the Very Large Oil Spill analysis provided in the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a: Section IV.E).

In the unlikely event of an oil spill, spill response and cleanup operations would begin immediately and continue as long as necessary. Stakeholders have expressed particular concern regarding an uncontrolled well incident resulting in an oil spill late in the drilling season, when encroaching seasonal ice can reduce the effectiveness of spill response and cleanup. To ensure a greater opportunity for late season spill response and cleanup, this proposed mitigation measure would institute a late season drilling hiatus. During the hiatus, no exploratory drilling would be allowed below the last casing point set prior to penetrating a zone capable of flowing liquid hydrocarbons in measurable quantities.

The first component of the late season drilling hiatus is the duration. Presented below for the decisionmaker are three Options, each reflecting a different mitigation strategy and, consequently, a different hiatus duration:

- **Option 1** institutes a 15-day late season drilling hiatus to ensure at least 15 days of ice-free spill response and cleanup. This timeframe also affords enough time to stop the flow of oil using capping technologies. (The estimated time for Shell to successfully deploy capping technology is 15 days.)
- **Option 2** institutes a 38-day late season drilling hiatus to ensure at least 38 days of ice-free spill response and cleanup. This timeframe also affords enough time to stop the flow of oil using capping technologies and drill a relief well via a second vessel. (The estimated time for Shell to drill a relief well for Burger J is 34–38 days.)
- **Option 3** institutes a 60-day late season drilling hiatus to ensure at least 60 days of ice-free spill response and cleanup.

**Table 2. Comparison of three options with respect to duration.**

| Option | Hiatus Duration (Minimum Period for Ice-Free Cleanup) | Stop Flow of Oil? | Drill Relief Well? |
|---|---|---|---|
| 1 | 15 Days | Yes | No |
| 2 | 38 Days | Yes | Yes |
| 3 | 60 Days | Yes | Yes |

The second component of the late season drilling hiatus is the "trigger" date. This is the date from which BOEM would calculate backwards in order to determine when certain drilling activities must cease. The date of October 31st, the end of Shell's proposed drilling season, is a reasonable option. However, using a static calendar date, such as October 31st, would prove unresponsive to warming conditions in the Arctic. To respond to changing conditions and preserve maximum operational flexibility, BOEM investigated the feasibility of using scientific data and advanced ice forecasting techniques to determine a more flexible, science-based trigger. Unfortunately, current ability to accurately forecast sea ice conditions is rather limited—sea ice conditions in the Chukchi Sea are difficult to predict with confidence beyond the very near term. Forecasting will, therefore, be reserved for future consideration.

This proposed mitigation measure will instead use a form of hindcasting, or counting backwards from the date of first ice encroachment in prior years, to determine the trigger date. By reviewing interpretations of satellite imagery provided by the National Ice Center (NIC), BOEM can determine the calendar date at which the drilling areas were no longer "ice free" during past seasons. By utilizing this earliest calendar date of ice encroachment within any of the last 5 years as the trigger date, and counting back from that date, a reasonably protective period can be determined, while still maintaining some flexibility as conditions change in the future.

For example, during the 2012 drilling season BOEM would evaluate satellite imagery from 2007-2011. The earliest calendar date at which sea ice encroached on a drilling site during any of those years would constitute the trigger date applicable to that site for the 2012 drilling season. If Option 1 is selected, no drilling below the last casing point (as defined above) could occur within 15 days of the location's trigger date. If Option 2 is selected, no such drilling below the last casing point could occur within 38 days of the location's trigger date. Finally, if Option 3 is selected, no drilling below the last casing point could occur within 60 days of the location's trigger date.

Preliminary interpretation of satellite imagery shows that between 2007 and 2011, November 1st is the earliest calendar date on which sea ice covered a drilling site contemplated under Shell's Revised EP. Using the preliminary determination of November 1 as the trigger date, Table 3 provides the ramifications of each Option with respect to the drilling season and the number of wells that could be drilled.

**Table 3. Based on a preliminary trigger date of November 1, this table provides approximate dates, drilling season length, days to drill each well, and number of wells possible for each option.**

| Option | Hiatus Period | Trigger Date | Hiatus Period Begins | Total Days of Drilling Season[1] | Estimated Days to Drill Each Well[2] | Maximum Number of Wells Possible[3] |
|---|---|---|---|---|---|---|
| **1** | 15 Days | November 1 | October 17 | 106 | 32 | 3 |
| **2** | 38 Days | November 1 | September 24 | 83 | 32 | 2 |
| **3** | 60 Days | November 1 | September 2 | 61 | 32 | 1 |

[1] Reflecting drilling season commencing July 1.
[2] Reflecting Shell estimate of average time to drill each well to proposed total depth (PTD).
[3] Not accounting for travel between wells, positioning over well, anchoring, etc.

Each year, a new trigger date would be calculated for each site where Shell planned to conduct exploration drilling into hydrocarbon bearing zones. BOEM would calculate the trigger date using the best information available. Currently, the best information available for hindcasting is weekly and biweekly National Ice Center interpretation of sea ice data. Consistent with adaptive management principles, BOEM would continue to collect more and better data as technology improves, and would refine its hindcast calculations accordingly. BOEM would also consider developments in sea ice forecasting for potential use in determining the trigger date.

By the terms of Shell's proposal, no drilling would occur past October 31. Each of the Options under this Proposed Mitigation Measure would increase the time available for ice-free spill response and cleanup, assuming ice conditions occur as anticipated. The clean-up efforts would not, however, end with the first incursion of sea ice. As described in the Sale 193 Final SEIS, in-situ burning and mechanical recovery will continue until access is impossible. Once the oil is incorporated into the sheet ice and ice becomes stable, response can continue through excavation or trenching through the ice (USDOI, BOEMRE, 2011a: Section IV.E). Option 1 assures an ice-free period long enough to stop the flow of oil using capping technology. Options 2 and 3 assure ice-free periods long enough to cap the well and also complete a relief well. The estimated period of ice-free cleanup under Option 2 is up to three weeks longer than Option 1, but roughly two weeks shorter than Option 3. However, the longer the hiatus period selected, the shorter the drilling season becomes. Thus a longer hiatus period increases the difficulty of achieving the proposed action.

These options will only have an impact in the unlikely scenario of a late-season oil spill. This mitigation measure could reduce the potential for the types of widespread and severe impacts that were analyzed in the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a: Section IV.E), particularly in terms of late season and multi-year impacts. For instance, the longer the operator has to respond to oil in ice-free conditions, the more likely it is that the operator will be able to keep oil from becoming entrained in the ice and released in the spring. Successful spill response and cleanup could help prevent impacts to sensitive resources like the spring polynya system and migrating bowhead whales (USDOI, BOEMRE, 2011a: Section IV.E). Therefore, each option would provide incrementally greater chances of mitigating the impacts of a low probability, high impact late season oil spill.

## 2.4 The Proposed Action (Alternative 2)

### 2.4.1 Overview

Shell's proposal is to use a single drillship, the *Discoverer*, to complete a six-well exploration drilling program at locations on the Burger Prospect in the Chukchi Sea (see Table 4). For analysis purposes, BOEM assumes that all six wells would be drilled; however, the information on the subsea geology and properties of the potential reservoir formations obtained from drilling the initial wells may result in Shell's canceling subsequent wells or submission of a revised EP to relocate subsequent well sites. Shell's proposed activities would be conducted during the open-water season to avoid difficult ice conditions. Locations for each drill site are presented in Table 4. No shallow hazards or archaeological and historical resources are present at these drill sites.

**Table 4. Proposed exploration drill sites.**

| Prospect | Area | Protraction | Lease | Shell Lease |
|---|---|---|---|---|
| Burger | Posey | NR03-02 | 6764 | OCS-Y-2280 |
| Burger | Posey | NR03-02 | 6714 | OCS-Y-2267 |
| Burger | Posey | NR03-02 | 6912 | OCS-Y-2321 |
| Burger | Posey | NR03-02 | 6812 | OCS-Y-2294 |
| Burger | Posey | NR03-02 | 6762 | OCS-Y-2278 |
| Burger | Posey | NR03-02 | 6915 | OCS-Y-2324 |

The *Discoverer* would move through the Bering Strait and into the Chukchi Sea on or about July 1, and would continue on to the Burger Prospect as soon as ice and weather conditions allow. Once the drilling vessel is mobilized to a drill site and securely anchored to the seafloor, drilling operations commence. Exploration drilling activities may continue through October 31, ice conditions permitting.

Shell anticipates that conducting exploratory drilling activities would take an average of 32 days at each drill site. This estimate includes the following:

- Construct a mud line cellar (MLC)
- Drill the well from spud to proposed total depth (PTD)
- Log and evaluate the well
- Conduct a zero-offset vertical seismic profile (ZVSP)
- Plug and abandon the well in accordance with BOEM/BSEE requirements at 30 CFR 550(q)

The actual number of wells drilled in a given season would depend upon ice conditions, length of time available in each drilling site, and conditions of EP approval. Shell's predicted "average" drilling season is long enough for two to three exploration wells to be drilled from spud to PTD. Shell may elect to construct additional MLCs or upper hole segments (partial holes) depending on available time. Any well on which exploration drilling operations are suspended at the end of a drilling season will be secured in accordance with BOEM regulations. Shell would then either drill the well to total depth in the subsequent year, or permanently abandon the well. To allow for operational flexibility in response to variable ice conditions, Shell has indicated that it will submit an Application for Permit to Drill (APD) for all six proposed wells during the initial year.

Certain conditions may trigger a suspension of activities at a drillsite prior to concluding exploration drilling activities there. Within its Critical Operations and Curtailment Plan (COCP) and Ice Management Plan (IMP), which are attached as Appendices J and K of the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), Shell presents procedures for monitoring and reacting to ice in the prospect areas. If certain conditions of the COCP are triggered by environmental conditions at a drill site, Shell would suspend drilling operation, secure the well, and move offsite if necessary. The well would either be drilled to completion later that season, during a subsequent season, or secured and permanently abandoned prior to lease termination. The uppermost part of any equipment remaining in an abandoned well will remain at least 26 feet below the mudline.

Shell's proposed operations must comply with applicable Federal, State, and local laws, regulations, and permit requirements. Shell's proposed operations must also comply with all lease stipulations included within Chukchi Sea OCS Lease Sale 193. BOEM and BSEE retain specific authority to require additional mitigation (including shut down) as appropriate to respond to actual conditions encountered. In addition, Shell will have trained personnel and monitoring programs in place to ensure such compliance. BOEM, BSEE, and other Federal regulatory agencies would maintain continuing oversight of all of Shell's exploration activities. The following are the major applicable permits and authorizations that impose mandatory requirements and collectively ensure safety, protect the environment, avoid interference with subsistence resources and activities, and otherwise mitigate potential adverse impacts:

- Permit to Drill, issued by BSEE.
- Shell Chukchi Sea Regional ODPCP (Shell ODPCP), reviewed and accepted by BSEE.
- National Pollutant Discharge Elimination Systems (NPDES) Permit under the Clean Water Act (CWA), issued by the US Environmental Protection Agency (EPA).
- Air Quality Permits under the Clean Air Act (CAA), issued by EPA Region 10.
- Incidental Harassment Authorization (IHA) under the MMPA, issued by NMFS.
- Letter of Authorization (LOA) under the MMPA, issued by FWS.
- Nationwide Permit No. 8 coverage under the Rivers and Harbor Act, administered in relevant part by the U.S. Army Corps of Engineers (USACE).

### 2.4.2 Drill Sites and Operating Environment

More specific information on the locations of the proposed drill sites is provided in Table 5, below. Water depth at each location is approximately 150 ft or less. The community in closest proximity to the planned exploration activities is Wainwright, roughly 78 miles to the southeast.

**Table 5. Possible drill sites for the 2012 Shell Revised Chukchi Sea EP Drilling Program**

| Drill Site | Lease Number | Surface Location | | Water Depth (ft) at Proposed Drill Site |
|---|---|---|---|---|
| | | Latitude (N) | Longitude (W) | |
| A | OCS-Y-2280 | 71° 18' 30.92" | 163° 12' 43.17" | 150 |
| F | OCS-Y-2267 | 71° 20' 13.96" | 163° 12' 21.75" | 149 |
| J | OCS-Y-2321 | 71° 10' 24.03" | 163° 28' 18.52" | 144 |
| R | OCS-Y-2294 | 71° 16' 06.57" | 163° 30' 39.44" | 143 |
| S | OCS-Y-2278 | 71° 19' 25.79" | 163° 28' 40.84" | 147 |
| V | OCS-Y-2324 | 71° 10' 33.39" | 163° 04' 21.23" | 147 |

### 2.4.3 Seafloor Conditions at the Drill Sites

BOEM regulations (30 CFR 550.214) require an assessment of shallow hazards prior to drilling or installing mobile drilling units for offshore oil and gas activities. Geophysical surveys conducted over potential drilling sites are analyzed to identify potential shallow hazards and conditions that would pose engineering constraints. A hazard is defined as a feature or condition that presents difficulties that cannot be easily mitigated by design, implementation, or procedures. A constraint is defined as a feature or condition that presents difficulties but can be mitigated by design, implementation, or procedures.

In 2008 and 2009, Shell conducted shallow hazards surveys at each of the six planned drill sites. Shallow hazards survey reports and assessments for each drill site were submitted to BOEM under separate cover in April 2009. No shallow hazards or archaeological and historic resources are present at these sites. Additional information regarding shallow hazards surveying at the Burger Prospect is provided in Sections 1.3 and 1.4 of the Shell EIA (Shell, 2011a: Appendix F).

These leases are located on the relatively shallow continental shelf of the Chukchi Sea. The seafloor in the vicinity of each proposed well is largely flat, nearly featureless, and predominately composed of sandy mud. While ice gouges exist near several of the drill sites, they do not appear to have occurred within the last 20 years. One possible exception exists at Burger J, where "fresh-looking" gouge is reported. Additional information on bathymetry and relief at the drill sites is provided in Section 3.2.1 of Shell's EIA.

### 2.4.4 Drillship, Support Vessels, Oil Spill Response Vessels, and Aircraft

Shell would conduct drilling operations using the *Discoverer*, a 514 ft (156 m) modern drillship retrofitted for operating in Arctic OCS waters. The *Discoverer* has state-of-the-art drilling and well-control equipment. Drilling equipment is operated from a turret amidships. The vessel is stabilized

**Table 6. Support Vessels for the *Discoverer*.**

| Function | Vessel (or similar) | Trip Frequency or Duration |
|---|---|---|
| **Ice Management Vessel** | *Fennica* | Will generally remain upwind of *Discoverer* (3–25 mi away) throughout the drilling season. |
| **Anchor Handler** | *Tor Viking* | To stay in the area of the *Discoverer* throughout the drilling season. |
| **Offshore Supply Boat** | *Harvey Spirit* | Up to 17 round trips (combined) for resupply between Dutch Harbor and *Discoverer* during the drilling season. Also, 4-6 refuel trips (combined) between the OST and the *Discoverer* during that same time period. |
| **Offshore Supply Vessel** | *C-Leader* | |
| **Shallow Water Landing Craft** | *Arctic Seal* | Up to 10 trips to Wainwright. |

over the drilling site using an eight-point mooring system. Its hull has been reinforced for ice resistance. Detailed specifications for the *Discoverer* are provided in the 2012 Shell Revised Chukchi Sea EP (see Shell, 2011a: Table 1.c-1).

The *Discoverer* would be attended by several support vessels. The primary ice management vessel is the *Fennica*, which will be located several miles away from the drill site when not being used for ice management. The *Tor Viking*, an anchor handler, will remain close to the *Discoverer* throughout the drilling season. Drilling operations will also require a transfer of supplies from Dutch Harbor to the drilling vessels. The *Harvey Spirit* and the *C-Leader* will transport needed supplies. Shell may also call upon a fifth support vessel—a shallow water landing craft—to transport goods and/or personnel between the drill site and Wainwright. Table 6, below, contains information regarding the function, trip frequency, and trip duration of these support vessels. Approximate locations and transit routes for these support vessels are depicted in Figure 2 (above).

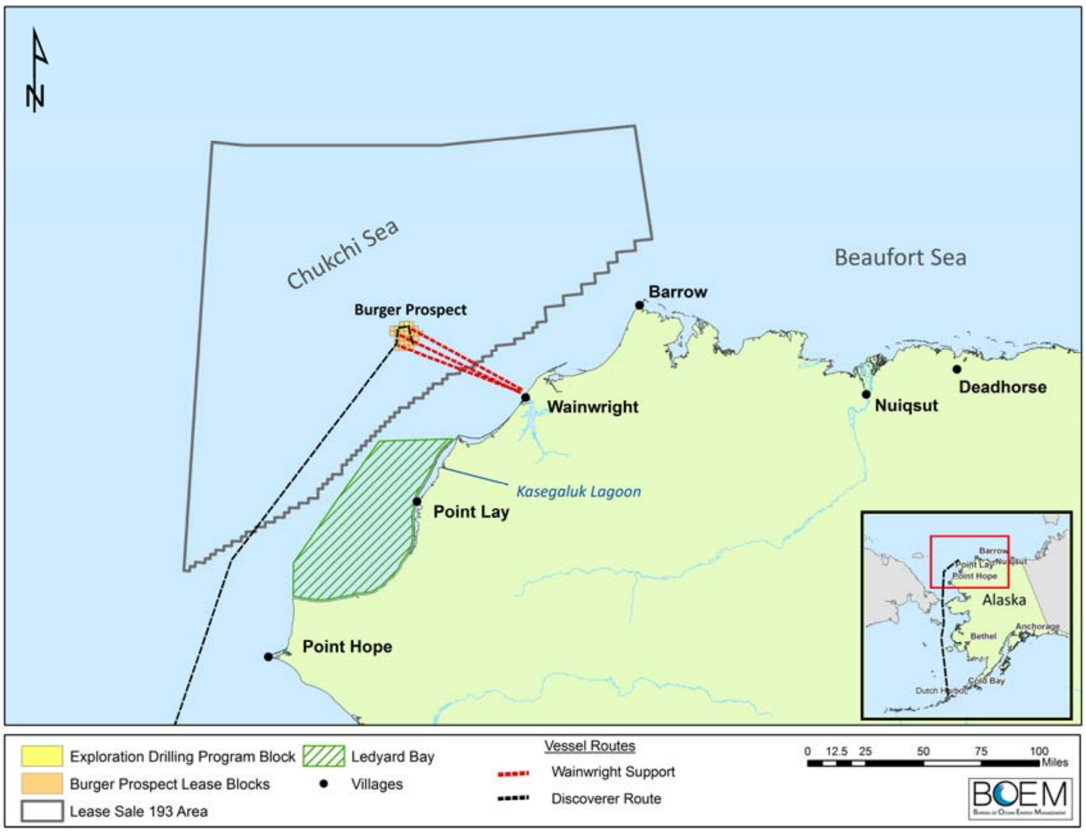


**Figure 2. Approximate marine transit routes for support vessels.**

Drilling operations will also be attended by a number of oil spill response vessels to be staged in various locations. Table 7 contains information regarding the function, trip frequency, and trip duration of these oil spill response vessels. A detailed description of the Shell ODPCP is provided in the Shell EIA.

**Table 7. Oil Spill Response Vessels**

| Function | Vessel (or similar) | Trip Frequency or Duration |
|---|---|---|
| Oil Spill Response (OSR) Vessel | Nanuq | To stay in the vicinity of the *Discoverer* throughout the drilling season. |
| OSR Barge | Unspecified | To stay in the vicinity of the *Discoverer* throughout the drilling season. |

| Function | Vessel (or similar) | Trip Frequency or Duration |
|---|---|---|
| Tug (for OSR Barge) | Unspecified | To stay in the vicinity of the *Discoverer* throughout the drilling season. |
| Oil Spill Tanker (OST) | Mikhail Ulyanov | To be staged such that it can reach drilling site within 24 hours. |
| Containment Barge | Unspecified | Remains in a location from which it can respond, if needed. |
| Tug (for Containment Barge) | Unspecified | Remains in a location from which it can respond, if needed. |
| Anchor Handler (for Containment Barge) | Unspecified | Remains with containment barge. |

Several aircraft would also be used in support of the Proposed Action. Information regarding the function, trip frequency, and trip duration of these aircraft is provided in Table 8. Anticipated transit routes are depicted in Figure 3.

**Table 8. Aircraft functions, descriptions, and trip characteristics.**

| Function | Make and Model (or similar) | Trip Frequency and Duration |
|---|---|---|
| **Transport from shorebase to regional jet service** | Fixed Wing – Saab 340 B, Beechcraft 1900, Dash 8 or similar | Up to 4 trips / week between Wainwright and Barrow or Anchorage. |
| **Crew rotation and supplies** | Helicopter – S-92, EC225 or similar | Approximately 12 trips / week between shorebase and drilling site. Approximately 3.0 hrs / trip. |
| **Search and Rescue** | Helicopter – S-61, S-92, EC225 or similar | Stationed in Barrow. Utilized 40 hrs / week for proficiency training and emergency trips. |

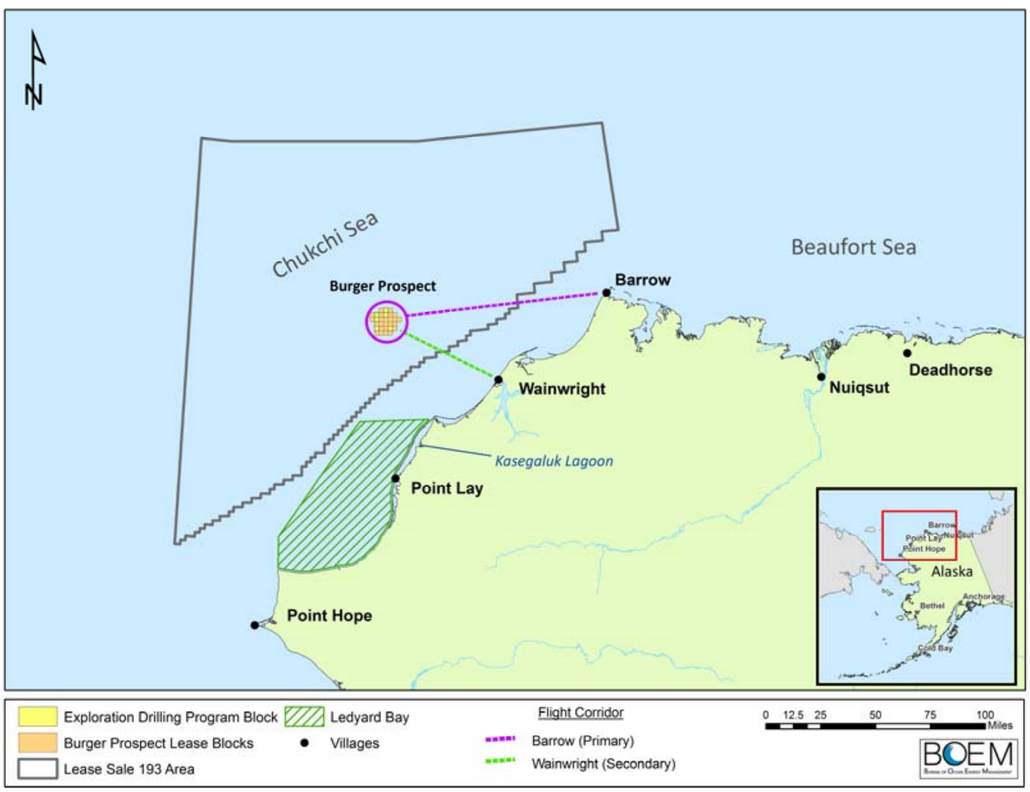


**Figure 3. Approximate travel routes for aircraft.**

### 2.4.5 Discharges and Waste Management

The drillship *Discoverer* will discharge several types of waste during exploration activities. These wastes include drill cuttings, spent drilling fluids, cuttings from water based intervals, domestic wastewater, excess cement, brine water from a desalination unit, (uncontaminated) deck drainage, non-contact cooling water, uncontaminated ballast water, (treated) bilge water, and BOP fluid. The drilling fluids to be discharged are water based mud (WBM) drilling fluids and may contain cuttings with adhered WBM. The drilling fluid would be recycled for use in multiple wells and diluted with seawater at 30:1 prior to its discharge into the sea. Additional information regarding these discharges, including quantities of discharges, is provided in Section 6.0 of the Revised EP and Section 2.7 of Shell's EIA. All discharges will be authorized under NPDES General Permit AKG-28-0000 or its replacement. Shell will only use water-based drilling fluids.

Support vessels will discharge domestic waste and treated sanitary waste. However, no untreated sanitary waste will be discharged, and no treated sanitary waste water will be discharged within three miles of the coastline.

Certain non-combustible, non-hazardous wastes will be transported to shore and disposed of in an approved landfill. Regulated wastes (i.e. paint, solvents, unused chemicals, batteries, lamps, used oil, and glycol) will be transported to a licensed facility.

### 2.4.6 Emissions

The majority of emissions caused by the Proposed Action would be associated with the drillship *Discoverer* and the support vessels, which include ice management ships, anchor handlers, supply ships, and oil spill response (OSR) vessels. The emissions result from the use of internal combustion engines that burn fossil fuel in two types of engines, main propulsion and auxiliary engines. The drillship and supporting vessels will emit the following regulated pollutants: nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), carbon monoxide (CO), volatile organic compounds (VOC), and particulate matter less than 10 micrometers in diameter ($PM_{10}$) and 2.5 micrometers ($PM_{2.5}$). Emissions of these pollutants would also occur from operating heaters, boilers, and incinerators on the vessels, but at a much lower level.

How emissions are regulated depends on whether they come from a stationary or mobile source. The drillship *Discoverer* is considered a stationary OCS source during actual drilling, meaning the ship is securely anchored to the seabed and the propulsion engines are not operating (40 CFR Part 55.2). During drilling, the *Discoverer* would produce emissions from auxiliary engines used to generate electric power and heat, create pneumatic compression and hydraulic compression, move large pieces of equipment, and operate an incinerator primarily for domestic purposes. Emissions from support vessels operating within 25 miles of the *Discoverer* during actual drilling are considered emissions from the stationary source; however, the vessels are not considered part of the *Discoverer* stationary OCS source (40 CFR Part 55.2). These emissions, whose quantities are provided in the table below, are permitted in a PSD/NSR permit issued by EPA on 31 March 2010. Emissions from these engines are controlled by using ultra-low sulfur diesel (ULSD) fuel and Best Available Control Technology (BACT), such as selective catalytic reduction controls and diesel particulate filters. The combined use of ULSD fuel and BACT reduces emissions of VOCs and $NO_x$, and lowers emissions of particulate matter to near zero. Additional information regarding regulated air emissions is provided in Section 2.8 of Shell's EIA.

Shell is not required to account for emissions from mobile sources in the PSD permit. Mobile sources associated with the Proposed Action include all other marine vessels operating in the program planning area in support of the exploration activities. (This category also includes the *Discoverer* and all support vessels whenever they are in transit or otherwise not considered as a "stationary" source.) The primary pollutant from the operation of the marine vessels, whether operating as a stationary source or mobile, would be $NO_x$, and in lesser amounts, CO and VOC emissions. Emissions from mobile source vessels are considered in the air quality analysis of this EA.

This EA also assesses emissions from helicopters and surface vehicles associated with the Proposed Action. Helicopters would be used for crew rotation, transport of materials and supplies, and search-and-rescue training. Emissions from helicopters will be accounted for by considering ground-based operations defined by the number of landing and takeoff cycles (LTO) throughout the drilling season (FAA, 1997). The helicopters would emit mostly emissions of CO, and in lesser amounts, VOC and $NO_x$. The operation of surface vehicles, most likely passenger vans, would be required to transport relief crews between the housing area and Barrow's airport for transport of personnel offshore to the drillship. The emissions would be accounted for by considering the number of crew changes required for the duration of the drilling season. The vehicles would emit mostly CO, and in lesser amounts, $NO_x$ and VOCs.

## 2.4.7 Sound Generation

Several components of the Proposed Action would introduce sound into the environment. These are summarized below and described in more detail within Section 2.9 of Shell's EIA.

### Drilling Sound

Sound levels generated by the *Discoverer* while drilling an exploration well have not been measured. However, Shell's EIA provides modeling of the propagation of sound that might be generated during exploration drilling on the Burger Prospect in the Chukchi Sea.

This modeling is based on a variety of information including sound levels recorded while *Discoverer* was drilling in a different location and sound levels generated by a different vessel while drilling in the U.S. Beaufort Sea, along with water depth, geoacoustic, and water sound speed profiles (based on salinity and temperature) specific to the area of Shell's Burger Prospect. Results of this modeling, along with measured underwater sound levels generated by the *Discoverer* during non-drilling activities, are provided in Tables 2.9-1 and 2.9-1 of Shell's EIA. Shell would perform in-field sound measurement while drilling.

### Vertical Seismic Profile

Shell proposes to conduct Vertical Seismic Profile (VSP) for each well drilled (see Section 2.4 of Shell's EIA). A VSP gathers geophysical data in the well which is used to correlate to or "tie-in" the geophysical data collected during previous seismic surveys over the prospect. During a VSP, an airgun array is deployed at a location near or adjacent to the drilling vessel, while receivers are placed (temporarily anchored) in the wellbore. The airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. The sizes, arrangement, and firing times of the individual airguns in an array are designed and synchronized to suppress the pressure oscillations subsequent to the first cycle.

Shell further proposes to conduct a particular form of VSP known as a zero-offset VSP (ZVSP), in which the sound source is maintained at a constant location near the wellbore. A typical sound source that may be used by Shell for its ZVSP surveys is an eight-airgun array which consists of four 150-$in^3$ airguns and four 40-$in^3$ airguns for a total size of 760 cubic inches. For each survey, Shell would use a crane to deploy the sound source over the side of the drillship to a depth of about 10-23 feet below the water surface. The receiver would be temporarily anchored in the wellbore at the appropriate depth. The sound source is then pressured up to 2,000 pounds per square inch and activated 5-7 times at approximately 20-second intervals. This process is then repeated with the receivers positioned at other portions of the wellbore until the entire exploration well is surveyed. Depending on the depth of the well and the number of anchoring points, a normal ZVSP survey is conducted during a period of about 10-14 hours.

Recorded sound levels from a similar array that was used during a 2008 seismic survey in the Beaufort Sea are discussed in Section 2.9 of the Shell EIA and are provided in Table 9.

**Table 9. Sound Source (airgun array) Specifications for ZVSP Surveys in the Beaufort.**

| Received Sound Level | Distance to Received Sound Level (Radius) | |
|---|---|---|
| 190 dB re1µPa @ 1 m | 1,719 ft | 524 m |
| 180 dB re1µPa @ 1 m | 4,068 ft | 1,240 m |
| 160 dB re1µPa @ 1 m | 12,041 ft | 3,670 m |
| 120 dB re1µPa @ 1 m | 34,449 ft | 10,500 m |

### Vessel Sound

A number of additional vessels (see Tables 6 and 7, above) would support the *Discoverer* and drilling operations. Each of these vessels would contribute sound to the environment. Vessel sounds have been reported extensively (Greene and Moore, 1995; Blackwell and Greene 2002, 2005, 2006). Numerous measurements of underwater vessel sound have been performed in support of recent industry activity in the Chukchi and Beaufort seas. Results of these measurements were reported in various 90-day and comprehensive reports since 2007. For example, Garner and Hannay (2009) estimated sound pressure levels of 100 dB at distances ranging from approximately 1.5-2.3 mi (2.4-3.7 km) from various types of barges. MacDonald et al. (2008) estimated higher underwater sound pressure levels from the seismic vessel *Gilavar* of 120 dB at approximately 13 mi (21 km) from the source, although the sound level was only 150 dB at 85 ft (26 m) from the vessel. Like other industry-generated sound, underwater sound from vessels is generally characterized by relatively low frequencies.

The primary sources of sounds from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery. Propeller cavitation is usually the dominant noise source for vessels (Ross, 1976). Propeller cavitation and singing are produced outside the hull, whereas propulsion or other machinery noise originates inside the hull. There are additional sounds produced by vessel activity, such as pumps, generators, flow noise from water passing over the hull, and bubbles breaking in the wake.

Icebreakers contribute greater sound levels during ice-breaking activities than ships of similar size during normal operation in open-water (Richardson et al., 1995a). This higher sound production results from the greater amount of power and propeller cavitation required when operating in thick ice. Shell does not intend to break ice with its ice management vessels unless ice poses an immediate safety hazard at the drill site. The ice management vessels will instead push ice out of the area. Reported and predicted sound levels associated with icebreaking activities are provided in Tables 2.9-5, 2.9-6 and 2.9-7 of Shell's EIA.

### Aircraft Sound

Several aircraft would support the *Discoverer* and drilling operations and introduce sound into the environment. The level and the duration of received underwater sounds depends on the altitude and aspect if the aircraft, receiver depth, and water depth. In general, received sound levels decrease as the altitude of the aircraft increases. Tables 2.9-3 and 2.9-4 of Shell's EIA provide detailed information for each type of aircraft supporting Shell's exploration activities.

## 2.4.8 Local Hire

Under the Proposed Action, Shell proposes to hire local residents in some positions, as discussed below:

### Marine Mammal Observers

Shell will employ Marine Mammal Observers (MMOs) to conduct vessel-based monitoring for marine mammals throughout exploration drilling operations. These MMOs will be trained, experienced field observers, to include biologists and Iñupiat personnel. The MMOs will be stationed aboard the drillship and associated support vessels throughout the exploration drilling period. Their duties would include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the exploration drilling operations; initiating mitigation measures where appropriate; and reporting the results.

### Subsistence Advisors

Shell proposes to hire Subsistence Advisors (SAs) in each of the villages along the Chukchi Sea, as well as Kotzebue. Shell would share information and maintain a dialogue with each SA, so that conflicts with subsistence may be minimized or avoided.

### Community and Call Center positions

Shell also proposes to employ local community members at its Community and Call Centers (Com Centers). These Com Centers will serve as information clearinghouses and enable communications between Shell operations and vessels, local subsistence users, and SAs.

Shell has also indicated that it would employ local residents as staff at its shorebase and, if necessary, contingency oil spill responders.

## 2.4.9 Analysis of Accidental Oil Spills

In the Lease Sale 193 Final EIS and Final SEIS (from which this EA tiers), BOEM analyzed a range of oil spill sizes—grouped by volume category—from small (<1,000 bbl) to very large (≥150,000 bbl). Likely consequences for environmental, social, and economic resources were evaluated. In this document BOEM updated the analysis of small and large oil spills provided in the Chukchi sea EA and the Arctic Multiple-Sale EIS.

To arrive at a spill volume and oil type for small (<1,000 bbl), large (≥1,000 bbl), and very large (≥150,000 bbls) spill size categories, BOEM used Shell's potential discharge volumes (Shell, 2011b: Table 2.3-1 summarized in Table 10. and in Appendix A of this EA). The potential discharge volumes are estimated without consideration of mitigation or response efforts. Mitigation and response are discussed in Sections 2.4.10 through 12 of this EA. Shell estimated a worst case discharge volume and provided this estimate to BOEM and BSEE (Wall, 2011, pers. comm.). BOEM concurs on geologic grounds with Shell's assertion that the Burger J well offers the highest potential discharge volume in both daily rate and cumulative flow. BOEM also independently modeled the WCD for Shell's Burger J well and verified that Shell's estimate is sufficient (Wall, 2011). BOEM's WCD calculation assumes no "bridging over" – a phenomenon whereby rocks, sand, clay and other debris can clog the hole and stop the blowout.

**Table 10. Spill volume and oil type estimated for each BOEM spill size category (from Shell's potential discharge volumes).**

| BOEMRE Spill-Size Categories | Type | Oil Type | Potential Discharge Volume[1] | Volume estimated to reach water |
|---|---|---|---|---|
| Small (<1,000 bbl) | Fuel Transfer | Diesel | 48 bbl | 48 bbl |
| Large (≥1,000 bbl) | Diesel Tank | Diesel | 1,555 bbl | 0 bbl |
| Very Large (≥150,000 bbl) | Loss of Well Control | Crude Oil | 750,000 bbl | 121,779 bbl[2] |

Note: [1]Total volume estimated with no mitigation or response
[2]Total volume estimated with mitigation and response as described in Sections 2.3.10 of this EA.

BOEM determined a reasonably foreseeable spill analysis scenario for Alternative 1 – No Action, Alternative 2 – Proposed Action, and Alternative 3 – One Well per Season. To determine the specific elements of the oil spill scenario BOEM reviewed and considered published documents and NEPA assessments on the likelihood of the potential discharges in the three spill size categories. BOEM evaluated the potential impact producing factors of an accidental oil spill for this EA. Further analytical details are found within Appendix A of this EA.

For purposes of analysis of Alternative 1, no small, large, or very large spills are estimated to occur in the project area as a result of Alternative 1 since no exploration activities associated with drilling would occur.

For purposes of analysis of Alternative 2 – Proposed Action and Alternative 3 – One Well per Season, BOEM estimates it is likely a small refined oil spill could occur. This estimate is based on consideration of 35 small exploration spills that have occurred while drilling 35 wells on the Arctic OCS. During the time of this exploratory drilling, industry has had 35 small spills totaling 26.7 bbl or 1,120 gallons (gal). Of the 26.7 bbl spilled, approximately 24 bbl were recovered or cleaned up. Table A-4 in Appendix A shows the exploration spills on the Beaufort Sea and Chukchi Sea OCS. No large spills (≥1,000 bbl) or very large spills (≥150,000 bbls) are estimated to occur (based on calculations and analyses presented in Appendix A of this EA) from the proposed exploration activities.

The large and very large crude oil spill occurrence estimates are based on the following: (1) the low rate of OCS exploratory drilling well-control incidents spilling fluids per well drilled; (2) the fact that since 1971, one large/very large spill has occurred from a loss of well control during temporary abandonment out of more than 15,000 exploratory wells drilled; (3) the low number (up to six) of exploration wells proposed in this action; (4) the fact that no crude oil would be produced and the wells would be permanently plugged and abandoned; (5) the history of Arctic OCS exploration spills, all of which have been small; (6) the fact that no large spills occurred while drilling 35 wells in the Arctic OCS; and (7) pollution prevention and oil spill response regulations and methods implemented by BOEM and Shell, respectively, since the *Deepwater Horizon* event.

Given the points made above, the most likely spill size that could occur is a small (<1,000 bbl) spill. For purposes of analysis, BOEM chose a 48 bbl diesel fuel-transfer spill (as identified in Shell's ODPCP Summary of Potential Discharges) to represent the spill volume and oil type for the effects analysis of a small spill for Alternative 2 and 3 (Shell, 2011b: Table 2.3-1).

To evaluate the potential effect of a 48 bbl diesel-fuel oil spill, BOEM estimated how much diesel fuel would evaporate, how much diesel fuel would naturally disperse, and how much diesel fuel would remain after a certain time period. The SINTEF oil weathering model (OWM) was used to generate these estimates. A 48 bbl diesel-fuel spill could evaporate and disperse in less than 3 days (Appendix A: Table A-7). The SINTEF OWM estimates do not include the mitigating effects of potential containment and recovery operations to remove spilled product. Such operations would include pre-booming downwind of vessels prior to transfer operations in accordance with BOEM lease stipulations, USCG requirements, and Shell's fuel transfer operating procedures. Also, recovery equipment would be deployed for the control and removal of diesel fuel resulting from a small spill. Should a 48 bbl diesel-fuel spill occur, the spill would be localized and persist less than 3 days.

Likely consequences for environmental, social, and economic resources from large and very large oil spills were evaluated in the Lease Sale 193 Final EIS and Final SEIS (from which this EA tiers). Although large are very large spills are not estimated to occur, summaries and impact conclusions for large and very large spills for each resource are included in Section 4.0.

### 2.4.10 Oil Discharge Prevention and Contingency Planning

No exploratory drilling may commence prior to submittal and BSEE approval of an Oil Discharge Prevention and Contingency Plan (ODPCP) that is consistent with applicable Federal regulations and guidance. The ODPCP must demonstrate that the operator has the spill response resources, equipment, personnel, and strategies necessary to efficiently and effectively respond to a worst case discharge (WCD).

Shell prepared a Chukchi Sea Regional Exploration ODPCP to support its 2010 Chukchi Sea Exploration Plan (EP). That ODPCP was approved by the State of Alaska in March 2010 and by BOEMRE (now BSEE) in April 2010. Because the 2012 Shell revised Chukchi Sea EP included changes to drilling plans and WCD volumes, amendments to the approved ODPCP were necessary. BSEE requested specific changes to the approved ODPCP by letter dated November 16, 2011.

Shell discusses certain key components of its ODPCP in Section 8 of the EP and Section 2.10 of the EIA.

### 2.4.11 Compliance with Lease Stipulations

Shell's leases were obtained under the Chukchi Sea OCS Lease Sale 193 in February of 2008. Shell's proposed exploration activities must comply with all applicable stipulations.

**Stipulation 1 –** Protection of Biological Resources

**Stipulation 2 –** Orientation Program

**Stipulation 3 –** Transportation of Hydrocarbons

**Stipulation 4 –** Industry Site-Specific Monitoring Program for Marine Mammal Subsistence Resources

**Stipulation 5 –** Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Marine Mammal Subsistence-Harvesting Activities

**Stipulation 6 –** Pre-Booming Requirements for Fuel Transfers

**Stipulation 7 –** Measures to Minimize Effects to Spectacled and Steller's Eiders During Exploration Activities

The full text of the lease stipulations associated with Lease Sale 193 and a summary of how Shell's proposed compliance with each stipulation are provided in Appendix G.

### 2.4.12 Other Mitigation Included in Shell's Exploration Plan

Discussed below are additional mitigation measures that Shell would implement during its proposed exploration drilling operations. This list is taken directly from Section 12.0(c) of the Revised EP and is provided here to inform the analysis of potential environmental impacts. These measures supplement, but do not supercede, requirements imposed by applicable laws, regulations, permits, authorizations, and lease stipulations.

#### Communications

- Shell has developed a Communication Plan and will implement this plan before initiating exploration drilling operations to coordinate activities with local subsistence users, as well as Village Whaling Captains' Associations, to minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale hunt and other subsistence hunts. The Communication Plan includes procedures for coordination with Com Centers to be located in coastal villages along the Chukchi and Beaufort Seas during Shell's proposed exploration drilling activities.
- Shell will employ local SAs from the Beaufort and Chukchi Sea villages that are potentially impacted by Shell's exploration drilling activities. The SAs will provide consultation and guidance regarding the whale migration and subsistence activities. There will be one per village, working approximately 8-hr per day and 40-hr per week during each drilling

season. The subsistence advisor will use local knowledge (Traditional Knowledge) to gather data on subsistence lifestyle within the community and to advise in ways to minimize and mitigate potential negative impacts to subsistence resources during each drilling season. Responsibilities include reporting any subsistence concerns or conflicts; coordinating with subsistence users; reporting subsistence-related comments, concerns, and information; coordinating with the Com and Call Center personnel; and advising how to avoid subsistence conflicts. SAs will have a handbook that will specify work tasks in more detail.

### Aircraft Travel

- Aircraft shall not operate below 1,500 ft (457 m) unless the aircraft is engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather (fog or low ceilings), or in an emergency situation, while over land or sea to minimize disturbance to mammals and birds. Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft (457 m) in areas of active whaling; such areas to be identified through communications with the Com Centers.
- Aircraft will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on land or ice.
- Shell will also implement non-MMO flight restrictions prohibiting aircraft from flying within 1,000 ft (300 m) of marine mammals or below 1,500 ft (457 m) altitude (except during takeoffs and landings or in emergency situations) while over land or sea. This flight will also help avoid disturbance of and collisions with birds.

### Vessel Travel

- The *Discoverer* and support vessels will enter the Chukchi Sea through the Bering Strait on or after July 1, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- Drillship and support vessel transit routes will avoid known fragile ecosystems and the Ledyard Bay Critical Habitat Unit, and will include coordination through Com Centers.
- To minimize impacts on marine mammals and subsistence hunting activities, the drillship and support fleet will transit through the Chukchi Sea along a route that lies offshore of the polynya zone. In the event the transit outside of the polynya zone results in Shell having to break ice (as opposed to managing ice by pushing it out of the way), the drillship and support vessels will enter into the polynya zone far enough so that ice breaking is not necessary. If it is necessary to move into the polynya zone, Shell will notify the local communities of the change in the transit route through the Com Centers. As soon as the fleet transits past the ice, it will exit the polynya zone and continue a path in the open sea toward the drill sites.
- MMOs will be aboard the *Discoverer* and all support vessels (see the 4MP in Appendix D of the 2012 Shell Revised Chukchi Sea EP).
- Vessels will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on land or ice.
- When within 900 ft (274 m) of marine mammals, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction.
- Vessel speed is to be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.

- Lighting on the drillship will be shaded and some have been replaced with ClearSky lighting. ClearSky lighting is designed to minimize the disorientation and attraction of birds to the lighted drillship to reduce the possibility of a bird collision (see the Bird Strike Avoidance and Lighting Plan in Appendix I of the 2012 Shell Revised Chukchi Sea EP).

### Exploration Drilling Operations

- Drilling mud will be cooled to mitigate any potential permafrost thawing or thermal dissociation of any methane hydrates encountered during exploration drilling, if such materials are present at the drill site.
- Drilling muds will be recycled to the extent practicable based on operational considerations (e.g., whether mud properties have deteriorated to the point where they cannot be used further) so that the volume of the spent mud is reduced.
- Critical operations will not be started if potential hazards (ice floe, inclement weather, etc.) are in the vicinity and there is not sufficient time to finish the critical operation before the arrival of the hazard at the drill site (see COCP in Appendix J of the 2012 Shell Revised Chukchi Sea EP).
- All casing and cementing programs will be certified by a registered professional engineer.
- Airgun arrays will be ramped up slowly during ZVSPs to warn cetaceans and pinnipeds in the vicinity of the airguns and provide time for them to leave the area and avoid potential injury or impairment of their hearing abilities. Ramp ups from a cold start when no airguns have been firing will begin by firing a single airgun in the array. A ramp up to the required airgun array volume will not begin until there has been a minimum of 30 min of observation of the safety zone by MMOs to assure that no marine mammals are present. The safety zone is the extent of the 180 dB radius for cetaceans and 190 dB for pinnipeds. The entire safety zone must be visible during the 30-min lead-in.to an array ramp up. If a marine mammal(s) is sighted within the safety zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30 min: 15 min for small odontocetes and pinnipeds, or 30 min for baleen whales and large odontocetes.
- The blowout prevention program will be enhanced through the use of two sets of blind/shear rams, increased frequency of BOP performance tests from 14 to 7 days, a remotely operated vehicle (ROV) control panel on the seafloor with sufficient pressured water-based fluid to operate the BOP, a containment system that includes capping stack equipment, treatment and flaring capabilities, a fully-designed relief well drilling plan, and provisions for a second relief well drilling vessel (Kulluk) to be available to drill the relief well if the primary drilling vessel is disabled and not capable of drilling its own relief well.

### Ice Management

- Ice management will involve preferentially redirecting, rather than breaking, ice floes while the floes are well away from the drill site (see the Ice Management Plan in Appendix K of the 2012 Shell Revised Chukchi Sea EP).
- Real time ice and weather forecasting will be from the Shell Ice and Weather Advisory Center (SIWAC).

### Oil Spill Response

- The primary OSR vessel will be on standby at all times when drilling into zones containing oil to ensure that oil spill response capability is available within one hour, if needed.
- Shell will deploy an OSR fleet that is capable of collecting oil on the water up to the WCD planning scenario which is greater than the calculated WCD flowrate of a blowout in the

unlikely event that one should occur. The primary OSR vessel will be on standby when drilling into zones containing oil to ensure that oil spill response capability is available within one hour, if needed. The remainder of the OSR fleet will be fully engaged within 72 hours.

- In addition to the OSR fleet, oil spill containment equipment will be available for use in the unlikely event of a blowout. The containment barge will be centrally located in the Beaufort Sea or Chukchi Sea and supported by an Invader Class Tug and possibly an anchor handler. The containment equipment will be designed for conditions found in the Arctic including ice and cold temperatures. This equipment will also be designed for maximum reliability, ease of operation, flexibility and robustness so it could be used for a variety of blowout situations.
- Capping stack equipment will be stored as equipment aboard one of the ice management vessels and will be available for immediate deployment in the unlikely event of a blowout. Capping stack equipment consist of subsea devices assembled to provide direct surface intervention capability with the following priorities:
  - Attaching a device or series of devices to the well to affect a seal capable of withstanding the MAWP and closing the assembly to completely seal the well against further flows (commonly called “capping and killing”)
  - Attaching a device or series of devices to the well and diverting flow to surface vessel(s) equipped for separation and disposal of hydrocarbons (commonly called “capping and diverting”)
- A polar bear culvert trap has been constructed in anticipation of OSR needs and will be available prior to commencing the exploration drilling operations.
- Pre-booming is required for all fuel transfers between vessels.

### Air Emissions

- Primary generators on the *Discoverer* have been retrofitted with selective catalytic reduction SCR devices to reduce NOx emissions to under 0.5 grams/kilowatt-hour (g/kW-hr), and OxyCat to reduce CO by at least 80 percent, volatile organic compounds VOCs by at least 70 percent, and PM10 by at least 50 percent.
- All other engines on *Discoverer* will either be Tier 3 (low emissions) or have been retrofitted with CDPF devices to reduce CO, VOCs, and hazardous air pollutants (HAPs) by at least 90 percent and fine particulate matter by at least 85 percent.
- Propulsion and generation engines on the ice management vessel and anchor handler will have SCR devices to reduce NOx emissions to under 1.6 g/kW-hr, and OxyCat devices to reduce CO by at least 80 percent, VOCs by at least 70 percent, and PM10 to under 0.25 g/kW-hr.
- ULSD (0.0015 percent sulfur by weight) fuel will be purchased for the *Discoverer* and for support vessels, which will reduce SO2 emissions by more than 97%.

## 2.4.13 Environmental Monitoring

During exploration activities, Shell will monitor for the following:

### Air Quality

Shell’s PSD air quality permit (R10OCS/PSD-AK-09-01) under the Clean Air Act requires monitoring of air emissions.

### Water Quality

The *Discoverer* will have waste monitoring equipment onboard and report discharges, as required by NPDES General Permit AKG-20-000 under the CWA.

### Marine Mammals

The *Discoverer* and support vessels will each have Marine Mammal Observers (MMOs) onboard to observe marine mammals and record all observations, as per the requirements of Shell's Marine Mammal Monitoring and Mitigation Plan (4MP) submitted in support of the NMFS IHA application.

### Other Environmental Conditions

As stated in Section 10.0 of the 2012 Shell Revised Chukchi Sea EP (excerpted below), Shell would also engage in other environmental monitoring activities during exploration drilling operations:

> In addition to monitoring of marine mammals, a comprehensive environmental monitoring program will be implemented during exploration drilling operations. A dedicated science vessel staffed by a team of physical and biological oceanographers will be responsible for assessing pre-, during, and post-drilling conditions in both biota and water and sediment quality. All drilling locations have been sampled at multiple times during the last three years to provide a baseline understanding of pre-existing conditions and interannual variability at these sites.
>
> Physical oceanography characteristics that will be monitored continuously at the each location throughout the drilling process include: surface wind direction and speed, ambient air temperature, current speed and direction throughout the water column, water temperature through the water column and salinity through the water column.
>
> Water chemistry and characteristics that will be monitored will include assessment of metals and organics through the water column at multiple fixed and random locations around the exploration drilling operation. These measurements will be made regularly before, during, and after drilling and will capture conditions during all significant phases of the exploration drilling operations and potential discharges. Physical characteristics of the water column will also be assessed including turbidity, temperature, and oxygen content in an effort to document and model plumes of released discharges.
>
> Biological observations will include assessments of benthos, epibenthos, zooplankton and phytoplankton, and fishes. In addition to characterization of the communities of these organisms at and near the drill site before, during, and after operations, samples of biota will be collected before and after operations for tissue analysis for metals and organics.
>
> Bird and mammal observations will be made from all surface operation vessels throughout the exploration drilling activities in accordance with the 4MP and Bird Strike Avoidance and Lighting Plan. (Shell, 2011a: Appendix C).

## 2.4.14 Adaptive Management

Consistent with DOI policies at 43 CFR 46.145 and 522 DM 1, BOEM and BSEE have developed standard operating procedures for implementing adaptive management of OCS activities. Under these procedures, BOEM and BSEE will conduct post-action reviews to evaluate whether monitoring, mitigation, and reporting requirements are meeting desired results, and will modify site-specific monitoring and mitigation requirements as needed.

# SECTION 3. Affected Environment

The following subsections summarize environmental conditions and resources found within areas that could be affected by the Proposed Action or other alternatives. Each summary focuses on information relevant to understanding potential environmental impacts. More detailed discussion of the marine, coastal, and human environment of the Chukchi Sea planning area is contained within the broader NEPA documents listed in Section 1.3 and incorporated into this Environmental Assessment (EA) by reference.

## 3.1 Meteorology

The North Slope of Alaska, adjacent to the Chukchi Sea, is a polar climate characterized by moderate winds, cold temperatures during the winter, cool temperatures in the summer, and little annual precipitation (Ahrens, 2009). The region is dominated by subfreezing temperatures for most of the year, and the Chukchi Sea is almost totally ice covered from early December to mid-May. During the winter, winds can be strong and prolonged, leading to extreme ice pressures and dangerous wind-chill conditions. A brief warm and snow-free season follows in June, July, and August. Summers over the Chukchi Sea are influenced by the Western pacific low-pressure system, which moves northeast along the Chukchi coastline causing cloudy skies and light precipitation (USDOI, BOEMRE, 2011a). During the summer, fog occurs frequently as warmer air moves over the colder water, which is sometimes covered with ice. Because of the fog, low visibility of one-half mile or less can occur, most commonly during June, July, and August. The following sections will provide a discussion of climate change in the Arctic, the expected weather conditions at the drill sites, and the expected ice conditions at the drill sites.

### 3.1.1 Climate Change

A thorough scientific examination of climate change in the Arctic is provided by the Inter-governmental Panel on Climate Change (IPCC, 2007) and the Arctic Climate Impact Assessment (ACIA, 2005). The two reviews offer the most comprehensive compilation of information available on climate change, agreeing that the Arctic is experiencing variations that are accelerating faster than previously realized (Karcher et al., 2010). Other research concurs the Arctic is undergoing a rapid transition, including surface warming (affecting cloudiness) and changes in the cryosphere, the frozen water part of the Earth system that includes sea ice (Matthes, Rinke, and Dethloff, 2009). A thorough discussion of climate change in the Arctic is also provided in the 2011 Final SEIS in Section III.A.2 (USDOI, BOEMRE, 2011a). There is a potential for climate change impacts to natural resources, and those impacts are considered in the individual evaluations provided in Section 4.0-Environmental Consequences, where relevant. A more thorough discussion of the science behind climate change and affects on the Arctic are provided in Appendix E.

Concurrent with climate change is a change in ocean chemistry known as ocean acidification. This phenomenon is described in the IPCC Fourth Assessment Report (Climate Change 2007), a 2005 synthesis report by members of the Royal Society of London (Raven et al., 2005), and an ongoing BOEM-funded study (Mathis, 2011). The greatest degree of ocean acidification worldwide is predicted to occur in the Arctic Ocean. This amplified scenario in the Arctic is due to the effects of increased freshwater input from melting snow and ice, and from increased $CO_2$ uptake by the sea as a result of ice retreat.

### 3.1.2 Expected Weather Conditions at the Drill Sites

The exploration plan proposes operations during the summer months from July through October. During these months in Wainwright, Alaska, the warmest month is July with an average high temperature of 49.5° Fahrenheit (F.). The average high temperature ranges from 49.5° F. in July to 22.7° F. in October; the average low temperature ranges from 35.8° F. in July to 11.8° F. in October.

By November, the average temperature is less than 10.0° F. Local annual precipitation is 6.52 inches, with most precipitation falling in July and August. With little precipitation in the winter, operators at the drilling site should expect the majority of annual precipitation to fall in the summer (up to 5.35 inches of precipitation).

The wind is influenced by the season in the Chukchi Sea. The average wind speed is 6-11 miles per hour (mph) and in the winter winds are generally from the northeast. Wind velocity is less predictable in the summer. When considering the average wind speeds and temperatures common to the North Slope, daily wind chills will likely be 15° F. to zero° F. by late October, dropping into the minus 10° F. to minus 15° F. range in the event of a late fall storm (NWS, 2009).

There are approximately 6 to 10 storm days each month in the Chukchi Sea, where a storm is defined by wind speeds of 34 mph or more. Some storms have been known to last 8 to 14 days. Occasional sudden storms can occur in the Chukchi Sea, where the lack of natural wind barriers results in unrestricted winds. These storms bring cold temperatures and occur most frequently between September and November. The combined effect of cold temperatures and high winds during storms makes the North Slope of Alaska a risk to persons exposed to outside conditions for even brief periods of time.

### 3.1.3 Expected Ice Conditions at the Drill Sites

This sea-ice description builds upon discussion in sections III.A.4 of the Sale 193 Final EIS and Sale 193 Final SEIS. Information from the Arctic Multiple-Sale Draft EIS, Sections 3.2.4.2 and 3.2.4.3 (USDOI, MMS, 2008) and the Shell EIA (Shell Gulf of Mexico Inc., 2011 – Appendix F) is also summarized and incorporated by reference. Salient points from these documents are summarized as follows. There are three general forms of sea ice in the project area (including the shorebase and areas where oil spill response could occur): (1) landfast ice, which is attached to the shore, is relatively immobile, and extends to variable distances offshore; (2) stamukhi ice, which is grounded and ridged ice; and (3) pack ice, which includes first-year and multiyear ice and moves under the influence of winds and currents.

Shell's proposed drilling activities are planned for the Arctic summer "open-water" season. The proposed drill sites are far seaward of the typical extent of landfast ice during the time of operations. From 1999-2007 the formation of fast ice generally commenced during the first two weeks in October (Weinzapel et al., 2011). Stamukhi ice is not anticipated in the project area at the time of operations. Pack ice could move into the project area during the time of operations due to wind or currents.

The start of on-site exploration activities would begin after July 1, which coincides with the retreat of the ice in most years (early June to late July). The duration of open water (less than 10% ice concentration) in the central Chukchi Sea has lengthened by up to four weeks over the past 30 years to a summer average of 17 weeks. However, the range of open water is variable from year to year and ice could be present at the proposed drill sites. High concentrations (>10%) of ice in early July may delay start of operations.

Generally the ice retreat starts in the southern Chukchi and advances northward. There can be significant differences in the timing of pack ice retreat and melting between years as shown in Table 11 (Weinzapel et al., 2011). It should be noted that the five lowest September sea ice extents have occurred in the last five years (2007-2011; NSIDC, 2011a).

Floating pack ice could approach established drilling operations. Shell's Ice Management Plan (Shell, 2011a, Appendix K, Section 9.0(b) would be implemented to change the direction of approaching ice, rather than ice breaking, to ensure safe operations at all times. Ice-management activities would also include keeping ice from forming or piling up at the drillship's hull. Thick winter sea ice begins to form on the surface of the Chukchi Sea as early as late October or as late as mid December. From 1996 through 2007, the onset of freeze-up (first appearance of new ice) in the

**Table 11. Sea Ice Free Conditions near the Burger Prospect from 1999 to 2011.**

| Year | Date Sea Ice Free | Year | Date Sea Ice Free |
|---|---|---|---|
| 1999 | August 31 | 2006 | September 30 |
| 2000 | August 15 | 2007 | July 30 |
| 2001 | August 5 | 2008 | August 11 |
| 2002 | August 12 | 2009 | July 10 |
| 2003 | July 7 | 2010 | July 8 |
| 2004 | June 15 | 2011 | June 6 |
| 2005 | June 21 | | |

Source: Weinzapel et al., (2011; 1999-2007) modified by BOEM (2008-2011).

vicinity of the previously drilled Burger Prospect occurred between early October and the third week of November. The offshore transition period from very open drift ice to 90% (or more) ice concentration is highly unpredictable, taking anywhere from one week to a month. Nearly complete ice cover occurred in the area offshore of Wainwright as early as October 22 and as late as December 11 (1996-2007) (Shell, 2011a).

The Arctic sea ice is undergoing rapid changes. There are reported changes in sea-ice extent, thickness, distribution, age, and melt duration. In general the sea-ice extent is becoming much less in the Arctic summer and slightly less in winter; overall, the decline in sea-ice extent is increasing (NSIDC, 2011 a, b). The thickness of Arctic ice is decreasing (Hass et al. 2010), the distribution of ice is changing, and its age is decreasing (Comiso, 2011). Melt duration is increasing. These factors lead to a decreasing perennial Arctic ice pack.

Additional information on Arctic sea ice trends, including information specific to the Chukchi Sea, is presented in Section 3.2.3 of Shell's EIA (Shell, 2011a: Appendix K) and in Section 3.4 of Shell's Chukchi Sea Regional ODPCP (Shell, 2011b).

## 3.2 Resources

### 3.2.1 Air Quality

This section describes the existing condition of air quality in northern Alaska, particularly over the land areas of the North Slope adjacent to the Chukchi Sea, and existing sources of air pollutants. A summary of the weather and climate conditions typical for the location of the Proposed Action is provided in Section 3.1. Also in this section is a discussion of the federal and state regulatory framework governing air quality and its relation to the Proposed Action and the project alternatives. Additional information regarding the air quality analysis is provided in Appendix D, Air Quality.

#### Air Quality on the Alaskan North Slope

The US Environmental Protection Agency (EPA) does not specify the air quality conditions of locations over the open sea; only landside geographical locations with homogeneous air quality characteristics are classified according to quality of the air. These geographic regions are referred to as air quality control regions (AQCR). Sources of emissions on the OCS that are within 25 miles of the State's three-geographical mile (gm) seaward boundary (a total of 28 miles) are subject to the local requirements of the Corresponding Onshore Area (COA), which would be the onshore area that is geographically closest to the OCS source (40 CFR 55(a). The proposed location of drilling on the Chukchi Sea OCS is beyond the 25-mile threshold, meaning no COA is designated for the project. The Nearest Onshore Area (NOA) is 64 miles from the proposed drilling site. The EPA has defined Alaska's North Slope to be within the Northern Alaska Intrastate Air Quality Control Region (NAI-AQCR9), which includes all the area of Alaska north of the Brooks Range (40 CFR Part 81.246), and is designated as a Class II area, meaning specific rules apply to the protection of air quality (18 AAC

Part 50.015). The EPA has classified the North Slope as a clean air resource (attainment) because pollutant concentrations in the area are well below the National Ambient Air Quality Standards (NAAQS) and the Alaska Ambient Air Quality Standards (AAAQS) (EPA, 2011a).

### Attainment Status

The EPA reports that the pollutant concentrations within the North Slope Borough from the very few existing sources of emissions are far below the NAAQS due to dispersion caused by nearly constant wind and low precipitation over the area (Serreze and Barrett, 2011). The wind is also the long-range transport mechanism of pollution from sources on the Eurasian continent during the winter and early spring.

### Existing Sources of Emissions on the North Slope

There are few industrial development areas on the North Slope to contribute to the budget of air emissions. The largest source of emissions is the Prudhoe Bay Oil Field, the largest oil field in North America, located far from the NOA on the shore of the Beaufort Sea, about 200 miles southeast (straight-line distance) from Barrow, Alaska and about 280 miles from Wainwright, Alaska. The closest community to the NOA would be Wainwright. Wainwright has a population of under 600 persons (U.S. Census Bureau, 2009) and there are few sources of emissions. In support of the oil and gas industry, the area would provide small vessel marine support for the Revised EP, such as shallow water landing craft for the occasional transport of supplies or crews between offshore vessels and the marine support shore base facilities on Wainwright. Air support for the exploratory drilling plan will be based at the Barrow airport, located about 80 miles (straight-line distance) northeast of Wainwright. Numerous flights of medium-range jet aircraft operate between Fairbanks and the Barrow airport to facilitate the workers' rotating schedules and for delivery of equipment and supplies. Implementation of the proposed exploration plan would require Shell to use the existing onshore facilities at Wainwright and Barrow, and no new construction is planned. Therefore, the only expected increase in onshore emissions associated with the proposed exploration would be the operation of helicopters and surface vehicles to transport personnel at Barrow.

### Arctic Haze

The Alaska Department of Environmental Conservation (ADEC) reports the Arctic atmosphere becomes contaminated with pollution through long-range transport in the winter months from emissions due to coal burning and metal smelting in Europe and Russia. Meteorological studies support the suggestion that about 95 percent of the pollution is coming from Europe and Russia propelled by winds associated with the seasonal Siberian high-pressure system (Serreze and Barrett, 2011). The phenomenon is referred to as Arctic haze, and consists of mostly sulfur oxides and soot, but includes both gaseous and aerosol components. The phenomenon usually begins in early winter and reaches a peak impact in March, after which time the haze dissipates. The haze particles are very lightweight, with a diameter usually in the range of 0.4-0.8 micrometers, so the particles may be suspended in the air for weeks, allowing light to scatter, which affects visibility. In the absence of Arctic haze, visibility in the area is greater than 160 statute miles. The EPA has determined the regional air quality over the North Slope continues to be better than the NAAQS, even with the seasonal occurrence of Arctic haze. Arctic haze would only be visible during the last stages of a summer drilling season, mostly likely in late October during the phenomenon's initial stages, and is not expected to interfere with exploration operations.

### Regulatory Overview

Elevated concentrations of pollution in the ambient air, which is outside air where the general public has access, have been shown to cause harm to human health and the natural environment (EPA, 2010a, January 9). As such, federal and state air agencies are obliged to develop plans, regulations, and guidelines to protect ambient air as a natural resource (EPA, 2010b). The following sections explore the various regulatory provisions established to protect air quality, particularly in the area of the North Slope and on the OCS in the Chukchi Sea.

### Clean Air Act

The Clean Air Act (CAA), including the 1990 Amendments, is the comprehensive law giving the EPA authority to clean up areas of polluted air in the United States. Section 328 of the CAA authorizes the EPA to regulate sources on the Alaskan OCS under the OCS Air Regulations (40 CFR Part 55). A thorough review of the CAA is provided in Appendix D.

### Federal OCS Air Regulations

Pursuant to CAA Section 328, the EPA establishes requirements to control air pollution from sources on the OCS, including Alaska. The requirements are published in the Code of Federal Regulations (CFR), Title 40, Part 55, and are referred to as the federal OCS Air Regulations (40 CFR Part 55). The federal OCS Air Regulations make a distinction between OCS sources located within 25 miles of the State's three-gm seaward boundary and sources located beyond the 25- mile threshold. The federal OCS Air Regulations provide an outline of the federal air quality requirements that apply at an OCS source relative to the 25-mile threshold, and describe the operating permit requirements.

### Alaska Air Quality Control Rules

Air quality management in Alaska is regulated by the ADEC. The ADEC is responsible for the control of sources of emissions in all parts of Alaska, including permitting requirements and mitigating measures to conserve the clean air resources that are enjoyed in many locations in Alaska. These mitigation measures and controls are summarized in the Alaska State Air Quality Control Plan (AQCP) (ADEC, 2008). Those portions of the AQCP that address federal air quality control requirements are submitted for EPA approval and become part of the federally-required Alaska State Implementation Plan (SIP). In addition, the AQCP contains state requirements and control measures that are not necessarily required by the EPA and are not included in the SIP. The entire AQCP is adopted by reference into the Alaska Administrative Code (AAC) (18 AAC 50), making the SIP an enforceable plan that outlines how the state will achieve and maintain the established state and federal air quality standards.

## 3.2.2 Water Quality

Water quality is a term used here to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose such as protection of fish, shellfish, or wildlife. Important water quality properties include temperature, salinity, density, dissolved oxygen, nutrients, organic carbon, chlorophyll, total suspended sediment, light transmissivity, trace metal concentrations, and hydrocarbon concentrations. All these properties are important in determining the distribution, movement and feeding grounds of marine biota. Because the water column interacts continuously with the seafloor surface sediments (e.g. deposition and suspension of particulate matter), these two aspects of overall water quality are tightly linked.

This discussion of water quality in the Chukchi Sea incorporates and summarizes information from the Sale 193 Final SEIS (USDOI BOEMRE, 2011a) and Sale 193 Final EIS (USDOI MMS, 2007a).

### Water Quality in the Northeastern Chukchi Sea

Water quality in the northeastern Chukchi Sea naturally varies throughout the year related to seasonal biological activity and naturally occurring processes, such as formation of surface ice, seasonal plankton blooms, naturally occurring hydrocarbon seeps, seasonal changes in turbidity due to terrestrial runoff, and localized upwelling of cold water. The rivers and streams that flow directly into the northeast Chukchi Sea contribute freshwater to the marine system, affecting salinity, temperature and other aspects of water quality (Table 17 in Section 3.2.5 presents the named waterways that directly flow into the northeasten Chukchi Sea between Point Hope and Barrow). River waters from the southern Chukchi coastline are carried north by the Alaska Coastal current and also influence the northern Chukchi nearshore environment.

Anthropogenic (human-generated) pollution in the northeastern Chukchi Sea is primarily related to aerosol transport and deposition of pollutants (AMAP, 1997, 2004); pollutant transport into the region by sea ice, biota and currents (Chernyak, Rice, and McConnell, 1996); discharges from international ship traffic (and consequent potential for marine invasive species); and effects from increasing carbon dioxide in the atmosphere. The potential for ocean acidification is a concern in the Chukchi Sea. As carbon dioxide increases in the atmosphere, the ocean absorbs more carbon dioxide. This increase in carbon dioxide in seawater forces an increase in the hydrogen ion concentration while lowering the pH and bioavailability of calcium carbonate over time.

Regional industrial impacts on water quality have been and are relatively low at this time. Five exploration wells were drilled in the Chukchi Sea between 1989 and 1991. Some trace metals, hydrocarbons, and other pollutants contributed by Bering Sea water or permitted discharges into the southern Chukchi Sea may move northwards towards the drilling area with the Alaska Coastal Current (USDOI, MMS, 2007: III-19).

### Water Quality in the Proposed Drilling Area

Specific to the Proposed Action area, Weingartner and Danielson (2010) examined the variations in winds, sea ice and water property distributions from July to October in 2008 and 2009. They found surface salinity ranges of 28.5 to 31.5 psu and surface temperature ranges of -1.0 to 5.0˚ C within 10 meters depth. Seasonal changes in water masses near the Burger Prospect were documented over the two seasons of research cruises (Table 12). They found that cold, salty winter water is replaced with warmer, fresher summer water, and that surface waters are warmer and fresher throughout the season when compared to bottom waters (Weingartner and Danielson, 2010).

**Table 12. Range of surface salinity and surface temperature (to 10 meters depth) in the area of proposed drilling in the northeast Chukchi Sea.**

| 2008 | | | 2009 | | |
|---|---|---|---|---|---|
| Date | Temperature (˚C) | Salinity | Date | Temperature (˚C) | Salinity |
| 3-12 August | -1 – 1.5 | 30.5-32 | 14 – 29 Aug | 0 - 7.5 | 29 – 30.5 |
| 18 Aug – 20 Sept | 1 - 3.5 | 28.5-31.5 | 5 – 19 Sept | 4.5 - 5 | 30 – 31.5 |
| 9 Sept – 9 Oct | 0 - 5 | 29.5-30.5 | 26 Sept – 10 Oct | 2 – 4 | 30-31 |

Source: Weingartner and Danielson (2010)

Trefry, Trocine and Cooper (2011) studied the distribution of 17 trace metals in sediments of the northeastern Chukchi Sea during open water seasons in 2009 and 2010. Assuming repeated re-suspension, these sediment concentrations would affect metal concentrations in the lower water column. They found anomalies at an old drill site in the Klondike lease area: 15 barium concentrations and one each of mercury, nickel and lead. The mercury, they concluded, originated from the cuttings brought up during drilling. Trefry, Trocine and Cooper (2011) determined that sediment concentrations of potentially toxic metals (silver, cadmium, mercury, lead and zinc) remained below sediment quality criteria developed by Long et al. (1995) throughout the study area, including at the old drill sites. More specifically, metal concentrations were below the Effects Low Range ELR and well below the Effects Median Range developed by Long et al. (1995) for a select number of metals in the sediments. Trefry, Trocine and Cooper (2011) suggest that sediment quality criteria be used cautiously, with an understanding of the limitations, and be used more as an indicator.

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Grebmeier and Cooper (2011) studied chlorophyll concentrations in the northeastern Chukchi Sea. They measured chlorophyll-a concentrations in the water column post-bloom, and found that most of the chlorophyll-a settled to sub-surface water and surface sediments. Higher chlorophyll-a values were found in surface sediments in the offshore waters of the northern Chukchi Sea (under Anadyr current water) compared to lower values in nearshore coastal water (influenced by Alaska Coastal current water). Total organic carbon (TOC) in surface sediments was highest in offshore waters of the northern Chukchi Sea and in the northeast section of the Chukchi Sea near upper Barrow Canyon, indicative of higher export production reaching the underlying sediments in these regions.

Neff et al. (2010) examined the chemical characterization of seafloor sediments in the region of the Burger and Klondike prospects in 2008. Their results showed that the concentration and distribution of hydrocarbons in surface sediments throughout the Burger and Klondike prospects were variable. They found higher concentrations in some surface and subsurface sediment samples at Klondike and Burger historic drill sites. With the exception of surface and subsurface sediments at the two historic drill sites, hydrocarbon concentrations at all the other sites within the prospects were within the range of background concentrations reported by other studies in Alaskan coastal and shelf sediments. There were higher concentrations of some types of hydrocarbons in the sediments at the Klondike drill site compared to the Burger drill site; the authors suppose the difference was related to the discovery of crude oil at the Klondike drill site (in 1989) versus the discovery of gas and condensate at the Burger drill site. The researchers also found elevated concentrations of barium in the upper 6 cm of sediments at the former 1989 drill sites compared to the rest of the sites sampled. Copper, mercury and lead were also higher than background in a few of the former drill site sediment samples.

### Water Quality Regulations

The water quality of the Chukchi Sea OCS is currently within the criteria for the protection of marine life according to CWA, Section 403, and no waterbodies within the Arctic region are identified as impaired (CWA, Section 303) by the State of Alaska (ADEC, 2011). EPA regulations at 40 CFR 125.121 define when marine discharges may cause an unreasonable degradation of the marine environment. This determination considers the following ten criteria (40 CFR 125.122):

- The quantities, composition, and potential for bioaccumulation or persistence of the pollutants to be discharged.
- The potential transport of such pollutants by biological, physical, or chemical processes.
- The composition and vulnerability of the biological communities that may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain.
- The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the lifecycle of an organism.
- The existence of special aquatic sites including, but not limited to, marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas, and coral reefs.
- The potential impacts on human health through direct and indirect pathways.
- Existing or potential recreational and commercial fishing, including finfishing and shellfishing.
- Any applicable requirements of an approved Coastal Zone Management Plan. (Note: The State of Alaska does not currently have an approved Coastal Zone Management Plan.)

- Such other factors relating to the effects of the discharge as may be appropriate.
- Marine water quality criteria developed pursuant to Section 304(a)(1).

### 3.2.3 Lower Trophic Levels

The affected environment of the lower trophic resources is discussed in detail in the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a: pp. 53-55) and is summarized below.

The Chukchi Sea shelf is among the largest and most productive of the world's continental shelves (Grebmeier et al., 2006). The high productivity of these waters has its origin in the northern Pacific currents that provide an upwelling of warm, nutrient-rich Pacific waters onto the wide expanse of the Bering Shelf and then travel northward (Pickart, et al., 2009). Each of these unique water masses contributes distinct sediment loads and assemblages of phytoplankton and zooplankton (Springer, McRoy, and Turco, 1989; Coyle, Chavtur, and Pinchuk, 1996). The waters of the Chukchi Sea are split into two major current flows that bifurcate into a path to the northwest into the Herald Canyon, and a path to the northeast across the Chukchi Sea and into the Beaufort Sea (Weingartner, et al., 2005; Pickart, et al., 2009). The continental shelf of the central Chukchi Sea is relatively shallow, with water depth averaging 50 meters. Sediment composition consists of high percentages of fine sand, silt and clay (Naidu, 1988; COMIDA, 2011). No known hotspots leading to unique marine mammal or pelagic bird feeding areas, or unique biological communities, exist directly within the Burger prospect or on the proposed exploratory drilling sites analyzed in this section. Hardrock communities are known to exist southwest of Wainwright near the Skull Cliffs region (Philips, et al., 1984).

The lower trophic organisms living in the Chukchi Sea consist of three diverse and abundant groups (Hopcroft, et al., 2008; Mathis, et al., 2009): the pelagic, epontic, and benthic communities.

**Pelagic Communities.** The pelagic communities consist of two major sub-groups, those that live on or near the surface (plankton) and those inhabiting the water column between the sea surface and benthic surface. The inhabitants of the pelagic realms between the surface and benthos are diverse and abundant, and form the basis for the high productivity of the area (Hopcroft, et al., 2008). Within Arctic waters, the combination of temperature, sea ice, and seasonal fluctuation in light regimes creates variation in the timing and extent of seasonal plankton blooms (Hopcroft, Kosobokova, and Pinchuk, 2009). Phytoplankton blooms (including zooplankton stocks) tend to occur in two separate events in early and late summer (generally July through August) with density and duration of blooms dependent upon weather conditions and nutrient fluxes (Kirchman, et al., 2009). The spatial distribution of phytoplankton and zooplankton communities in the Chukchi Sea has been frequently tied to the different water masses in the area. In 2008 and 2009, an oceanographic assessment of the plankton communities in the Klondike and Burger prospect areas of the Chukchi Sea was carried out by Hopcroft, Questel, and Clarke-Hopcroft, that included oceanographic and plankton data collections. These studies indicated that, despite the relative proximity of the two sites, there were statistical differences in the water masses and the plankton populations between them. Further, differences in water temperatures and spring bloom timing were also observed between the two sites (Hopcroft, Questel, and Clarke-Hopcroft, 2009, 2010).

**Epontic Communities.** The epontic organisms are the ice-dwellers that live on and within the multi-dimensional matrix of ice (Gradinger, Bluhm, and Iken, 2010). Primary production based on epontic organisms from melting ice contributes 4–26% to total primary production in seasonally ice-covered Arctic seas (Legendre et al., 1992). The mixing of nutrients and phytoplankton from the multiple watermasses creates the conditions for massive open-water plankton blooms that are further fed by ice algae and epontic organisms from the receding ice flows. This results in an excess within the pelagic column that cannot be utilized by the zooplankton (Grebmeier and Barry, 1991; Grebmeier, 2006), and a high benthic biomass as well (Feder, et al., 2005, 2007).

**Benthic Communities.** The benthic group consists of organisms living within the upper sedimentary matrix (infaunal organisms) and those living on or strongly associated with the benthic surface (epifaunal organisms). Benthic ecology studies done by Blanchard, Parris, and Nichols (2009, 2010) found that the benthic fauna of the Burger prospect area was diverse and very abundant. Average abundance, biomass, and diversity were higher at Burger than at nearby sites. No interannual differences occurred between 2008 and 2009 (Blanchard, Parris, and Nichols, 2009, 2010). The Chukchi Sea Offshore Monitoring in Drilling Area, Chemical And Benthos (COMIDA, 2011) monitoring was carried out in an area corresponding to the Chukchi Sea Lease Sale 193, including the Burger prospect site area. This work agreed with Blanchard, Parris, and Nichols (2008) in finding high diversity and biomass of invertebrate communities, including reports of high biomass of the snow crab (*Chionoecetes opilio*). Both studies found increases in biomass and diversity from south to north, and from west to east, within the lease areas of the Chukchi basin.

### 3.2.4 Fish

The three primary assemblages of Arctic fishes are marine fish, anadromous and migratory fish, and freshwater fish. The Alaskan Chukchi Sea and western Beaufort Sea support at least 98 fish species representing 23 families (Mecklenburg, Mecklenburg, and Thorsteinson, 2002).

Several important studies have contributed to the knowledge of the fish species that occur in the Chukchi Sea including: Norcross et al. (2010); Mecklenberg et al. (2007); Mecklenburg et al. (2002); Barber et al. (1997); Frost and Lowry (1983); Hopcroft, et al., (2008); Fechhelm et al. (1985); and Alverson and Wilimovsky (1966). A more detailed discussion of fish in the Chukchi Sea is presented in the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) and the Sale 193 Final EIS (USDOI, MMS, 2007a), portions of which are summarized and incorporated by referenced.

#### Marine Fish

The most common marine fishes (adult and juvenile) documented in various research cruises in the northeastern Chukchi Sea include: Arctic cod (*Boreogadus*); saffron cod (*Eleginus*); Bering flounder (*Hippoglossoides*); yellowfin sole (*Limanda*); sculpin species (families Cottidae and Hemitripteridae); sand lance (*Ammodytes*); capelin (*Mallotus*); eelpout species (family Zoarcidae); snailfish (Family Liparidae); alligator fish (Family Gasterosteidae) and prickleback species (Family Stichaeidae) (Table 13) .

The distribution of demersal marine fish in the northeastern Chukchi Sea was found to be a function of salinity, substrate type (sediment type and percent gravel) and bottom water temperature (Norcross et al., 2010; Barber et al., 1997; Mecklenburg et al., 2007).

Some Chukchi Sea marine fish species associate with drifting or fast ice to feed, hide, and spawn; these species are referred to as cryopelagic fishes. Most notable of the cryopelagic fish species in the northeastern Chukchi Sea is the Arctic cod which associates with ice in various life stages and seasons for shelter and as a forage habitat to feed on microorganisms on the underside of the ice. Under-ice amphipods are an important food source for Arctic cod (Lonne and Gulliksen, 1989; Gradinger and Bluhm, 2004). Rough, irregular textures of the underside-ice may provide preferred habitat for Arctic cod to avoid predators (Cross, 1982). Arctic cod are discussed in greater detail in the following section on Essential Fish Habitat (EFH).

NOAA has conducted nearshore fish sampling along the northern Chukchi sea coast (NOAA, 2011). Fish that were commonly captured over 15 sites were: staghorn sculpin, Arctic sculpin, saffron cod, sand lance, capelin, juvenile prickleback, and yellowfin sole.

Harvey et al. (2011) studied hydrocarbons in sediments and the possible toxicological effects on Arctic cod in the northeastern Chukchi Sea, including the area of the Burger and Klondike prospects. They used enzymatic activity and DNA damage to assess the possible effects. The results showed

**Table 13. Marine fish that commonly occur in the northeastern Chukchi Sea in the region of proposed drilling and support operations.**

| Common Name | Taxonomic Names |
|---|---|
| Arctic cod | *Boreogadus saida* |
| Saffron cod | *Eleginus gracilis* |
| Bering flounder | *Hippoglossoides robustus* |
| Yellowfin sole | *Limanda aspera* |
| Sculpin species | Family Cottidae |
| Sailfin sculpin species | Family Hemitripteridae |
| Pacific herring | *Clupea pallasii* |
| Sand lance | *Ammodytes hexapterus* |
| Capelin | *Mallotus villosus* |
| Eelpout species | Family Zoarcidae |
| Alaska plaice | *Pleuronectes quadrituberculatus* |
| Starry flounder | *Platichthys stellatus* |
| Snailfish | Family Liparidae |
| Alligator fish | Family Gasterosteidae |
| Prickleback species | Family Stichaeidae |

some significant differences between Arctic cod specimens examined from different stations; however, there were no overall differences between stations. All Arctic cod specimens showed low levels of oxidative stress and were comparable to baseline levels reported in previous studies.

Fox et al. (2011) sampled total mercury and monomethyl mercury in eight invertebrate species and in Arctic cod in the northeastern Chukchi Sea, including the area of the Burger and Klondike prospects. Total mercury concentrations in Arctic cod averaged 130+/- 24 ng/g (dry wt, fillets) and was best related to the mercury concentrations in the sediments. Monomethyl mercury concentrations averaged 122+/- 27.4 ng/g (dry wt, fillets). Total mercury and monomethyl mercury were found to biomagnify upwards in the trophic ladder. Zinc concentrations, used as the control, did not show biomagnification.

## Anadromous and Migratory Fish

Anadromous fish that spend part of their life at sea and return to spawn in rivers and streams along the Arctic coast include five species of Pacific salmon (*Oncorhynchus* spp.) (Table 14). Of these five species, pink salmon (*O. gorbuscha*) and chum salmon (*O. keta*) occur most commonly in the northern Chukchi environment. Juvenile pink and chum salmon were captured in substantial numbers in offshore surveys that extended as far north as Point Lay (approximately 40 miles south of the proposed drilling) during the autumn of 2007 (Moss, et al., 2009). Salmon are discussed further in the following section (Essential Fish Habitat), which includes a list of anadromous rivers and streams used by salmon between Point Hope and Barrow.

Other anadromous fish in the northern Chukchi region include rainbow smelt (*Osmerus*), Dolly Varden-sea-run (*Salvelinus*) and Arctic lamprey (*Lampetra*), which spend some of their life in the marine environment and return to freshwater to spawn (Table 14). Some fish species in the Chukchi Sea follow a coastwise migration from freshwater to freshwater but do not spend substantial periods in the marine environment (e.g. some species of cisco and whitefish, *Coregonus*). Several fish species such as capelin, sand lance, saffron cod, and some sculpin species are not considered anadromous or coastwise migratory fish, but they move from offshore to nearshore for spawning and rearing in nearshore habitats. For a more extensive list of Chukchi Sea fish species and their life history environments, refer to Appendix C of the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a).

**Table 14. Anadromous and migratory fish occurring in marine and coastal environments in the northeastern Chukchi Sea in the region of proposed drilling and support operations.**

| Common Name | Taxonomic Name |
|---|---|
| Pink salmon | *Oncorhynchus gorbuscha* |
| Chum salmon | *Oncorhynchus keta* |
| Coho salmon | *Oncorhynchus kitsutch* |
| Chinook salmon | *Oncorhynchus tshawtscha* |
| Dolly varden (sea-run) | *Salvelinus malma* |
| Rainbow smelt | *Osmerus mordax* |
| Arctic lamprey | *Lamptera camschatica* |
| Whitefish species | *Coregonus* sp. |
| Cisco species | *Coregonus* |

### Freshwater Fish

Fish that occur as freshwater residents in rivers, streams, and inlets draining to the northeastern Chukchi Sea include humpback whitefish, broad whitefish, sticklebacks, Dolly Varden, Arctic char, slimy sculpin, blackfish and Arctic grayling.

### Fish as Part of the Trophic System

Ringed seals, ribbon seals, spotted seals, beluga whales, and several seabird species depend heavily on various life stages of Arctic cod (Bradstreet, 1982; Bradstreet and Cross, 1982). Polar bears, which feed on ice seals, are indirectly supported by the seals' predation of Arctic cod and saffron cod. Fish in the northeastern Chukchi also play an important role as predator in the trophic system, feeding on many types of organisms, including epibenthic invertebrates, infaunal invertebrates, zooplankton, and the various life stages of the many fish species themselves.

## 3.2.5 Essential Fish Habitat

The Chukchi Sea contains designated Essential Fish Habitat (EFH) for eight species. EFH for seven of these species overlaps with the Burger Prospect. Information regarding EFH contained in the Sale 193 Final SEIS (BOEMRE, 2011a) Sale 193 Final EIS (MMS, 2007a) is summarized and incorporated where relevant here. In addition to this analysis, BOEM will provide a separate EFH assessment for NMFS to satisfy its consultation requirements.

The Fishery Management Plan for Fish Resources of the Arctic Management Area (Arctic FMP) was approved by the Secretary of Commerce in 2009. The Plan closed the U.S. Arctic Area to commercial fishing. The Arctic FMP does not regulate subsistence or personal-use harvests of any fish, shellfish, birds, or marine mammals (NPFMC, 2009). Based on the best scientific information available at the time of publication, the Arctic FMP identified three species as potential commercial target species and defined EFH for certain life stages of those species (Table 15).

**Table 15. Target species and life stage for which EFH has been described in the Arctic FMP for the Chukchi Sea.**

| Arctic Fishery Management Plan: EFH Species | Eggs EFH | Larvae EFH | Late Juvenile EFH | Adult EFH |
|---|---|---|---|---|
| Arctic cod (*Boreogadus saida*), | | | X | X |
| Saffron Cod (*Eleginus gracilis*) | | | X | X |

| | | | | |
|---|---|---|---|---|
| Opilio Crab (*Chionoecetes opilio*) | X | | X | X |

The following subsections provide descriptions of the three target species identified in the Arctic Fishery Management Plan. Figures depicting location of EFH for these species are provided in the Sale 193 Final SEIS (USDOI, BOEMRE, 2011). Ecosystem Component Species and the Salmon Fishery Management Plan are then discussed.

### Arctic Cod EFH

Arctic cod is widely distributed in the U.S. Arctic in the pelagic, demersal, and nearshore environments, depending on the time of year and the stage of their life history. The absolute numbers of Arctic cod and their biomass is one of the highest of any finfish in the region (Frost and Lowry, 1983). EFH is designated for adult and late juvenile Arctic cod. The general distribution areas for this life stage are located in pelagic and epipelagic waters from the nearshore to offshore areas along the entire shelf (0–200 m) and upper slope (200–500 m) throughout Arctic waters, and often associated with ice floes which may occur in deeper waters. The NPFMC has not determined EFH for eggs, larvae, and early juveniles (NPFMC, AFMP, 2009).

### Saffron Cod EFH

Saffron cod occurs in the Chukchi Sea primarily in nearshore waters. Saffron cod move seasonally from summertime feeding offshore to inshore for spawning. Juveniles remain in the shallow nearshore water throughout the year. Saffron cod enter coastal waters and tide-influenced riverine environments. Adults and juveniles forage on the epibenthos, opportunistically taking small crustaceans and fish (Froese and Pauly, 2010). Saffron cod are important in the diet of several seabirds (Piatt, et al., 1989), ringed seals, spotted seals and beluga whales (Frost and Lowry, 1984; Lowry, Frost, and Burns, 1980).

Saffron cod have been captured in several surveys in the Chukchi Sea. Barber, et al. (1997) caught a high abundance of saffron cod in a demersal fish survey during August and September in 1990 and 1991 at sampling sites in the Chukchi Sea from Point Hope north. In 2004, saffron cod were collected in the Chukchi Sea in depths from 34–51 m as part of the Russian-American Long-term Census of the Arctic (RUSALCA) (Mecklenburg, et al., 2007, Norcross, et al., 2009). These studies indicate that saffron cod are influenced by water temperature, salinity, and substrate type and are commonly found nearshore in warmer coastal waters.

EFH is designated for adult and late juvenile saffron cod. The general distribution area for this life stage is located in pelagic and epipelagic waters along the coastline, within nearshore bays, under ice along the inner (0–50 m) shelf throughout Arctic waters, and wherever there are substrates consisting of sand and gravel. The NPFMC has not determined EFH for eggs, larvae, and early juveniles (NPFMC, 2009).

### Opilio crab EFH

Opilio crab have been collected in various surveys over the past decades in the Chukchi Sea. A discussion of the current literature on the distribution, size, and density of opilio crab in the Chukchi Sea is presented in the Environmnental Assessment for the Arctic Fishery Management Plan (NMFS, 2009) and is incorporated by reference.

The benthic community in the Chukchi Sea is highly diverse and patchy. Adult opilio crab occur in the Chukchi Sea along the inner and middle shelf where benthic habitat consists mainly of mud. They have been collected at depths ranging up to 100 m and are commonly collected in the 25–40 m range. For EFH designation, the distribution of opilio crab eggs was inferred from the distribution of female opilio crab; EFH for opilio crab juveniles and pelagic larvae has not yet been designated. Opilio crab are important prey to several higher trophic species in the Chukchi Sea food web, including bearded seals.

EFH is designated for adult and late juvenile opilio crab. The general distribution area for this life stage is located in bottom habitats along the inner (0–50 m) and middle (50–100 m) shelf in Arctic waters south of Cape Lisburne, wherever there are substrates consisting mainly of mud. Essential fish habitat of snow crab eggs is inferred from the general distribution of egg-bearing female crabs. The NPFMC has not determined EFH for larvae and early juveniles (NPFMC, 2009). EFH designated for opilio crab is approximately 200 miles southeast of the proposed drilling site.

### Ecosystem Component Species

The Arctic FMP describes and maps eight ecosystem component species that "are thought to be, should conditions allow, commercially viable." Based on literature published from various fish surveys, it is likely that six of the ecosystem component species (yellowfin sole, Bering flounder, starry flounder, capelin, rainbow smelt, and Alaska plaice) (Table 16) occur in the vicinity of the proposed project (Norcross, et al. 2010; Mecklenburg, et al., 2007, Barber, et al., 1994, 1997; Frost and Lowry, 1983; Mecklenburg et al., 2002; Mecklenburg, Moller, and Steinke, 2011; Hopcroft, et al., 2008, Froese and Pauly, 2003). The other two ecosystem component species, flathead sole and blue king crab, generally occur south of Bering Strait, which is approximately 350 miles south of the proposed exploration drilling.

**Table 16. Ecosystem component species that occur in the region of the drilling prospect (habitat descriptions from the Arctic Fishery Management Plan (NPFMC, 2009)).**

| Ecosystem Component Species in the Action Area | Adult Habitat and Distribution | Adult Migration | Eggs, Larvae, Juveniles |
|---|---|---|---|
| Yellowfin sole (*Limanda aspera*) | Demersal in nearshore bays and continental shelf; inhabit sand, mud, gravel substrates. | Migrates between outer shelf (100-200m) and inner shelf (up to 50m) to feed and spawn. | Juveniles separate from adults and inhabit soft substrates to feed on infauna and to bury for protection. Larvae are planktonic, in shallow areas. Egg and larval distribution extents unknown. |
| Bering flounder (*Hippoglossoides robustus*) | Demersal in nearshore bays and along the inner shelf (0-50 m ) and middle shelf (50-100 m); inhabits substrates consisting of sand and mud. | Adults known to migrate between outer shelf (100-200 m) spawning grounds and inner shelf (0 - 50 m) feeding grounds. | Juveniles (<2 yrs) inhabit shallow areas separate from adults. Egg and larval distribution extents are unknown. |
| Starry flounder (*Platichthys stellatus*) | Demersal in nearshore bays, estuaries, river mouths and along the entire shelf (0-200 m). Inhabit substrates consisting of sand, mud, and gravel. | Adults are known to seasonally migrate between outer shelf (100-200 m) summer areas and inner shelf (0 to 50 m) winter areas. | Juveniles inhabit shallow estuarine areas. Egg and larval distribution extents are unknown. |
| Capelin (*Mallotus villosus*) | Distributed in epipelagic and epibenthic waters along the coastline, within nearshore bays and along the inner shelf (0-50 m). Spawn in sand and gravel substrates within intertidal and subtidal shallow areas. | Migrate from coastal waters to intertidal and shallow subtidal areas for spawning. | Egg and larval distribution is unknown. |
| Rainbow smelt (*Osmerus mordax*) | Distributed in epibenthic waters along the nearshore in areas mainly consisting of sandy gravel and cobbles; spawn in freshwater streams. | Migrate from nearshore to inshore for spawning. | Egg and larval distribution is unknown |
| Alaska plaice (*Pleuronectes quadrituberculatus)* | Located in the lower portion of the water column (demersal) within nearshore bays and along the entire shelf (0 to 200 m). Adults are found in areas consisting of sand, mud, and Gravel. | Adults are known to migrate in association with seasonal ice movements and from the shelf to shallower areas (<100 m) for spring spawning. | Larvae and eggs have been found in the late spring and early summer throughout the entire shelf (0 to 200 m). Egg and larval distribution extents are unknown. |

### Salmon Fishery Management Plan

The Salmon Fishery Management Plan for Coastal Alaska (Salmon FMP) was approved in 1990 (NPFMC, 1990), designating EFH for the five Pacific salmon species (including all life stages) that occur in Alaska: pink salmon (*Oncorhyncus gorbuscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), and king salmon (*O. tshawytscha*). Marine EFH for salmon includes all estuarine and marine areas used by Pacific salmon of Alaska origin, extending from the influence of tidewater and tidally submerged habitats out to the limit of the U.S. Exclusive Economic Zone (EEZ). Freshwater EFH for salmon includes all streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon as identified in the Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes (ADFG, 2011).

Pink and chum salmon are the most common of the five species documented in the Chukchi Sea (ADFG, 2011). In the marine environment, adult pink and chum salmon in Alaska seas can be found down to 200m (660 ft) depth. In the deeper waters of the continental slope and ocean basin, salmon occupy the upper water column. Moss, et al. (2009) trawled high densities of juvenile pink and chum salmon at or near the surface offshore in the Chukchi Sea in September, 2007

Alaska Department of Fish and Game maintains the Anadromous Waters Catalog of Alaska for the waterbodies and species documented to date (ADFG, 2011). Table 17 presents a list of the rivers and creeks used by salmon between Point Hope and Barrow based on the data in the Anadromous Waters Catalog. While the entrances to specific salmon-spawning streams are relatively easy to identify on the ground, other resource areas important to fish also exist along the Chukchi coastline, such as Kasegaluk Lagoon.

**Table 17. Anadromous rivers and creeks located between Point Hope and Barrow.**

| Anadromous Waters | Salmon Species | General Location of Waterbody |
|---|---|---|
| Kukpuk River | Pink salmon | Point Hope |
| Sulupoaktak Channel | Pink salmon | Point Hope |
| Ayugatak Creek | Pink salmon | Cape Lisburne |
| Pitmegea River | Chum salmon, Pink salmon | Cape Lisburne |
| Kuchiak Creek | Chum salmon, Coho salmon | Point Lay |
| Kukpowruk River | Chum salmon | Point Lay |
| Kokolik River | Chum salmon, Pink salmon | Point Lay |
| Utukok River | Chum salmon, Pink salmon | Between Point Lay and Point Hope |
| Kungok River | Pink salmon | Wainwright |
| Kuk River | Pink salmon | Wainwright |
| Kugrua River | Chum salmon, Pink salmon | Wainwright |
| Mikigeakiak River | Pink salmon | Wainwright |
| Ivisaruk River | Pink salmon | Wainwright |

Source: ADFG, 2011 - Anadromous Waters Catalog

Climate change in the Arctic affects the quality of EFH in several ways, including changes in seawater temperature and acidity, changes in extent and quality of sea ice habitat, and changes in freshwater discharge and nearshore salinities (Hopcroft, et al, 2008). These climate change factors could affect the range of EFH species, particularly of Pacific salmon extending north from the Bering Sea. Warming temperatures could affect characteristics of rivers and streams, such as the degree of ice cover in winter, basin runoff and stream flow regime.

### 3.2.6 Marine and Coastal Birds

Most birds occurring in the Chukchi Sea area are present on a seasonal basis. During spring migration, arrival times at coastal breeding areas usually coincide with the formation of leads. Many seabirds (such as murres) and sea ducks (such as common eiders and long-tailed ducks) will closely follow leads that typically form along the edge of the landfast ice. Migration times vary between species, but spring migration for most species takes place between late March and late May. Many birds that breed on the North Slope must migrate through the southern Chukchi Sea twice each year. Departure times from the Beaufort and Chukchi seas during postbreeding or fall migration vary between species and often by sex within the same species, but most marine birds will have moved out of the Chukchi Sea by late fall before the formation of sea ice.

The following sections summarize movement patterns, locations, and life history characteristics for several key avian groups. These groups include species that are the most numerous in the project area, are particularly sensitive to certain activities, have special legal status, and/or have common life history characteristics. The groups are Threatened and Endangered Birds, Cliff-Nesting Seabirds, Bering Sea Breeders and Summer Residents, High-Arctic Associated Seabirds, Tundra-Breeding Migrants, Waterfowl and Loons, Shorebirds, and Ravens and Raptors.

In 2007, MMS (now BOEM) prepared a Final EIS for oil and gas leasing and seismic surveying activities in the Chukchi Sea (USDOI, MMS, 2007a). This document was later updated in a Final Supplemental EIS (USDOI, BOEMRE, 2011a). These documents provided full descriptions of the most important marine and coastal bird species in the Chukchi Sea. These descriptions are summarized and updated below.

In July 2009, MMS (now BOEM) provided an updated Biological Evaluation (BE) to FWS for consultation on Steller's eider, spectacled eider, Kittlitz's murrelet, and yellow-billed loon (USDOI, MMS, 2009d). The FWS provided their Biological Opinion (BO) to BOEMRE (now BOEM) on September 3, 2009 (USDOI, FWS, 2009). Full descriptions of each species are provided in the 2009 BE and the 2009 BO. These descriptions are summarized and updated below.

#### Threatened and Endangered Birds

Threatened and endangered species in the Chukchi Sea include the spectacled eider (threatened) and Steller's eider (threatened). The Kittlitz's murrelet and the yellow-billed loon are candidate species under the ESA. All four species occur seasonally in the Chukchi Sea.

**Spectacled Eider.** Spectacled eider was listed as a threatened species under the ESA in May 1993 (58 FR 27474). The breeding population on the North Slope currently is the largest breeding population of spectacled eiders in North America. The North Slope population in the fall (October) is estimated to be 33,587 birds (Stehn et al., 2006). Spectacled eider density varies across the Alaskan Arctic Coastal Plain (ACP) (Larned, Stehn, and Platte, 2006).

Spectacled eiders make use of the spring lead system when they migrate from the wintering area. The spring lead system includes the Ledyard Bay Critical Habitat Unit and typically has represented the only open-water area along their path.

Spectacled eiders on the North Slope breed across the ACP, east to approximately the Canadian border. Once tundra nesting habitats are sufficiently melted to allow nesting (historically around June 10), most breeding pairs leave nearshore coastal areas to begin nesting—as many as a few thousand pairs might nest on the North Slope. Spectacled eider nesting density on the ACP is variable, ranging from 0 to 0.95 nests per square kilometer (Larned, Stehn, and Platte, 2006). The estimated nesting density in 2009 was 0.37 birds per square kilometer (Larned, Stehn, and Platte, 2010).

Male spectacled eiders leave the nesting area at the onset of incubation and seek open waters of the Chukchi and Beaufort seas until they move to molting areas in the Chukchi Sea or Russia. Many postbreeding male spectacled eiders slowly begin to converge in offshore aggregations in Ledyard Bay starting in July and begin a flightless molt that lasts several weeks. Males that breed on the ACP (but return to molting areas in Russia) likely make limited use of Ledyard Bay and other coastal areas of the Beaufort or Chukchi seas on their westward migration. Some eiders crossing to Russia may take routes roughly west of Barrow (Sexson, Peterson, and Powell, 2010; Sexson, 2011) and an individual eider was observed during the early fall near the Klondike Prospect during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

Female spectacled eiders begin to move to coastal areas at the end of their nesting effort. Females whose nests fail early on go to the coast and may linger in nearshore areas. Female spectacled eiders also use Ledyard Bay for flightless molt lasting a few weeks. Spectacled eider females and hatch-year birds are the last to arrive at Ledyard Bay around the end of the first week of September.

The Ledyard Bay area was designated critical habitat for the spectacled eider in 2001 (66 FR 9145). The critical habitat area includes the waters of Ledyard Bay within about 74 km (40 nmi) from shore, excluding waters <1.85 km (~1 nmi) from shore. The Ledyard Bay Critical Habitat Unit (LBCHU) is an important molting area for North Slope-breeding spectacled eiders in the summer (males) and fall (breeding females) (Sexson, 2010, 2011). The molt is an energetically demanding period, and eiders are believed to use LBCHU for molting because of a combination of environmental conditions, abundance and accessibility of prey organisms, and low level of disturbance and predation. Overall, many spectacled eiders remain in LBCHU until forced out by sea ice (typically late October through mid-November). Following the molt, spectacled eiders move to their wintering area south of St. Lawrence Island in the Bering Sea.

**Steller's Eider.** The Alaska breeding population of Steller's eider is listed as a threatened species under the ESA. It is the least-abundant eider in Alaska, representing less than 5% of the worldwide breeding population. Over 95% of the Alaskan breeding Steller's eiders occur on the Arctic Coastal Plain, with a small nesting population centered on Barrow. The ACP nesting population is estimated to be 576 (Stehn and Platte, 2009).

Steller's eiders are paired within flocks when they arrive on the ACP, typically from early to mid-June. They often nest on coastal wetland tundra, but some nest near shallow ponds or lakes well inland; the greatest breeding densities were found near Barrow, although they do not breed every year when present. The calculated average nesting density across the North Slope during 2002–2006 was 0.0045 birds/$km^2$ (USDOI, FWS, 2007).

Paired male Steller's eiders depart the North Slope after the nest is initiated in mid- to late June. Female eiders and their young-of-the-year typically depart the North Slope from late September to early October. Unlike spectacled eiders, Steller's eiders do not molt in the Chukchi Sea. During molt migration, Alaskan breeding Steller's eiders stop and rest in areas of the Alaska Chukchi Sea, often in nearshore waters (within 2 km or 1 nmi of shore) near Ledyard Bay and Icy Cape. There is less use at more northerly locations near Wainwright and Peard Bay. More males than females migrate from Alaska to areas along the coast of Chukotka, while males that do not go to Chukotka spend more time on the Alaska Chukchi Sea coast.

Although Steller's eiders may occur in nearshore waters of the Chukchi Sea, the total numbers probably are low given the small numbers that breed on the North Slope. No Steller's eiders were observed at the Burger prospect during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Kittlitz's Murrelet.** The Kittlitz's murrelet is listed as a candidate species (Listing Priority Number 8) throughout Alaska under the ESA. This species nests as far north as Cape Beaufort (100 km northeast of Cape Lisburne) in the Amatusuk Hills. These birds are solitary nesters and extensive survey efforts are required to determine local abundance. Breeding along the Arctic Coastal Plain is unlikely due to lack of suitable habitat.

Murrelet foraging areas occur in the Chukchi Sea (Day, Gall, and Pritchard, 2011). Kittlitz's murrelets have been observed on an infrequent basis in the Chukchi Sea as far north and east as Point Barrow. Kittlitz's murrelets have not been regularly observed at sea, which suggests there is a great deal of annual variation in their occurrence in the Chukchi Sea. Small numbers of Kittlitz's murrelets were recorded during late fall seabird surveys in the Klondike and Burger Prospect areas in 2009, but none were observed in 2008 (Gall and Day, 2010).

**Yellow-billed Loon.** On March 25, 2009, the yellow-billed loon was designated a candidate species (Listing Priority Number 8) throughout its range under the ESA (74 FR 12932). Yellow-billed loons typically nest near large, deep, tundra lakes where they nest on low islands or near the edges of lakes to avoid terrestrial predators. In total, there are fewer than 5,000 yellow-billed loons on the Arctic coast breeding grounds and near shore marine habitat (Earnst et al., 2005). There may be approximately 1,500 yellow-billed loons, presumably non-breeding adults and immatures, in near shore marine waters or in large rivers during the breeding season. Breeding yellow-billed loons typically remain on their lakes until young are fledged.

Most yellow-billed loons from the ACP have moved into nearshore coastal waters by September. In addition, approximately 8,000 yellow-billed loons from the Canadian Arctic travel across the Chukchi Sea during spring and fall migration between Canada and wintering grounds in eastern Asia (Schmutz et al., 2010). Most loons stay very close to shore during fall migration until they reach the Lisburne Peninsula, where they head farther out to sea towards the Bering Strait (Rizzolo and Schmutz, 2010). Yellow-billed loons were observed at the Burger Prospect during seabird surveys in 2008 and 2009 (Gall and Day, 2010). Most sightings of yellow-billed loons represented low numbers of birds during the survey period; however, 24 were observed during the early fall period in 2009. No yellow-billed loons were observed during seabird surveys in the Chukchi Sea in late August and early September 2011 (Kuletz, 2011b). Low numbers, patchy distributions, and specific habitat requirements may make yellow-billed loons more susceptible to environmental perturbations such as disturbance, habitat alterations, and oil spills than species that are more abundant, widely distributed, and able to exploit a greater diversity of habitats.

### Cliff-Nesting Seabirds

**Common murres and thick-billed murres.** Common murres and thick-billed murres breed as far north as Cape Lisburne and farther south at Cape Thompson. The Cape Lisburne colony is estimated to support about 400,000–500,000 murres (Dragoo, Schneeweis, and Kuehn, 2011). Murres are primarily piscivorous and rely on dispersed schools of offshore fish. Murre foraging areas from the two largest colonies overlap in an offshore area north of Cape Lisburne. In the fall, adult males remain with their hatch-year offspring and undergo a flightless molt in offshore molting areas north of the Bering Strait. Flightless individuals are not capable of undertaking large scale movements to other areas and tend to move south with prevailing currents.

Most observations of common and thick-billed murres totaled fewer than 100 during any survey period at the Burger Prospect during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Horned puffin and tufted puffin.** The horned puffin and the tufted puffin are found in the Chukchi Sea area, with horned puffins restricted to cliff habitats like Cape Lisburne. Horned puffins are primarily piscivorous, rely on dispersed schools of offshore fish, and have been reported to forage in excess of 100 km offshore of breeding colonies. Tufted puffins breed at cliff colonies, but can also nest on suitable beach habitats by digging burrows or hiding under large pieces of driftwood or debris. Fewer than 10 horned or tufted puffins were observed during any survey period at the Burger Prospect during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Black-legged kittiwake.** Breeding colonies of the black-legged kittiwake in the Chukchi Sea (Cape Thompson and Cape Lisburne) are at the northern limit of their breeding range in Alaska. There are about 20,000-30,000 black-legged kittiwakes breeding at the Cape Lisburne colony (Dragoo, Schneeweis, and Kuehn, 2011). Divoky (1987) reported about 400,000 black-legged kittiwakes from mid-July until late September in pelagic areas of the Chukchi Sea. Flocks totaling in the low hundreds were observed during the early fall around the Klondike and Burger prospects during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

### Bering Sea Breeders and Summer Residents

**Northern fulmar.** The northern fulmar does not breed along the Chukchi Sea coast, and those observed in this area during the spring and summer are nonbreeders or failed breeders from southern areas. Divoky (1987) estimated 45,000 northern fulmars in pelagic waters of the southern Chukchi Sea during late August to mid-September. Flocks totaling in the low hundreds were observed during the late summer and early fall around the Klondike and Burger prospects during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Short-tailed shearwater.** The short-tailed shearwater in the Chukchi Sea are most common in the southern portion, and are routinely found in the exploration program area from late August to late September. At northern latitudes, short-tailed shearwaters likely forage on dense patches of euphausiids and amphipods. Gall and Day (2010) suggested that the shearwaters can rapidly respond to changes in oceanic conditions and exploit food resources when and where they are available. For example, Kuletz (2011a) reported a single flock numbering over 15,000 short-tailed shearwaters in the western Beaufort Sea in late August–early September, 2011. Kuletz (2011b) reported over 4,000 shearwaters during a seabird survey in the Chukchi Sea in late August – early September 2011 (the most abundant species reported), with many flocks numbering between 150–300 birds. Similarly, flocks totaling in the low hundreds were observed during the early fall around the Klondike and Burger prospects during seabird surveys in 2008 and 2009 (Gall and Day, 2010); however, during the early fall period in 2009, almost 12,000 short-tailed shearwaters were observed near the Klondike Prospect.

**Auklets.** Three species of auklets (parakeet, least, and crested) breed as far north as the Bering Strait, but move into the Chukchi Sea from late August into early October. Kuletz (2011b) reported thousands of auklets during a seabird survey in the Chukchi Sea in late August – early September 2011, with all but a few least auklets south of Point Hope and numerous flocks of crested auklets north of Point Hope. Crested auklets were the most numerous alcid observed by Gall and Day (2010) during seabird surveys of the Klondike and Burger prospects in 2008 and 2009. Over 5,000 crested auklets were observed during the early fall at the Burger Prospect in 2009, with numbers in the thousands consistently reported during other survey periods that year. Crested auklet counts did not exceed 1,000 birds during any survey period in 2008. As with shearwaters, Gall and Day (2010) suggested that the auklets rapidly respond to changes in oceanic conditions and exploit food resources when and where they are available. Small flocks of least auklets were also observed during the Gall and Day (2010) surveys, numbering no more than 260 during any particular survey period. Parakeet auklets were seldom observed by Gall and Day (2010).

### High Arctic-Associated Seabirds

**Black guillemot.** Black guillemot breed along the Chukchi Sea from Cape Thompson northward. Despite the relatively small breeding population in Alaska (the Chukchi and Beaufort seas have a combined total of fewer than 2,000 nesting birds), the post-breeding population of guillemots from the U.S. and Russia is estimated to be around 70,000 in pelagic areas of the Chukchi Sea. Black guillemots remain closely associated with sea ice throughout their lifetime, where they feed extensively on Arctic cod. Small numbers of black guillemot were observed during seabird surveys around the Klondike and Burger prospects in 2008, but none were counted in 2009 (Gall and Day, 2010).

**Ross' gull.** Ross' gulls may be encountered near Point Barrow. Many migrate south through the Chukchi Sea in the late fall and pass through the Bering Strait to winter in the Bering Sea. The Ross' gull was only observed during the late fall period at the Burger Prospect during seabird surveys in 2008 and 2009 (Gall and Day 2010). The numbers were 127 in 2008 and 48 in 2009.

**Ivory gull.** Ivory gulls are closely associated with the ice edge throughout their lifecycle and small numbers migrate through in fall to wintering areas in the northern Bering Sea. The ivory gull is uncommon to rare in pelagic waters of the Chukchi Sea during summer. Two ivory gulls were observed in the late fall at the Burger Prospect during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Arctic tern.** Arctic terns nest near lakes of the ACP. Aerial surveys along coastal habitats of the entire ACP typically observe fewer than 1,500 birds, with most of these along the mainland areas along the Chukchi Sea (Dau and Bollinger, 2009). Arctic terns are rare in the pelagic waters of the Chukchi Sea. Small numbers were occasionally observed during seabird surveys at the Klondike and Burger prospects in 2008 and 2009 (Gall and Day, 2010).

### Tundra-Breeding Migrants

**Jaegers.** The three species of jaegers (pomarine, parasitic, and long-tailed) are common in nearshore areas of the Chukchi Sea in summer until late September, when they move south to the Bering Sea. Jaegers are dispersed throughout pelagic areas of the Chukchi Sea, with no obvious high concentration areas. Small numbers of all three species were occasionally observed during seabird surveys at the Klondike and Burger prospects in 2008 and 2009 (Gall and Day, 2010).

**Glaucous gull.** Glaucous gulls are most common in the Chukchi Sea from late July to late September within 70 km of shore between Icy Cape and Barrow. Most glaucous gulls in the Chukchi Sea area breed inland near freshwater, but some breed at coastal seabird colonies. Glaucous gulls typically occur in low densities in the Chukchi Sea, but commonly congregate at food sources. Small flocks of glaucous gulls were observed during the Gall and Day (2010) surveys in 2008 and 2009, numbering no more than 70 during any particular survey period.

### Waterfowl and Loons

**Loons.** Pacific loons are the most common loon species nesting and migrating along the Chukchi Sea coast. Red-throated loons are less common and nest on smaller ponds than Pacific loons. In spring, loons typically migrate along coastal routes, although some may use inland routes. Most of the postbreeding loon migration takes place in September. Most loons stay very close to shore during fall migration until they reach the Lisburne Peninsula, where they head farther out to sea towards the Bering Strait (Rizzollo and Schmutz, 2010). Observations of Pacific loons were most numerous during the early fall period at the Burger Prospect, when 181 were observed during seabird surveys in 2008 and 2009 (Gall and Day, 2010). In contrast, only one red-throated loon was observed (early fall at the Burger Prospect).

**Long-tailed duck.** The long-tailed duck is a common species in the Chukchi Sea after the first week of September until late October. Many long-tailed ducks molt in Kasegaluk Lagoon and Peard Bay on the Chukchi Sea coast. Molting long-tailed ducks tend to stay in or near the lagoons, feeding heavily in passes between barrier islands. Aerial surveys along coastal habitats of the entire ACP typically observe fewer than 7,500 long-tailed ducks, with about two-thirds of these associated with mainland habitats (Dau and Bollinger, 2009). Kasegaluk Lagoon and Peard Bay are important locations during molting and migration.

Fewer than 70 long-tailed ducks were observed during any survey period at the Burger Prospect during seabird surveys in 2008 and 2009 and most survey periods observed no long-tailed ducks (Gall and Day, 2010).

**Common eider.** The common eider typically migrates during spring along the Chukchi Sea coast using offshore open-water leads. Common eiders nest on barrier islands or spits along the Chukchi Sea coast. Aerial surveys along coastal habitats of the entire ACP typically observe fewer than 3,000 brant, with about half of these observed in the mainland areas along the Chukchi Sea (Dau and Bollinger, 2009)

Beginning in late June, postbreeding male common eiders begin moving towards molting areas in the Chukchi Sea; by late August, most common eiders in the Chukchi Sea are molting males. Most breeding female common eiders and hatch-year birds begin to migrate to molt locations in late August and September. Common molt areas in the Chukchi Sea are near Point Lay, Icy Cape, and Cape Lisburne. Kasegaluk Lagoon and Peard Bay also are important locations for molting and during migration. Hundreds of thousands of common eiders move through the Chukchi Sea during their migration to breeding grounds in eastern Canada.

After the molt is completed, some common eiders move offshore into pelagic waters, but most eiders remain close to shore. Five common eiders were observed in the early fall at the Burger Prospect during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**King eider.** The location and timing of offshore leads along the Chukchi Sea is a major factor determining routes and timing of king eider migration. Most king eiders begin to migrate through the Chukchi Sea, including Ledyard Bay, in mid-May. Many post-breeding male king eiders move to staging areas along the Chukchi Sea in mid- to late July. The typical staging time in Ledyard Bay was 17–24 days and Ledyard Bay may be a critical stopover area for foraging and resting during spring migration (Oppel, Dickson, and Powell, 2009). Peard Bay is also particularly important to molting and migrating king eiders. Hundreds of thousands of king eiders move through the Chukchi Sea during their migration to and from breeding grounds in eastern Canada.

No more than two king eiders were observed during any seabird survey period in 2008 at the Klondike and Burger prospects and no king eiders were observed in 2009 (Gall and Day, 2010).

**Brant.** Many brant migrate along the west coast of Alaska en route to breeding areas on the North Slope or the Canadian High Arctic. Brant typically nest on offshore spits, barrier islands, or on islands formed in large river deltas. Aerial surveys along coastal habitats of the entire ACP typically observe fewer than 2,500 brant, with about half of these observed in the mainland areas along the Chukchi Sea (Dau and Bollinger, 2009). Kasegaluk Lagoon is an important stopover location during postbreeding migration.

No brant were observed during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Greater white-fronted goose.** The greater white-fronted goose breeds along the Chukchi Sea coast, typically within 30 km of the coast. Most greater white-fronted geese reach Alaska via overland routes. Several thousand can be observed at a time in Kasegaluk Lagoon, with migration peak in the first week of June and the last week of August. No greater white-fronted geese were observed during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Lesser Snow Goose.** There are very few lesser snow geese nesting in Alaska. This species nests on an island in the Kukpowruk River delta (about 60 km south of Point Lay) in the southern portion of Kasegaluk Lagoon, one of two consistently used nesting colonies for lesser snow geese.

No lesser snow geese were observed during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Tundra swans.** Tundra swans have been observed in Kasegaluk Lagoon with flightless young-of-the-year birds indicating that tundra swans breed there. No swans were observed during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

### Shorebirds

Although many shorebirds breed on tundra, they also rely on coastal areas such as beaches, barrier islands, lagoons, and mudflats for some portion of their lifecycle. These coastal areas are especially important habitats where shorebirds replenish energy reserves after breeding and prior to southward migration. The most common shorebird species breeding on the Arctic Coastal Plain include dunlin, semipalmated sandpiper, pectoral sandpiper, and red phalarope. Many shorebirds leaving the Beaufort Sea move west along the Chukchi Sea coast. Large numbers of shorebirds move west along the Chukchi Sea coast, stopping at high-productivity shoreline sites to replenish energy reserves and rest.

Other than phalaropes, described below, few shorebirds were observed at the Burger or Klondike prospects during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

**Phalaropes.** Both red and red-necked phalaropes are present in the Chukchi Sea during the open-water periods. Phalaropes are common in pelagic waters as well as within a few meters of shore, where their distribution typically is tied to zooplankton abundance. Due to their reliance on zooplankton, their distribution is patchy and variable; however, because they are tied to a moving prey source they may be encountered throughout the Chukchi Sea in varying concentrations. Phalaropes were the most abundant shorebird species observed during seabird surveys at the Klondike and Burger prospects in 2008 and 2009, with fewer than 300 observed during any one survey period (Gall and Day, 2010).

Phalaropes are one of the most abundant species groups of shorebirds that use Kasegaluk Lagoon and Peard Bay, where they stage or stop over in nearshore marine and lacustrine waters.

**Dunlin.** Two subspecies of Dunlin breed in Alaska. Dunlins are another of the most abundant species of shorebirds that use Kasegaluk Lagoon, where they stage or stop over in silt tidal flats and salt-grass meadows. No dunlins were observed during seabird surveys in 2008 and 2009 (Gall and Day, 2010).

### Raptors and Ravens

A variety of raptors and corvids may be present in the coastal zone along the Chukchi Sea coast. On the North Slope, raptors typically are more common within 20 km of the Brooks Range foothills and population densities are lower near the coast, especially during the breeding season. Snowy owls are the raptor most commonly encountered near coastal areas. Raptors and ravens seldom interact with the marine environment. One wayward short-eared owl was observed during the late summer period at the Burger Prospect by Gall and Day (2010) during seabird surveys in 2009.

## 3.2.7 Marine Mammals

Marine mammals are protected under the MMPA. Requirements of this Act generally prohibit the take by injury or harassment of marine mammals. More detailed information on distribution, life history parameters, and other relevant background can be found in the Sale 193 Final EIS (USDOI, MMS, 2007a) and Sale 193 Final SEIS (USDOI, BOEMRE, 2011a). Relevant new information and site specific information is presented here.

### Seals

Observations of seals in the vicinity of the Burger Prospect have been reported in several surveys over the past 20 years. While these surveys use different methods and occurred under different circumstances, when taken together they can help to illustrate the use of the area by seals. Results of these survey reports are given in Table 18. Other information on the affected environment for seals is described below for each species.

**Table 18. Numbers of individuals of seal species sighted by vessel-based and aircraft-based surveys in the vicinity of the Proposed Action, and the northeastern Chukchi Sea.**

| | Number of individuals reported by eight surveys | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species Observed | Brueggeman et al. 1991a – Popcorn, Burger, and Crackerjack Prospects 1990 walrus monitoring | Brueggeman et al. 1992a – Crackerjack and Diamond Prospects 1991 | Brueggeman et al. 2010 – Klondike and Burger Prospects 2009 | Brueggeman et al. 2009 – Klondike and Burger Prospects, pipeline route 2008 | Reiser et al. 2010 – Burger, Snickers, Ulu, Caramel, and Honeyguide prospects 2009 | Blees et al. 2010 – Seismic Survey NE Chukchi Sea 2010 | Clarke et al. 2011c – COMIDA Final Report;:2008-2010 NE Chukchi Aerial Surveys | Haley et al. 2010 in Funk et al. 2010 – Chukchi Sea Vessel-Based Monitoring Program, NE Chukchi Sea 2006-2008 |
| **Bearded Seal** | 79 | 3152 | 33 | 39 | 12 | 128 | 3-140 | 57-261 |
| **Ribbon Seal** | 1 | ** | ** | 1 | ** | 1 | ** | 1 |
| **Ringed Seal** | 146 | 668 | 18 | 6 | 29 | 35 | ** | 102-587 |
| **Ringed/Spotted Seal** | ** | ** | 69 | 53 | ** | ** | ** | ** |
| **Spotted Seal** | 4 | ** | 15 | 31 | ** | 5 | ** | 26-191 |
| **Steller Sea Lion** | ** | ** | ** | ** | ** | ** | ** | 1 |
| **Unidentified Seal** | ** | 660 | 44 | 84 | 25 | 161 | ** | 151-911 |
| **Unidentified Pinniped** | 93 | 0 | 10 | 3 | 5 | 56 | 33-703 | 19-34 |

**Bearded Seals.** The bearded seal (*Erignathus barbatus*) is the largest of the northern seals (Kelly, 1988) and is largely ice-associated. Bearded seals stay mostly within the mobile pack ice, concentrating around its edge (Smith and Stirling, 1975) where they forage primarily on benthic organisms. Because of their epibenthic feeding habits, bearded seals are limited to feeding in water depths of 426 ft (130 m) or less (Nelson, Burns, and Frost, 1984). Surveys from 1990 to present have noted that bearded seals may occur near the proposed drill sites in variable numbers from year to year (Table 18).

Allen and Angliss (2011) reported there is no reliable population estimate for the bearded seal population in the Bering, Chukchi, and Beaufort seas, however, Cameron et al. (2010) estimated 155,000 bearded seals in the Beringian Distinct Population Segment (DPS) (Bering-Chukchi-Beaufort Sea subpopulation), about 27,000 of which are year long residents in the Chukchi Sea. Cameron et al. (2010) reported the population density of bearded seals in the Chukchi Sea to average 0.07 and 0.14 bearded seals/km$^2$ based on coastal aerial surveys flown between Barrow and Shishmaref, Alaska (Bengtson et al., 2005). The population data provide in Cameron et al. (2010) allows for a well informed effects analysis to be conducted. In December 2010, NMFS issued proposed rules to list bearded seals as threatened under the ESA.

**Ringed Seals.** Ringed seals are the most numerous and widely distributed of the northern seals and occur in all Arctic and sub-Arctic seas where seasonal or permanent ice is present (Kelly, 1988). The ringed seal (*Phoca hispida*) population in the Bering-Chukchi-Beaufort Seas has been estimated to number at least 1 million seals (Kelly et al. 2010). Of this population, some are residents in the Chukchi Sea while others are residents in the Beaufort Sea or seasonal migrants that winter in the Bering Sea, and summer in the Chukchi or Beaufort seas. Surveys from 1990 to the present have noted that ringed seals may occur near the proposed drill sites in variable numbers from year to year (Table 18).

During summer, ringed seals are found dispersed throughout open-water, though in some locales they may frequent coastal areas. They are opportunistic feeders, consuming a wide variety of pelagic and epibenthic organisms. Arctic cod are their primary prey during the winter months (November to April), but in late spring and summer their diet shifts to marine crustaceans, such as gammarid and hyperiid amphipods, shrimp, euphausiids, mysids, and isopods (Lowry et al., 1980; Frost and Lowry, 1984). It is believed that they typically seek out areas where food items are plentiful during the open-water season and their population distribution shifts accordingly.

NMFS has formulated a minimum population estimate of ringed seals in the eastern Chukchi Sea at 249,000 (Allen and Angliss, 2011). In December 2010, NMFS issued proposed rules to list ringed seals as threatened under the ESA.

**Ribbon Seals.** Ribbon seals are distributed in pelagic waters across the northern North Pacific Ocean and adjacent Arctic and sub-Arctic waters (Boveng et al., 2008). Surveys from 1990 to the present have noted that ribbon seals may occur near the proposed drill sites in variable numbers from year to year (Table 18). This species spends most of the year in pelagic waters near the shelf slope feeding on fishes and squid, hauling out on ice to whelp, breed, and molt in the spring and early summer. The more important whelping, reproduction, and molting areas occur in a 150 km band starting at the southern edge of the ice front and extending north, and usually in waters <200 m deep but near the shelf slope, mostly south of the Bering Strait (Boveng et al. 2008). Ribbon seals eat a variety of crustaceans (e.g., shrimps, mysiids, and crabs) and squid, but their main prey is fish. Fish species include walleye pollock, Arctic and saffron cod, eelpout, capelin, Greenland halibut, pricklebacks, herring and Sandlance (Dehn et al. 2007; Nelson and Griese 2008).

Although there is no reliable population estimate for the Alaskan ribbon seal stock (Allen and Angliss, 2011), Burns (1981) estimated between 90,000 and 100,000 ribbon seals inhabit the Bering Sea. Numbers using the Chukchi Sea are expected to be lower since most ribbon seals are believed to spend their summers in the northern Bering Sea. The National Marine Mammal Laboratory (NMML) presently uses a provisional population estimate of 49,000 ribbon seals for the central and eastern Bering Sea (Allen and Angliss, 2011). In spite of the unknowns in NMFS Stock Assessment (Allend and Angliss, 2011), the Species Status Review (Boveng et al, 2008) and the provisional population estimate allow for a thorough effects analysis for this species in the Chukchi Sea. In December 2007, NMFS received a petition to list ribbon seals under the ESA; however, in December 2008 it was determined that an ESA listing was not warranted (Boveng et al., 2008).

**Spotted Seals.** A reliable spotted seal population estimate for the Bering, Chukchi, and Beaufort seas does not exist (Allen and Angliss, 2011). NMML developed a provisional population estimate of 101,568 +/- 17,869 spotted seals in the eastern and central Bering Sea survey areas, while others estimated 100,000–135,000 spotted seals form the Bering Sea spotted seal stock (Boveng et al., 2009). Surveys from 1990 to the present have noted that spotted seals may occur near the proposed drill sites in numbers that vary from year to year (Table 18). Though the NMFS Stock Assessment for this species states that no reliable population estimate for spotted seals exists, the Status Review's (Boveng et al., 2009) provisional population estimate, along with recent surveys in the northeastern Chukchi Sea (Table 18), provide sufficient information to support a reasoned effects analysis.

The primary haulout areas used by spotted seals in the eastern Chukchi are Kasegaluk Lagoon, and to a lesser degree other areas with substantial areas of sand or mud bars. Individual spotted seals generally remain closer to the coast than those of other ice seal species, and evidence also indicates spotted seals are not as tightly linked to sea ice as are the other ice seal species.

Adult spotted seals eat a variety of fish, crustaceans, and cephalopods and their diet varies with age, season, and location. Young spotted seals consume euphausiids, copepods, and other crustaceans, and their preferred prey base generally increases in size as individual seals mature. Adult spotted seals consume salmon, Arctic cod, capelin and pollock, and flatfishes (Dehn et al., 2007; Nelson and Griese, 2008).

In May 2008, NMFS received a petition to list spotted seals under the ESA; however, in October 2009, NMFS determined an ESA listing is not warranted for spotted seals in the Bering, Chukchi, or Beaufort seas (Boveng et al., 2009).

### Pacific Walrus

Observations of walrus in the vicinity of the Burger Prospect have been reported in several surveys over the past 20 years. While these surveys use different methods and occurred under different circumstances, when taken together they can help to illustrate the use of the drilling area by walrus. Results of these survey reports are given in Table 19. Other information on the affected environment for walrus is described below.

**Table 19. Numbers of Pacific walruses sighted by vessel-based and aircraft-based surveys in the vicinity of the Proposed Action, and the northeastern Chukchi Sea.**

| | Number of individuals reported by eight surveys | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species Observed | Brueggeman et al. 1991a – Popcorn, Burger, and Crackerjack Prospects 1990 walrus monitoring | Brueggeman et al. 1992a – Crackerjack and Diamond Prospects 1991 | Brueggeman et al. 2010 – Klondike and Burger Prospects 2009 | Brueggeman et al. 2009 – Klondike and Burger Prospects, pipeline route 2008 | Reiser et al. 2010 – Burger, Snickers, Ulu, Caramel, and Honeyguide prospects 2009 | Blees et al. 2010 – Seismic Survey NE Chukchi Sea 2010 | Clarke et al. 2011c – COMIDA Final Report,;2008-2010 NE Chukchi Aerial Surveys | Haley et al. 2010 in Funk et al. 2010 – Chukchi Sea Vessel-Based Monitoring Program, NE Chukchi Sea 2006-2008 |
| **Pacific Walrus** | 24889 | - | 309 | 50 | 114 | 1042 | 5995-51991 | 763-2954 |
| **Unid. Pinniped** | 93 | 0 | 10 | 3 | 5 | 56 | 33-703 | 19-34 |

On February 10, 2011, the US Fish and Wildlife Service (FWS) completed a status review of the Pacific walrus (*Odobenus rosmarus divergens*) and determined that although listing the species as endangered or threatened was warranted, the listing was precluded by other higher priority actions (76 FR 7634). The Pacific walrus is currently listed as a candidate species under the ESA. The continuing loss of sea ice habitat and harvest levels are likely the biggest stressors on the population (Jay, Marcot, and Douglas, 2011). The most recent population survey was conducted in 2006. Due to weather constraints approximately 50% of the available walrus habitat was surveyed. The final population estimate of 129,000 (Speckman et al., 2010) represents a minimum population estimate since it was not possible to extrapolate from the area surveyed to the entire habitat area.

Pacific walrus range varies with the extent of sea ice. A few walrus may move into the eastern Beaufort Sea during the open water season, but most are found west of Barrow along the pack-ice front in the northeastern Chukchi Sea. Since 2007, walrus have increasingly used terrestrial haulout sites between Barrow and Cape Lisbourne when the sea ice retreats north of the Continental Shelf.

The spring migration usually begins in April, with most walrus moving north through the Bering Strait by late June. Walrus begin to migrate south with the advance of pack ice during the fall. Both of these migrations bring walrus through the proposed drilling area.

The number of walrus observed in the proposed drilling area during monitoring efforts associated with seismic surveys in 2006-2009 varied depending upon the location of sea ice, but occurrences of walrus in the area of the Burger Prospect are regular and common. A total of 5,626 walrus were observed in the Lease Sale 193 Area over a period of four years (2006-2009) by vessel based MMOs while monitoring seismic surveys in this area of the northeastern Chukchi Sea (Hannay et al, 2009). Brueggeman et al. (1990, 1991a) observed 85 walrus in or near the Burger Prospect area in 1989 and 534 in 1990, and 1,002 walrus were observed in two years (2008-2009) of baseline marine mammal surveys at the Burger Prospect (Brueggeman, 2009a, 2009b, 2010). A large number of walrus (1,042, mostly in groups of 1-4 individuals) were also observed just north of the Burger Prospect during the monitoring of a seismic survey program in August-September 2010 (Blees et al., 2010). Most of these observations (73 percent) occurred on just a few days (28–31 August) when a large number of walrus moved from a receding ice edge towards land (Blees et al., 2010). Their presence in the area is strongly linked to the presence of pack ice. The likelihood of encountering a walrus in or near the Burger Prospect will depend largely upon ice conditions at the time of exploration drilling activity, but it is likely that a number of walrus will occur in the area of the Burger Prospect during the planned exploration drilling program.

## Mysticete Whales

Observations of mysticete whales in the vicinity of the Burger Prospect have been reported in several surveys over the past 20 years. While these surveys use different methods and occurred under different circumstances, when taken together they can help to illustrate the use of the area by whales. Results of these survey reports are given in Table 20. Other information on the affected environment for mysticete whales is described below for each species.

**Table 20. Numbers of individuals of mysticete whale species sighted by vessel-based and aircraft-based surveys in the vicinity of the Proposed Action, and in the northeastern Chukchi Sea.**

| | Number of individuals reported by eight surveys | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species Observed | Brueggeman et al. 1991a – Popcorn, Burger, and Crackerjack Prospects 1990 walrus monitoring | Brueggeman et al. 1992a – Crackerjack and Diamond Prospects 1991 | Brueggeman et al. 2010 – Klondike and Burger Prospects 2009 | Brueggeman et al. 2009 – Klondike and Burger Prospects, pipeline route 2008 | Reiser et al. 2010 – Burger, Snickers, Ulu, Caramel, and Honeyguide prospects 2009 | Blees et al. 2010 – Seismic Survey NE Chukchi Sea 2010 | Clarke et al. 2011c – COMIDA Final Report,;2008-2010 NE Chukchi Aerial Surveys | Haley et al. 2010 in Funk et al. 2010 – Chukchi Sea Vessel-Based Monitoring Program, NE Chukchi Sea 2006-2008 |
| **Bowhead Whale** | ** | 15 | 3 | ** | 2 | 6 | 4-106 | 7-44 |
| **Fin Whale** | ** | ** | ** | ** | ** | ** | 1 | 4 |
| **Gray Whale** | 8 | 258 | 77 | 9 | 2 | 10 | 226-390 | 50-165 |
| **Humpback Whale** | ** | ** | ** | ** | ** | ** | 1 | 1-5 |
| **Minke Whale** | 1 | ** | 2 | 1 | ** | 5 | ** | 3-10 |
| **Unidentified Mysticete Whale** | ** | 0 | ** | ** | 14 | 20 | ** | 3-113 |
| **Unidentified Cetacean** | 1 | 5 | 2 | 1 | ** | 1 | 15-96 | 14-16 |

**Bowhead Whale.** Bowhead whale stocks occur in Arctic and sub-Arctic waters off eastern and western Canada, Alaska, Chukotka, and the sea of Okhotsk. The minimum population estimate for the western Arctic stock of bowhead whales off Alaska, western Canada, and Chukotka is 9,472 (Allen and Angliss, 2011). The Western Arctic bowhead whale stock generally occurs in seasonally ice-covered waters of the Arctic, generally north of 60° N. and south of 75° N. in the western Arctic Basin (Bering, Chukchi, and Beaufort seas)(Moore and Reeves, 1993). They have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year. Surveys from 1990 to the present have noted that bowhead whales may occur near the proposed drill sites. Numbers near the Burger Prospect are usually low (though variable from year to year) until September or October, when bowhead whale migrate in pulses out of the Beaufort Sea and through the Chukchi Sea.

During spring, bowheads migrate through spring lead systems to feeding areas in the eastern Beaufort Sea, and the vicinity of Barrow Canyon. A few individuals remain scattered through the Chukchi Sea during summer (Ireland et al., 2009); however, tracking data indicates most bowheads move to or between their primary feeding areas in the Beaufort Sea (ADFG, 2009). Moore and Reeves (1993) indicated the fall migration takes place in pulses or aggregations of whales. Iñupiat whalers report that smaller whales precede large adults and cow-calf pairs on the fall migration (Braham et al., 1984, as reported in Moore and Reeves, 1993). When the fall migration out of the Beaufort Sea occurs, large numbers of whales could pass through the leased areas; however, after passing Point Barrow, the migration paths of individual bowhead whales fan out across the Chukchi Sea with most heading towards the coastal waters of Chukotka where it is believed they feed (Quakenbush, Small and Citta, 2010) before eventually heading south to winter in the Bering Sea (ADFG 2009; Ireland et al., 2009). The numbers of bowhead whales detected in the northeastern Chukchi Sea by COMIDA flights and Marine Mammal Monitoring (by industry) show a little variance from year to year; however, evidence indicates bowhead whales are uncommon at the Burger Prospect until the fall migration commences, at which time large numbers of whales could migrate across the Chukchi Sea.

Preliminary data from satellite tracking (Quakenbush, Small and Citta, 2010), agency monitoring (Clarke et al., 2011a) and industry monitoring efforts (2006–2008) (Funk et al., 2010) have noted bowhead movement and feeding uses in the Chukchi Sea during summer and fall. Satellite tracking data (Quakenbush, Small, and Citta, 2010) for bowhead whales from 2006–2008 and passive acoustic monitoring (Moore, Stafford, and Munger, 2010) indicated most bowhead whales pass Barrow in September and October heading towards Wrangel Island (Russia). Once near Wrangel Island whales may linger up to 21 days, before traveling Southeast to coastal waters of Chukotka where they may feed for another 59 days, before departing for the Bering Sea.

The most common prey species found in the stomachs of harvested bowheads are euphausiids, copepods, mysids, and amphipods (Moore et al., 2010; Lowry, Sheffield, and, George 2004). Euphausiids and copepods are thought to be their primary prey since other crustaceans (isopods and decapods), and fish constitute minor fractions of their stomach contents. Carbon-isotope analysis of bowhead baleen indicates a significant amount of feeding occurs in wintering areas (Schell, Saupe, and Haubenstock, 1987). There are no known concentrations or notable feeding areas for bowhead whales in the northeastern Chukchi Sea. The nearest feeding area of particular consequence is in the vicinity of Barrow Canyon where the Beaufort and Chukchi Seas meet.

**Fin Whale.** Fin whales are widespread throughout temperate oceans of the world (Leatherwood et al., 1982; Perry, DeMaster, and Silber, 1999a) and in the Arctic Ocean (Allen and Angliss, 2011). Individual and small groups of fin whales seasonally inhabit areas within and near the Chukchi Sea Planning Area during the open water period. Based on observations and passive acoustic detection (Hannay et al., 2009; Delarue et al., 2010), and on direct observations from monitoring and research projects of fin whales from industry (e.g., Ireland et al., 2009) and government (e.g., Clarke et al., 2011c), fin whales are considered uncommon but regular visitors to the Alaska Chukchi Sea. An increase in observations of fin whales in recent years may be due to factors including renewed marine mammal monitoring by industry, and/or an increase in fin whale use of the Chukchi Sea. Data from COMIDA and Marine Mammal Monitoring activities indicate that fin whales are uncommon to rare at the Burger Prospect. The North Pacific fin whale population is estimated to have ranged from 42,000-45,000 before whaling began (Ohsumi and Wada, 1974). Allen and Angliss (2011) provide a current, minimum population estimate of 5,700 for the proportion of the Northeast Pacific Stock of fin whales west of the Kenai Peninsula. Surveys from 1990 to present have noted very few fin whales occurring near the proposed drill sites (Table 20).

Although there may be some degree of specialization, most individuals probably prey on both invertebrates (including crustaceans and squid) and fish, depending on availability (Watkins et al., 1984; Edds and Macfarlane, 1987). There appears to be variation in the predominant prey of fin whales in different geographical areas depending on local abundance of prey species (NMFS, 2010). Perry, DeMaster and Silber (1999a: p. 49) reported fin whales "depend to a large extent on the small euphausiids and other zooplankton" and fish. Fin whales aggregate where prey densities are high (Piatt and Methven, 1992; Moore, Stafford, and Dahlheim, 1998) chiefly in areas with high phytoplankton production and along ocean fronts (Moore, Stafford, and Dahlheim, 1998).

The PBR level for fin whales = 11.4. Fin whales are not hunted by subsistence hunters (Allen and Angliss, 2011).

**Gray Whale.** Most of the Eastern North Pacific Stock of gray whales spends its summer feeding in the northwestern Bering Sea, and in the Chukchi Seas (Rice and Wolman, 1971; Berzin, 1984; Nerini, 1984), migrating to winter and calve in the waters of Baja California. Allen and Angliss (2011) reported a minimum population estimate of 18,017 individuals, putting the population at a level similar to what is believed to approximate the pre-commercial whaling population level. Primary feeding areas in the Chukchi Sea include the eastern Chukchi, some shoal areas, and the western Chukchi from Wrangel Island to the Bering Strait, but they may be found throughout the Chukchi Sea in shallow waters over the continental shelf. Gray whales are the species of cetacean most frequently detected during marine mammal monitoring in the northeastern Chukchi Sea during the open water season (Funk et al., 2010; Brueggeman et al., 2009a and 2009b). Surveys from 1990 to the present have noted that, relative to other cetaceans, gray whales are relatively common near the proposed drilling sites and throughout the northeastern Chukchi Sea (Table 20). Gray whale feeding areas offshore of northern Alaska are characterized by low species diversity, high biomass, and the highest secondary production rates reported for any extensive benthic community (Rugh et al., 1999).

Gray whales are primarily bottom feeders restricted to shallow continental shelf waters for feeding. They mostly remain in coastal waters although in the Chukchi and Bering seas they feed at greater distances from shore over the shallow continental shelf. Their primary prey include swarming mysids, tube-dwelling amphipods, and polychaete worms in the Bering and Chukchi seas, but they also consume red crabs, baitfish, and other food (crab and fish larvae, amphipods, fish eggs, cephalopods, megalops, etc.) opportunistically or off the main feeding grounds (Reilly et al., 2008).

Stoker (1990) studied one of the high-use areas, the central Chirikov Basin between St. Lawrence Island and the Bering Strait, and found gray whales disturb at least 6% of the benthos each summer while consuming >10% of the yearly amphipod production. According to Highsmith and Coyle (1992), gray whales rely on rich benthic amphipod populations in the Bering and Chukchi Seas to renew fat resources needed to sustain them during their winter migration to and from Baja California. Nelson et al. (1993) noted that in the Chukchi Sea, within areas where gray whales were observed feeding off Wainwright, amphipod species observed were *Ampelisca macrocephala*, *A. estrichti*, *Byblis gaimardi*, *Aty1us bruggeni*, *Ischyrocerus*, *Protomedeia* spp., *Grandifoxus*, and *Erichthonius*, with amphipods comprising 24 percent of the biomass (Feder et al., 1989).

**Humpback Whale.** Humpback whales are found in all oceans with apparent worldwide geographical segregation into at least 10-11 distinct populations. For management purposes, the IWC places all humpback whales in the North Pacific Ocean into one stock (Donovan, 1991); however, NMFS recognizes three "management units" or stocks within the North Pacific. Individuals from the Western North Pacific Stock (population est. 732) and the Central North Pacific Stock (population est. 5,833) could occur in the Bering Sea with access to the Chukchi and Beaufort seas (Allen and Angliss, 2011). To date there have been few observations of humpback whales in the northeastern Chukchi Sea. Surveys conducted from 2006-2008 noted a maximum of five humpback whales in a given season (Haley et al., 2010). They are very rarely sighted near the proposed drill sites or during area-wide surveys. On those rare occasions when they are seen, humpback whales are present only in extremely low numbers (Table 20).

Humpback whales are relatively generalized in their feeding compared to some other baleen whales. In the Northern Hemisphere, known prey includes euphausiids (krill), copepods, juvenile salmonids, *Oncorhynchus* spp., Arctic cod, *Boreogadus saida*; walleye pollock, *Theragra chalcogramma*; pollock, *Pollachius virens*, pteropods, and cephalopods (Johnson and Wolman, 1984; Perry, DeMaster, and Silber, 1999b).

**Minke Whale.** The distribution of minke whales is considered cosmopolitan because they can occur in polar, temperate, and tropical waters in most seas and areas worldwide. Minke whales, like some other species of cetaceans, migrate seasonally and are capable of traveling long distances. Some animals and stocks of this species have resident home ranges and are not highly migratory. The distribution of minke whales varies by age, reproductive status, and sex. Older mature males are commonly found in the polar regions in and near the ice edge, and often in small social groups, during the summer feeding season. Mature females will also migrate farther into the higher latitudes, but generally remain in coastal waters. Immature animals are more solitary and usually stay in lower latitudes during the summer. Minke whales are occasionally detected in the northeastern Chukchi Sea during the open water seasons (Funk et al., 2010) as indicated in Table 20.

Presently NMFS has been unable to produce a minimum population estimate for the Alaska Stock of minke whales (Allen and Angliss, 2011); however, an estimate of 1,003 was produced for the east-central and southeastern Bering Sea, based on surveys in the central-eastern Bering Sea (1999) and southeastern Bering Sea (2000). A subsequent survey of a 30-45 nm zone from Kenai Fjords to the central Aleutian Islands (2001-2003) led to an estimate of 1,233 minke whales for that area, with most sightings in the Aleutian Islands and in water <200 m. deep. Most likely the Alaska stock of minke whales numbers into the thousands; however, this is speculative because only a portion of this species' range has been surveyed. Still, minke whales are the most abundant rorqual in the world, and their population status is considered stable through virtually all of its range (NMFS, 2011). Minke whales opportunistically feed on crustaceans (e.g., krill), plankton (e.g., copepods), and small schooling fish (e.g., anchovies, dogfish, capelin, coal fish, cod, herring, eels, mackerel, salmon, sand lance, and wolfish)(Reeves et al., 2002).

### Odontocete Whales

The toothed whales (Odontocetes) likely to occur in the proposed drilling area are the beluga (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), and killer whale (*Orcinus orca*). Narwhals (*Monodon monoceros*) have rarely been observed in the Chukchi Sea and are considered by NMFS to be extralimital (FR 69959, Nov 9, 2011). Observations of odontocete whales in the vicinity of the Burger Prospect have been reported in several surveys over the past 20 years. While these surveys use different methods and occurred under different circumstances, when taken together they can help to illustrate use of the area by whales. Results of these survey reports are given in Table 21. Other information on the affected environment for odontocete whales is described below for each species.

**Table 21. Numbers of individuals for respective odontocete cetacean species sighted by vessel-based and aircraft-based surveys in the vicinity of the Proposed Action, and the northeastern Chukchi Sea.**

| | Number of individuals reported by eight surveys | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species Observed | Brueggeman et al. 1991a – Popcorn, Burger, and Crackerjack Prospects 1990 walrus monitoring | Brueggeman et al. 1992a – Crackerjack and Diamond Prospects 1991 | Brueggeman et al. 2010 – Klondike and Burger Prospects 2009 | Brueggeman et al. 2009 – Klondike and Burger Prospects, pipeline route 2008 | Reiser et al. 2010 – Burger, Snickers, Ulu, Caramel, and Honeyguide prospects 2009 | Blees et al. 2010 – Seismic Survey NE Chukchi Sea 2010 | Clarke et al. 2011c – COMIDA Final Report,:2008-2010 NE Chukchi Aerial Surveys | Haley et al. 2010 in Funk et al. 2010 – Chukchi Sea Vessel-Based Monitoring Program, NE Chukchi Sea 2006-2008 |
| **Beluga Whale** | 3 | 1276 | ** | ** | ** | ** | 351-881 | 2 |
| **Harbor Porpoise** | ** | ** | 3 | ** | ** | ** | ** | 16-25 |
| **Killer Whale** | ** | 12 | ** | ** | ** | ** | ** | 1-2 |
| **Unidentified Odontocete Cetacean** | ** | 0 | ** | ** | ** | 2 | ** | 2-4 |
| **Unidentified Cetacean** | 1 | 5 | 2 | 1 | ** | 1 | 15-96 | 14-16 |
| **Unidentified Small Cetacean** | ** | 0 | ** | ** | ** | ** | ** | ** |

**Beluga Whale.** Of the five stocks of beluga that occur in Alaska (Allen and Angliss, 2011) only the eastern Chukchi Sea and Beaufort Sea stocks occur in the Lease Sale 193 Area. Both stocks overlap in the Chukchi Sea and winter in the Bering Sea (Suydam et al., 2001; Miller, Elliott, and Richardson, 1998). Much of the Chukchi Sea stock congregates in Kasegaluk Lagoon in June and July, at which time the village of Point Lay conducts a subsistence hunt. In the spring, beluga whales migrate along open leads north from their wintering grounds in the Bering Sea, often near the coast. Fall migrant beluga whales from the Canadian Beaufort Sea transit the Alaskan Beaufort Sea in a more dispersed pattern, but often along the southern edge of the pack ice, to reach western Chukchi Sea waters primarily during September (Richard, Martin, and Orr, 1998). During this time, pods can exceed 500 individuals (Lowry, 1994). Preferred summer habitats are well north of the Burger Prospect.

The most reliable estimate of the number of beluga whales in the eastern Chukchi stock is 3,710 individuals based on 1989-1991 aerial surveys (Frost, Lowry, and Carroll, 1993; Allen and Angliss, 2011). Subsequently, partial surveys were conducted in 1998 (DeMaster, Perryman, and Lowry, 1998) and in July 2002 (Lowry and Frost, 2002). Belugas are not commonly observed in the area of the Burger Prospect but may be encountered there in small numbers during the drilling season. They have been observed there during BWASP surveys (Clarke et al., 2011c). MMOs monitoring marine mammal occurrence from vessels during seismic surveys in offshore waters of the northeastern Chukchi Sea reported 46 beluga whales from marine vessels in 2006-2008 (Hannay et al., 2009), but many more were observed during aerial surveys in more coastal waters. Belugas were not observed in the Burger Prospect area during past exploration efforts in 1989-1990 (Breuggeman et al., 1991). None were observed around the Burger Prospect during Shell’s July-October 2008-2009 baseline marine mammal surveys (Hannay et al., 2009).

**Harbor Porpoise.** Harbor porpoises are found in relatively shallow coastal and shelf waters less than 330 ft (100 m) in depth (Allen and Angliss, 2011). Offshore of Alaska they are found from southeast Alaska throughout the Chukchi Sea shelf (Allen and Angliss, 2011) and have been observed as far north as the Barrow area (Suydam and George, 1992) and as far east as Harrison Bay in the Beaufort Sea (Funk et al., 2010). Although there is no official designation of separate stocks of harbor porpoises in Alaska, three stocks have generally been recognized, with harbor porpoises found in the Chukchi Sea being considered part of the Bering Sea group. Harbor porpoises use echolocation to find prey while foraging (Nowak, 1999). Harbor porpoises normally travel in small groups consisting of a few individuals, but form larger groups for feeding and mating purposes. Allen and Angliss (2011) provided a minimum population estimate of 40,039 for the Bering Sea stock of harbor porpoise.

Harbor porpoises are common cetaceans in the northeastern Chukchi Sea. They were the second most commonly observed cetacean by MMOs monitoring seismic surveys in the area, with a total of 106 observed over four years (Hannay et al, 2009). An average density of 0.0112/km$^2$ has been calculated for harbor porpoises based on these industrial surveys. They were not observed during exploration drilling efforts conducted in 1989-1991 (Breuggeman et al, 1991). None were observed within the Burger Prospect study area during baseline studies, but three were observed in more coastal waters during transit between the Burger Prospect and Wainwright in 2009 (Brueggeman, 2010). These data indicate that harbor porpoises may be encountered in the prospect area, or in transit to the prospect, in small numbers during the drilling season.

**Killer Whale.** Killer whales can be found in all Alaskan waters, although they are considered rare in the Chukchi Sea. Of the eight killer whale stocks recognized in the Pacific, the trans-boundary Alaska Resident stock, found from southeastern Alaska to the Chukchi Sea (Allen and Angliss, 2011) is the only stock likely to be encountered in the area of Shell's planned exploration drilling operations. Based on surveys conducted by the NMML, a minimum estimate of 1,123 killer whales comprises the Alaska Resident stock (Allen and Angliss, 2011).

MMOs recorded observations of 10 killer whales (in five groups) from vessels while conducting monitoring surveys for seismic surveys in the northeastern Chukchi Sea in 2006-2009 (Hannay et al., 2009). None were observed in the prospect during historical drilling in 1989-1991 (Breuggeman et al., 1991). None were observed in the Burger Prospect area during Shell's July-October, 2008-2009 marine mammal surveys, but a few were observed elsewhere in the Lease Sale 193 Area at that time (Brueggeman et. al., 2009a, 2009b). Although it is unlikely, they could be encountered in the prospect area in small numbers during the planned exploration drilling program.

### Polar Bear

Observations of polar bears in the vicinity of the Burger Prospect have been reported in several surveys over the past 20 years. While these surveys use different methods and occurred under different circumstances, when taken together they can help to illustrate the use of the area by polar bears. Results of these survey reports are given in Table 22. Other information on the affected environment for polar bears is described below.

The polar bear (*Ursus maritimus*) was listed by FWS as a threatened species under the ESA on May 14, 2008 (73 FR 28212). The listing was based primarily on the observed and continuing decline of sea ice habitat which polar bears rely on for foraging, movements, breeding, and denning.

Polar bear distribution is determined largely by seasonal ice. When sea ice retreats northward over deep waters not commonly inhabited by seals, polar bears may remain with the ice, fasting; others may retreat to shore. Small numbers of polar bears have been observed during the drilling of most of the past exploration wells in the Chukchi and when conducting baseline marine mammal surveys near

**Table 22. Numbers of polar bears sighted by vessel-based and aircraft-based surveys in the vicinity of the Proposed Action, and the northeastern Chukchi Sea.**

| Species Observed | Number of individuals reported by eight surveys | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Brueggeman et al. 1991a – Popcorn, Burger, and Crackerjack Prospects 1990 walrus monitoring | Brueggeman et al. 1992a – Crackerjack and Diamond Prospects 1991 | Brueggeman et al. 2010 – Klondike and Burger Prospects 2009 | Brueggeman et al. 2009 – Klondike and Burger Prospects, pipeline route 2008 | Reiser et al. 2010 – Burger, Snickers, Ulu, Caramel, and Honeyguide prospects 2009 | Blees et al. 2010 – Seismic Survey NE Chukchi Sea 2010 | Clarke et al. 2011c – COMIDA Final Report,:2008-2010 NE Chukchi Aerial Surveys | Haley et al. 2010 in Funk et al. 2010 – Chukchi Sea Vessel-Based Monitoring Program, NE Chukchi Sea 2006-2008 |
| **Polar Bear** | 25 | 0 | 4 | 1 | 0 | 0 | 1-17 | 3-8 |

the Burger Prospect during August-September 2008-2009 (Brueggeman, 2009). All observed bears were associated with pack ice.

The polar bear population in Alaska is considered to consist of two stocks, the Chukchi/Bering Sea stock and the southern Beaufort Sea stock, although there is considerable overlap between the two stocks (Amstrup et al., 2005). The two populations overlap between Point Hope and Point Barrow (Amstrup, 1995). In 2001, the southern Beaufort Sea stock was estimated at 2,200 bears (USDOI, FWS, 2010b). There currently is no reliable estimate for the Chukchi/Bering Sea stock, but the current estimate of at least 2,000 animals (Aars et al., 2006; USDOI, FWS, 2010a) is sufficient for evaluating potential impacts.

Polar bears are found throughout the Lease Sale 193 Area when ice is present. None were observed within the Burger Prospect study area in 2009, but four were observed in nearby waters (Brueggeman, 2010). All observed polar bears were associated with pack ice. A small number of polar bears may be encountered in the Burger Prospect during the planned exploration drilling operations, dependent on ice conditions.

FWS published a final rule on December 7, 2010 designating critical habitat for the threatened polar bear, effective January 6, 2011 (75 FR 76086). Designated critical habitat encompasses three areas or units: Unit 1 – sea ice, Unit 2 – terrestrial denning habitat, and Unit 3 – barrier island habitat. Potentially relevant here is the sea ice habitat that occurs seasonally over the Burger Prospect, as well as the habitat designated on and adjacent to barrier islands along the Chukchi shoreline.

### 3.2.8 Terrestrial Mammals

The affected environment for terrestrial mammals is the same as was described in the Sale 193 Final EIS (USDOI, MMS, 2007a) and the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a). Relevant summery of those more detailed descriptions is provided below.

Individual caribou from the Western Arctic Herd (WAH) and Teshekpuk Lake Caribou Herd (TCH) are the only caribou that typically occur along the Chukchi coast between Barrow and Wainwright, Alaska. Male caribou from the WAH typically segregate out to their summer ranges at Cape Lisburne, while parturient females calve inland and seek the Brooks Range foothills for insect relief. Muskoxen prefer shrubby riparian areas, but occasionally visit the coast during summer. An occasional grizzly bear could be expected to periodically visit the coast searching for potential prey or carrion. Arctic foxes and other furbearing species are ubiquitous throughout the area and would likely be found along the Chukchi coast.

### 3.2.9 Subsistence Activities

This section summarizes the affected environment for subsistence resources used by the people of the Chukchi Sea communities: Barrow, Wainwright, Point Lay, and Point Hope, Alaska.

Subsistence activities are assigned the highest cultural values by the Iñupiaq Eskimo of the North Slope and provide a sense of identity, in addition to being a pivotal economic pursuit. Subsistence is viewed by Alaskan Natives not just as an activity that is imbedded in the culture; it is viewed as the very culture itself (USDOI, MMS, 2009: pp. 213-223; Wheeler and Thornton, 2005). The bowhead whale is a subsistence resource of paramount importance, and, consequently, the social organization pertaining to the crew, the hunt, quantity, and distribution of the whale dominate when discussing North Slope Iñupiaq Eskimo subsistence. Bowhead whaling traditions underscore the central values and activities for the Iñupiat of the North Slope. Bowhead whale hunting strengthens family and community ties and the sense of a common Iñupiat heritage, culture, and way of life, and provides a strength, purpose, and unity in the face of rapid change (USDOI, MMS, 2008; EDAW, 2007). Although bowhead whaling traditions are unquestionably significant, harvest of other wild resources—including other marine mammals, caribou, fish, and avian species—are important to the local inhabitants in providing variety to the diet and needed nutrition, as well as satisfying basic nutritional needs when few or no bowhead whales are taken.

#### Barrow

Subsistence whaling and marine mammal hunting activities for the community of Barrow are summarized in Table 23. Updated information regarding specific groups of subsistence resources is described below.

**Bowhead Whale.** Barrow residents hunt the bowhead whale during both spring and fall. Historically, more whales have been harvested during the spring whale hunt, but changing ice conditions have increased the importance of the fall hunt. In 2011, Barrow whalers took 11 bowhead whales between October 8 and October 29 (AWEC, 2011, pers. comm.).

**Beluga.** Harvest of Beluga whales can occur in ice-free waters from the beginning of the spring whaling season through June and occasionally into July and August. Belugas are also occasionally harvested on both sides of the barrier islands of Elson Lagoon in the late summer.

**Seals.** The hunting of bearded seals (*ugruk*) is an important subsistence activity in Barrow. The bearded seal is a preferred food and bearded seal skins are a preferred covering material for the skin boats used for whaling. Most bearded seals are harvested during the spring and summer months in open water during the pursuit of other marine mammals in both the Chukchi and Beaufort seas.

**Walrus.** Walrus are harvested during a summer marine-mammal hunt west of Point Barrow and southwest to Peard Bay. Most hunters travel no more than 15-20 mi to hunt walrus, although recent reports indicate that hunters may travel as far as 100 mi north from Point Barrow. The major walrus-hunting effort occurs from late June through mid-September, with the peak season in August.

Caribou. Caribou are harvested throughout the year, with peak harvest periods from February through early April and from late June through late October. Some caribou hunting also occurs along rivers during the fall and in coastal areas during the summer when the animals seek relief from insects.

**Migratory Birds.** Migratory birds, particularly eider ducks and geese, provide an important food source for Barrow residents because of the dietary importance of birds as the first source of fresh meat in the spring. Most spring bird hunting occurs between April and June. In late August ducks and geese are again hunted along the coast from Point Franklin to Admiralty Bay and Dease Inlet as they migrate south (USDOI, MMS, 2010).

A detailed description of Barrow's subsistence resources, their significance to the community, and the patterns of subsistence harvesting, is contained in Section III.C.2.c(3)(a) of the Lease Sale 193 Final EIS (USDOI, MMS, 2007a), Section 3.4.2.5.3 of the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008) and Section III.C.2 of the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a), which are incorporated herein by reference. Information from these analyses has been updated by recent reports on subsistence mapping (USDOI, MMS, 2010) and on traditional knowledge (SRB&A, 2011), and the data from the recent studies indicates the activities take place in the area described in the detailed analyses as summarized in Table 24.

**Table 23. Summary of subsistence harvest management, locations, and seasons for the Iñupiat community of Barrow.**

| Species | Management | Location | Season |
|---|---|---|---|
| **Bowhead Whale** | --NMFS (IHA)<br>--Alaska Eskimo Whaling Commission | Spring Whaling:<br>Ice leads from Point Barrow southwestward along the Chukchi Sea coast to the Skull Cliff area.<br>See MMS, 2010 Map 10, and Shell 2011 Figure 3.11.7-4 for detailed depiction of bowhead whale subsistence use areas. | April to June: 92% of 158 whales landed from 1995 to 2010 were landed between April 25th and May 25th; 84% were landed between May 1st and May 25th. |
| **Bowhead Whale** | --NMFS (IHA)<br>--Alaska Eskimo Whaling Commission | Fall Whaling:<br>An area circumscribed by a western boundary extending approximately 10 mi west of Barrow, a northern boundary 30 mi north of Barrow, then southeastward to a point about 30 mi off Cooper Island, with an eastern boundary on the east side of Dease Inlet. Occasional use may extend eastward as far as Smith Bay and Cape Halkett.<br>See MMS, 2010, Map 10, and Shell 2011 Figure 3.11.7-4 for detailed depiction of bowhead whale subsistence use areas. | September to October: 93% of 207 whales landed from 1995 to 2010 were landed between September 10th and October 20th; 84% were landed between September 19th and October 19th. |
| **Beluga Whale** | --NMFS (IHA)<br>--Beluga Whale Committee | Spring leads between Point Barrow and Skull Cliff; later in the season, belugas are hunted in open water around the barrier islands off Elson Lagoon. | June to early July |
| **Pacific Walrus** | --FWS (LOA)<br>--Eskimo Walrus Commission | From Point Franklin on the Chukchi Sea coast to Pitt Point on the Beaufort Sea coast and up to 60 mi offshore; nearshore from Pitt Point to Prudhoe Bay.<br>See MMS, 2010, Map 33, and Shell 2011 Figure 3.11.7-3 for detailed depiction of Pacific Walrus subsistence use areas. | June to August |
| **Polar Bear** | --FWS (LOA)<br>--Nanuuq Commission | Generally in the same vicinity used to hunt walrus. | January to March<br>May to June |
| **Bearded Seal (Ugruk)** | --NMFS (IHA)<br>--Ice Sea Commission | From 35 mi southwest of Wainwright on the Chukchi Sea coast to Dease Inlet on the Beaufort Sea coast and up to 90 mi offshore.<br>See MMS, 2010, Map 31, and Shell 2011 Figure 3.11.7-4 for detailed depiction of bearded seal subsistence use areas. | November to January, some open water sealing |
| **Ringed Seal** | --NMFS (IHA)<br>--Ice Seal Commission | From Point Franklin on the Chukchi Sea coast to Pitt Point on the Beaufort Sea coast and up to 60 mi offshore.<br>Open water nearshore.<br>See MMS, 2010, Map 29, and Shell 2011 Figure 3.11.7-4 for detailed depiction of ringed seal subsistence use areas. | November to January<br>April to July |

| Species | Management | Location | Season |
|---|---|---|---|
| **Spotted Seal** | --NMFS (IHA)<br>--Ice Sea Commission | Nearshore Chukchi coastline east as far as Dease Inlet and Admiralty Bay in the Beaufort Sea. | November to January<br>July to September |
| **Ribbon Seal** | --NMFS (IHA)<br>--Ice Seal Commission | Nearshore/offshore Chukchi coastline east as far as Dease Inlet and Admiralty Bay in the Beaufort Sea. | Some open-water sealing |

### Wainwright

Subsistence hunting of bowhead whales, beluga, Pacific walrus, polar bear, bearded seal, ringed seal, spotted seal, and ribbon seal for the community of Wainwright are summarized in Table 24. The hunting seasons and harvest location for various marine mammals sometimes overlap in location and time of year. Subsistence hunting in Wainwright has been described as occurring to the north or south of the community in any given year, but over time, the pattern of offshore subsistence hunting is a "fan spreading outward from Wainwright in all directions" (SRBA-ASR, 2011).

**Bowhead Whale.** Bowhead whales are Wainwright's most important marine resource and are available in the Wainwright area beginning in late April. Wainwright whalers recognize three distinct runs of bowhead whales, all of which occur before the proposed commencement of Shell's exploration activities. The first run occurs when leads first open in the ice. Historically, this would occur in late April but in recent years the leads have opened earlier in the spring and the whales have begun to appear in early April and sometimes even in March. The second run also requires open leads and occurs in late April to early May. The third run takes place in the second half of May and early June. Following the whaling season, as hunters pursue bearded seals in pack ice, they have reported bowhead whales still migrating and on a few occasions, whales have been reported in July near Wainwright and Icy Cape. In the fall, whales have been reported a few times near Wainwright in October, but they do not generally follow the coast southward from Barrow. In October 2010, Wainwright landed a whale in the autumn for the first time since at least 1974 and likely the first in more than 50 years (Suydam et.al., 2011). Bowhead whaling tracks for the October 2010 hunt are northeast of Wainwright, the furthest extending 37 miles northwest of Wainwright. Again, in 2011, the same Wainwright crew took a single bowhead whale on October 28 (AEWC, 2011, pers. comm).

**Beluga.** There are two separate periods when beluga whales migrate past Wainwright, one in early May and another in late June. Due to the focus on the bowhead harvest in May, Wainwright whalers only hunt belugas during the late June migration. Beluga whaling records from the July 2010 hunt indicate beluga whaling took place close to shore from Kaselgaluk Lagoon to the Sinaruruk River (SRBA-ASR, 2011).

**Seals.** Wainwright residents hunt four seal species: ringed, spotted, ribbon and bearded seals. Seal hunting records from March, April, June, and July 2010 show that the bearded seal was the species most hunted, although ring and spotted seals were targeted. The 2010 hunt occurred from Kasegaluk Lagoon at Akoliakatat Pass in the south to Point Franklin in the north, and as far as 37 miles offshore from Wainwright, with the highest concentrations of hunting directly offshore and within 10 miles of Wainwright (SRB&A-ASR, 2011).

**Caribou.** Caribou is the primary source of meat for Wainwright residents. Before freeze up, caribou hunting is conducted along inland waterways, particularly along the Kuk River system. Coastal hunting records in July 2010 report that caribou were hunted from a point just south of Pingorarok Pass in Kasegaluk Lagoon to a point approximately 20 miles northeast of Wainwright (SRBA-ASR, 2011).

**Fish.** Wainwright residents harvest a variety of fish in most marine and freshwater habitats along the coast and in lagoons, estuaries, and rivers. The most important local fish harvest occurs from September through November in the freshwater areas of the Kuk, Kugrua, Utukok, and other river drainages. Marine fishing is conducted from Peard Bay to Icy Cape and in Kuk Lagoon. Fishing occurs exclusively in nearshore coastal areas.

**Migratory Birds.** The spring migration of ducks, murres, geese, and cranes begins in May and continues through June. A waterfowl harvest is initiated in May at whaling camps and continues through June. During the fall migration south, hunting success is limited. Eider hunting records in March through July 2010 indicate that hunting occurred from a point approximately 10 miles offshore from Akoliakatat Pass in the south almost to Point Franklin in the north (SRB&A-ASR, 2011).

Detailed information regarding Wainwright subsistence resources (summarized in Table 24) are available in Volume III, Section C.2.c(3)(c) of the Lease Sale 193 Final EIS (USDOI, MMS, 2007a), Section 3.4.2.6.1 of the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008), and Section III,C.2 of the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) which are incorporated herein by reference.

**Table 24. Summary of subsistence harvest management, locations, and seasons for the Iñupiat community of Wainwright.**

| Species | Management | Location | Season |
|---|---|---|---|
| **Bowhead Whale** | --NMFS (IHA)<br>--Alaska Eskimo Whaling Commission | Spring Whaling:<br>Leads offshore of Wainwright; with whaling camps from 15 mi southwest to 30 mi northeast of Wainwright sometimes and up to 15 mi offshore; also some whaling has occurred 6 mi southwest and 6 mi northeast of Icy Cape and 6 mi offshore.<br>See MMS 2008 Figure 3.4.2-72 and Shell 2011 Figure 3.11.7-6 for detailed depiction of bowhead whale subsistence use areas. | April to June, primarily May: 92% of 53 whales landed from 1995 and 2010 were landed between April 24th and May 29th; 84% were landed between April 24th and May 24th |
| **Bowhead Whale** | --NMFS (IHA)<br>--Alaska Eskimo Whaling Commission | Fall Whaling:<br>Northwest of Peard Bay | October<br>1 whale in 2010 (first autumn whale since at least 1974) and 1 whale in 2011. |
| **Beluga Whale** | --NMFS (IHA)<br>--Beluga Whale Committee | Along the coastal lagoon systems.<br>See Shell 2011 Figure 3.11.7-6 for detailed depiction of beluga whale subsistence use areas. | June to August |
| **Pacific Walrus** | --FWS (LOA)<br>--Eskimo Walrus Commission | At the southern edge of the retreating pack ice.<br>Walrus hunted at local haulouts with the focal area from Milliktagvik north to Point Franklin.<br>See Shell 2011 Figure 3.11.7-5 for detailed depiction of walrus subsistence use area. | Mid-June to August<br>August to September |
| **Polar Bear** | --FWS (LOA)<br>--Nanuuq Commission | Around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island. | August to March |
| **Bearded Seal** | --NMFS (IHA)<br>--Ice Sea Commission | Nearshore directly offshore of Wainwright to the mouth of Kuk Lagoon.<br>See Shell 2011 Figure 3.11.7-6 for detailed depiction of seal subsistence use areas. | April to August<br>December to January |
| **Ringed Seals** | --NMFS (IHA)<br>--Ice Sea Commission | Nearshore from Point Lay to Point Franklin. Not commonly harvested.<br>Nearshore from Point Lay to Point Franklin. Not commonly harvested. | April to August<br>December to January |
| **Spotted Seal** | --NMFS (IHA)<br>--Ice Sea Commission | At Icy Cape and nearshore Point Lay to Point Franklin, with most taken in Kuk Lagoon.<br>See Shell 2011 Figure 3.11.7-6 for detailed depiction of seal subsistence use areas. | September to October |
| **Ribbon Seal** | --NMFS (IHA)<br>--Ice Sea Commission | Nearshore/offshore Point Lay to Point Franklin.<br>See Shell 2011 Figure 3.11.7-6 for detailed depiction of seal subsistence use areas. | April to August |

## Point Lay

Detailed analyses of subsistence whaling and marine mammal hunting activities for the community of Point Lay are summarized in Table 25. These analyses are informed by a recent report on traditional knowledge for Point Lay (SRB&A, 2011) as well as by information developed from monitoring efforts of offshore subsistence hunting for key marine mammals (bowhead and beluga whales, walrus, seals, and polar bears) during the offshore boating season, March through October 2010.

**Beluga.** Point Lay's most important subsistence marine resource is the beluga whale. A major community activity centers around a single hunt in the summer, usually occurring during the first 2 weeks of July, within Kasegaluk Lagoon and on the outer coast of the barrier islands where schools of belugas migrating north are known to feed. Most hunting is concentrated south of the village in Kukpowruk and Naokok passes.

**Bowhead.** Point Lay recently received a bowhead whale quota and village whalers resumed spring and fall bowhead whaling, landing one whale in the spring of 2009, no whales during the spring 2010 hunt, and one whale in the spring 2011 hunt. No whales were landed during the fall hunts (AEWC, 2011, pers. comm.). Whaling records for the April and May 2010 hunt show activity concentrated within the lead system approximately 10 miles south and 10 miles north of Point Lay. Vessel tracks indicate that the whalers remained relatively close to Point Lay for the duration of the 2010 season, though the location of activities changes from year to year and may occur as far north as Utukok Pass (SBRA-ASR, 2011).

**Seals.** Bearded seal hunting records for April and June 2010 indicate that activities ocurred from a point near Omalik Lagoon in the south to Wainwright in the north, with the heaviest concentration of activity five to 10 miles offshore between Kukpowruk and Utukok Passes. Lack of sea ice has diminished the number of bearded seals that are available to Point Lay hunters (SRB&A-ASR, 2011).

**Caribou.** Coastal caribou hunting records for July, August, and September 2010 show activity along the coast between the southernmost point of Kasegaluk Lagoon and Utukok Pass, inside the lagoon or on the ocean side of the barrier islands (SRBA-ASR, 2011).

A summary of Point Lay's annual harvest of beluga whales, walrus, and polar bear from the 1980s-2007, as well as detailed information regarding other subsistence resources is available in Section 3.4.2.6.2, Figures 3.4.2-77 through 3.4.2-86 and Tables 3.4.2-10 , 3.4.2-11, and 3.4.2-6 of the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008),Volume III, Section C.2.c(3)(d ) of the Lease Sale 193 Final EIS (USDOI, MMS, 2007a), and Section III.C.2 of the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) which are incorporated herein by reference.

**Table 25. Summary of subsistence harvest management, locations, and seasons for the Iñupiat community of Point Lay.**

| Species | Management | Location | Season |
|---|---|---|---|
| **Bowhead Whale** | --NMFS (IHA)<br>--Alaska Eskimo Whaling Commission | Leads offshore Point Lay. Point Lay took its first whales since 1941 on May 5, 2009 at a lead 10 mi northwest of the community.<br>See SRB&A 2011 Map 18 and Shell 2011 Figure 3.11.7-8 for detailed depiction of bowhead whale subsistence use areas. | April to June: first whale taken since 1941 was a single bowhead in May 2009. |

| Species | Management | Location | Season |
|---|---|---|---|
| **Beluga Whale** | --NMFS (IHA)<br>--Beluga Whale Committee | Hunt concentrated in Naokak and Kukpowruk Passes south of Point Lay where hunters use boats to herd the whales into the shallow waters of Kasegaluk Lagoon. If the July hunt is unsuccessful, hunters can travel as far north as Icy Cape, as far south as Cape Beaufort in search of whales and up to 20 mi offshore.<br>See MMS 2008 Figure 3.4.2-77 and -78, SRB&A 2011 Map 11, Shell 2011 Figure 3.11.7-8 for detailed depiction of beluga whale subsistence use areas. | mid-June to mid-July |
| **Pacific Walrus** | --FWS (LOA)<br>--Eskimo Walrus Commission | From Cape Beaufort to Icy Cape and up to 25 mi offshore.<br>See MMS 2008 Figure 3.4.2-82, SRB&A 2011 Map 14 for Shell 2011 Figure 3.11.7-8 for detailed depiction of Pacific Walrus subsistence use areas. | June to August |
| **Polar Bear** | --FWS (LOA)<br>--Nanuuq Commission | From Cape Beaufort to Icy Cape and up to 10 mi offshore.<br>See MMS 2008 Figure 3.4.2-85 and SRB&A 2011 Map 12, for detailed depiction of polar bear subsistence use areas. | January to April |
| **Bearded Seal (Ugruk)** | --NMFS (IHA)<br>--Ice Sea Commission | From Cape Beaufort to Icy Cape and up to 25 mi offshore.<br>See MMS 2008 Figure 3.4.2-81 and SRB&A 2011 Map 13 for detailed depiction of bearded seal subsistence use areas. | June |
| **Ringed Seals** | --NMFS (IHA)<br>--Ice Sea Commission | From Cape Beaufort to Icy Cape and up to 20 mi offshore.<br>See MMS 2008 Figure 3.4.2-80 and SRB&A 2011 Map 13 for detailed depiction of ringed seal subsistence use areas. | March to May |
| **Spotted Seal** | --NMFS (IHA)<br>--Ice Sea Commission | From 10 mi east of Cape Lisburne to Icy Cape and up to 25 mi offshore.<br>See MMS 2008 Figure 3.4.2-83 and SRB&A 2011 Map 13 for detailed depiction of spotted seal subsistence use areas. | July to September |
| **Ribbon Seal** | --NMFS (IHA)<br>--Ice Sea Commission | From Cape Beaufort to Icy Cape and up to 25 mi offshore. | March to May |

## Point Hope

Point Hope hunters harvest bowhead whales, beluga whales, seals, polar bear, and walrus. Table 26 summarizes harvest management, locations, and seasons for subsistence resources used by Point Hope. Updated information for certain groups is described below.

**Bowhead.** No other marine mammal is harvested with the intensity and concentration of effort that is focused on the bowhead whale. The traditional whaling season runs from mid-April to late May. Although fall whaling was planned for 2011 no bowhead whales were taken by Point Hope crews (AEWC, 2011, pers. comm.).

**Caribou.** Caribou is the primary source of meat for Point Hope residents. Caribou are available throughout the year, with peak harvest times occurring from February to March, and from late June through mid-November. Waterfowl and other migratory birds are another preferred subsistence food source, with most bird hunting occurring in the spring in nearshore coastal areas.

Detailed information regarding Point Hope subsistence resources (summarized in Table 26) are available in Volume III, Section C.2.c(3)(e) of the Lease Sale 193 Final EIS (USDOI, MMS, 2007a), Section 3.4.2.6.3 of the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008), and Section III,C.2 of the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) which are incorporated herein by reference..

**Table 26. Summary of subsistence harvest management, locations, and seasons for the Iñupiat community of Point Hope.**

| Species | Management | Location | Season |
|---|---|---|---|
| **Bowhead Whale** | --NMFS (IHA)<br>--Alaska Eskimo Whaling Commission | Along the ice edge south and southeast of the point as far as Point Thompson. The pack-ice lead is rarely more than 6-7 mi offshore but hunting can range up to 15 mi offshore.<br>See MMS 2008 Figure 3.4.2-96 and Shell 2011 Figure 3.11.7-10 for detailed depiction of bowhead whale subsistence use areas. | April to June: 95% of 39 whales landed from 1995 and 2008 were landed between April 16th and June 4th; 1 whale in 2009 (out of 1) 1 whale in 2010 (out of 2) 85% were landed between April 20th and May 25th, 0 out of 1 in 2009, 1 whale in 2010 (out of 2) |
| **Beluga Whale** | --NMFS (IHA)<br>--Beluga Whale Committee | Same area used for the bowhead whale hunt<br>In open water near the southern shore of Point Hope close to the beaches, as well as areas north of the point as far as Cape Dyer.<br>See MMS 2008 Figure 3.4.2-99 and Shell 2011 Figure 3.11.7-10 for detailed depiction of beluga whale subsistence use areas. | March to June<br>July to August |
| **Pacific Walrus** | --FWS (LOA)<br>--Eskimo Walrus Commission | From Cape Thompson to Cape Lisburne and 15 mi east to Ayugatak Lagoon and up to 20 mi offshore<br>See MMS 2008 Figure 3.4.2-98 and Shell 2011 Figure 3.11.7-9 for detailed depiction of Pacific Walrus subsistence use areas. | May to July |
| **Polar Bear** | --FWS (LOA)<br>--Nanuuq Commission | Area south of the point and as far out as 10 mi from shore. | January to April<br>October to January |
| **Bearded Seal (Ugruk)** | --NMFS (IHA)<br>--Ice Sea Commission | From Cape Thompson to Cape Lisburne and 15 miles east to Ayugatak Lagoon and up to 20 mi offshore.<br>See MMS 2008 Figure 3.4.2-97 and Shell 2011 Figure 3.11.7-10 for detailed depiction of bearded seal subsistence use areas. | January to June |
| **Ringed Seals** | --NMFS (IHA)<br>--Ice Sea Commission | From Cape Thompson to Cape Lisburne and 15 mi east to Ayugatak Lagoon and up to 20 mi offshore.<br>See MMS 2008 Figure 3.4.2-97 for detailed depiction of seal subsistence use areas. | January to June<br>November to December |
| **Spotted Seal** | --NMFS (IHA)<br>--Ice Sea Commission | From Cape Thompson to Cape Lisburne and 15 mi east to Ayugatak Lagoon and up to 20 mi offshore.<br>See MMS 2008 Figure 3.4.2-97 for detailed depiction of seal subsistence use areas. | January to June<br>November to December |
| **Ribbon Seal** | --NMFS (IHA)<br>--Ice Sea Commission | From Cape Thompson to Cape Lisburne and 15 mi east to Ayugatak Lagoon and up to 20 mi offshore.<br>See MMS 2008 Figure 3.4.2-97 for detailed depiction of seal subsistence use areas. | January to June<br>November to December |

## 3.2.10 Sociocultural Systems

Sociocultural systems encompass three concepts: (1) social organization, (2) cultural values, and (3) institutional organizations of communities. The term "social organization" refers to how people are divided into social groups and networks. The term "cultural values" refers to desirable values that are widely shared explicitly and implicitly by members of a social group. The term "institutional organization" refers to the government and non-government entities that provide services to the community. These three concepts are interrelated. For most Alaska Natives, subsistence (and the relationship between people, land, water, and its resources) is the expression of cultural identity, and production of subsistence foods is the activity around which social organization and generational transmission of the culture occurs. Institutional organizations, in turn, reflect and affect the social organization and cultural values.

For the North Slope of Alaska, Iñupiat traditions and practices largely define social organization and cultural values, while the civil and tribal governments and Alaska Native Claims Settlement Act Native corporations largely define institutional organization. A detailed explanation of sociocultural factors appears in Section 3.4.3 of the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008) and Section III.C.3 of the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a). A summary of the major sociocultural trends occurring in North Slope communities is presented in cumulative effects analysis in
Section 4.7.

Subsistence activities are often central to many aspects of social organization and cultural values of the community, including patterns of family life, artistic expression, and community religious and celebratory activities. Although there have been substantial social, economic, and technological changes in Iñupiat lifestyle, subsistence continues to be the visible central organizing value of Iñupiat sociocultural systems and it is primarily through impacts to subsistence activities that impacts to sociocultural systems are assessed (USDOI, MMS, 2008, Section 3.4.3.1).

A recent study (SRB&A, 2009) of active harvesters, including harvesters from Wainwright, determined that the combination of offshore and cumulative onshore oil and gas development is perceived as constituting a new threat to subsistence on the North Slope, with impacts related to bowhead and caribou of greatest concern. Development is also seen as leading to social problems, including higher rates of substance abuse and suicide. The benefits brought by development are recognized, as well as the efforts underway to mitigate impacts. While there has been remarkable success in maintaining their subsistence lifestyle, since 2003 active harvesters have been experiencing the impacts of development at a higher rate, and well-being is declining.

A study of traditional knowledge of bowhead whales near Wainwright reports that whalers in that community are concerned about offshore oil and gas activities in the Chukchi Sea. For planned activities in the Chukchi Sea, the Wainwright whalers believe stringent conditions should be imposed to protect marine mammals and their food. The whalers believe that bowhead reaction to industry activity means whales would not travel southwest near the eastern coast of the Chukchi Sea where they might be accessible to whalers in the fall, but would stay offshore to the north as they migrate across to the Russian coast (Quakenbush and Huntington, 2010).

### 3.2.11 Economy

OCS oil and gas activities generate economic effects on the NSB, State of Alaska, and the Federal government in the form of direct and indirect employment, personal income associated with employment, and various types of revenues accruing to each level of government. The NSB receives revenues primarily from property taxes on high value onshore oil and gas infrastructure, as well the Federal government, State of Alaska, and local governments. The State of Alaska receives revenues from oil and gas activities in the form of property taxes, state corporate income tax, revenues associated with the Trans-Alaska Pipeline System (TAPS), and rentals and royalties from OCS leases as provided by Section 8(g) of OCSLA. Oil and gas activities generate revenues for the Federal government through royalties, bonus bids, and rental revenues.

The description and analysis of effects on the economy below focuses on the economy of the NSB, as the location, timing, and scale of the proposed exploration activities are not expected to generate economic effects at the State or Federal level.

### Local Employment and Personal Income

Descriptions of the NSB economy in the Shell EIA (Shell, 2011a: Appendix F) are incorporated by reference, and salient points are summarized below. Additional information on the NSB economy is also provided below. The NSB is a mixed economy, characterized by a traditional cash economy and subsistence economy. The NSB economy is characterized by high unemployment and underemployment. Training programs and workforce development will continue to be important in the future to increase the low number of NSB residents that receive employment and personal income in the oil industry. More local hire is needed to increase employment and personal income benefits from oil and gas activities within the local communities.

### Revenues

The NSB government receives a large share of its revenues from property taxes levied on high value onshore oil and gas infrastructure. As the depreciable value of that infrastructure has decreased, the revenues accruing to the NSB from oil and gas activities have also declined.

## 3.2.12 Public Health

The health and welfare of the residents of the NSB is a primary concern in any decision regarding proposed offshore oil and gas activity in the Chukchi Sea. Detailed discussion of public health within Chukchi Sea coastal communities is provided in the Shell EIA (Shell, 2011a: Appendix F), salient point of which are incorporated by reference and summarized below. The main public health issues in the NSB include:

- General health
- Psychosocial health
- Accidental injuries
- Nutrition
- Contaminant exposure to environmental pollutants
- Noncommunicable disease
- Cardiovascular and cerebrovascular disease
- Chronic lung disease
- Cancer
- Respiratory Infections
- HIV
- Maternal child health
- Sanitation
- Health services infrastructure
- Cultural stress mitigation

Indicators of general population health include life expectancy, mortality rates, infant mortality, and general health and well being surveys. North Slope communities have experienced a decline in epidemic infectious disease, with mortality rates declining and life expectancy increasing. Since the era of epidemic infectious diseases, the health status of North Slope communities is now characterized by increases in diabetes, cancer, and ongoing social and psychological stress and change.

### 3.2.13 Archaeological Resources.

Potential submerged archaeological resources in the project area range from historic to prehistoric. Historic resources include man-made objects or structures older than 50 years, such as shipwrecks, abandoned relics of historic importance, or submerged airplanes. The likelihood of historic resources occurring is determined by historical records and such areas are tentatively identified in the Alaska Shipwreck Database (cite). No such objects are listed for the area defined by activities described in the 2012 Shell Revised Chukchi Sea EP (USDOI, MMS, 2007a, Section III.C.4; USDOI, MMS, 2008, Section 3.4.4.2; USDOI, BOEMRE, 2011a: Section III.C.4; Shell, 2011a: Section 3.10).

Prehistoric submerged archaeological resources may occur in areas that were sub-aerially exposed during the low stand of sea level approximately 13,000 years before present (generally 60 meters below sea level on the Alaska OCS), an area which encompasses activities described in the 2012 Shell Revised Chukchi Sea EP. Relict terrestrial landforms such as preserved levees or terraces associated with paleo-river channels, river confluences, ponds, lakes, lagoons, or paleo-shorelines are areas where archaeological sites are most likely to occur. No prehistoric resources are expected in some areas of the shelf in water depths less than 60 meters, where: (1) there are no Quaternary sediments, and (2) where extensive ice gouging has reworked the Quaternary section (USDOI, MMS, 2007a, Section III.C.4; MMS, 2008: Section 3.4.4.2; USDOI, BOEMRE, 2011a: Section III.C.4; Shell, 2011: Section 3.10).

The coastline of the North Slope is an extensive area for the presence of archaeological resources. The National Register of Historic Places lists nine sites in the vicinity of Wainwright (http://www.cr.nps.gov/nr/index.htm). Other sites, which provide unique information about the region and its people, include buildings, shipwrecks, plane wrecks, and archaeological sites. These additional sites have been cataloged in the Alaska Heritage Resource Inventory maintained by the State of Alaska (http://dnr.alaska.gov/parks/oha/ahrs/ahrs.htm) and the Cultural Resource Site Inventory and Traditional Land Use Inventory maintained by the North Slope Borough. Several sites from these three inventories exist in the vicinity of Wainwright (North Slope Borough, Coastal Management Program, Map 2, Traditional Land Use and Archaeological Sites). The Borough's Iñupiat History, Language and Culture Division has instituted clearance procedures for protecting activities and values at historic, archaeological, and cultural sites, including TLUI sites, near development activities (http://www.north-slope.org/departments/planning/ihlc.php).

BOEM's review of the site-specific geophysical data indicates that there are no historic properties at the proposed drill sites.

### 3.2.14 Environmental Justice

Executive Order 12898 requires Federal Agencies to evaluate whether proposed projects would have "disproportionately high adverse human health (i.e., community health) and environmental effects…on minority populations and low income populations." Alaska Iñupiat Natives, a recognized minority, are the predominant residents of the North Slope and Northwest Arctic Borough, the area potentially affected by OCS oil and gas activities. The ethnic composition of Point Hope, Point Lay, Wainwright, and Barrow demonstrates that all four communities would be classed as minority communities on the basis of their proportional American Indian and Alaska Native residency.

# SECTION 4. Environmental Consequences

The following subsections analyze potential direct, indirect, and cumulative effects on environmental resources as a result of Alternative 1 - No Action, Alterative 2 - Proposed Action, and Alternative 3-One Well per Season. Under each resource category, there is analysis of the potential direct and indirect effects associated with each alternative. Both action alternatives (Alternative 2 and 3) contemplate Shell's proposal to drill six exploration wells.

Alternative 3 would limit Shell to drilling one well to total depth per season, spreading proposed exploration activities across six or more drilling seasons. Under Alternative 2, Shell may drill these six wells in as few as two drilling seasons, but may extend operations into subsequent seasons. Consequently, effects on resources could fall somewhere between the opposite ends of the spectrum represented by as few as 2 seasons (Alternative 2) to at least 6 seasons (Alternative 3). This section discusses the potential effects of each alternative along this spectrum of possible adjustments to the scenario for each resource of concern.

Further variations may occur in terms of the length of a given drilling season. Shell proposes to drill up to October 31, but would not necessarily remain in the project area until that date each year. An early departure from the drilling area would also be more likely should the late-season drilling mitigation described in Section 2.3 be instituted. The effects analyses for each resource in Section 4 also account for potential variations in timing of activities within individual seasons.

Potential cumulative effects are then discussed under each resource category. Each cumulative effects subsection discusses past, present, and reasonably foreseeable future actions that could affect each resource, and analyzes the potential for each of the three alternatives to contribute (either incrementally or synergistically) to these impacts. Analysis of potential impacts from fuel and oil spills of various sizes is also included within each resource category. Assumptions informing this portion of the analysis are explained in Section 2.4.9 and Appendix A.

A level of effects determination (i.e. negligible, minor, moderate or major) is provided for each alternative. These determinations are based on the definitions provided in Appendix B.

## 4.1 Air Quality

The offshore oil exploration plan proposed for the Chukchi Sea would cause emissions of potentially harmful air pollutants that are regulated under the Clean Air Act (CAA, as amended, 42 USC §7401 et seq.). This section assesses the potential for adverse air quality effects due to the Proposed Action and the project alternatives, and evaluates the effects relative to CAA Section 165(a)(3) and Section 163(b)(2) and (4), for compliance with maximum allowable emission increases, and the National Ambient Air Quality Standards (NAAQS). The potential air quality impacts were assessed by evaluating the dispersion analysis based on an inventory of emissions projected to occur throughout an exploratory drilling plan of 120 days per year. The Proposed Action is located more than 25 miles from the three-geographical mile seaward boundary in the Chukchi Sea; therefore, the assessment was prepared pursuant to the federal OCS Air Regulations (40 CFR Part 55). Because of the location of the proposed drilling sites, the Proposed Action is not subject to Alaska air quality control rules and there is no designated Corresponding Onshore Area (COA) where State rules apply. The Nearest Onshore Area (NOA), the onshore area that is geographically closest to the drilling sites, is located 64 miles from the proposed drilling locations. Information reviewed and incorporated into this assessment includes the analytical review of projected emissions and pollutant concentrations as provided in the Shell EIA in Appendix F of the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a). Additional information was available through the permit review documents prepared by the EPA, including the Statement of Basis (EPA, 2011a). Various sections in this environmental review provide information relative to the air regulations, meteorology, and climate of the Arctic; existing air quality on the North Slope; and characteristics of the emission sources considered in the air quality assessment. A list of the relevant sections is provided in Appendix D, Air Quality.

### 4.1.1 Alternative 1 – No Action

Under this alternative, the exploration plan would not be approved and no new direct or indirect emissions would occur. As such, this alternative would have no impact on air quality.

### 4.1.2 Alternative 2 – Proposed Action

The air quality impact of the Proposed Action was assessed by preparing an inventory of emissions from direct and indirect sources. The inventory of marine vessel emissions considers the use of ultra-low sulfur diesel (ULSD) fuel and Best Available Control Technology (BACT) to reduce emissions to the lowest practicable levels. A summary of the annual emissions inventory is provided in Table 27. Nitrogen oxide ($NO_x$) emissions from the stationary OCS source are greater than 250 tons per year and the use of ULSD fuel and BACT is not sufficient to lower the value to below 250 tons per year. For this reason, the stationary OCS source is considered a major stationary source and Shell is required to submit an application for a Prevention of Significant Deterioration (PSD) pre-construction permit from EPA Region 10 in Seattle, Washington.

**Table 27. Annual emissions summary.**

| Emission Source | Emissions[1] (tons per year) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $NO_X$ | $PM_{2.5}$ | $PM_{10}$ | CO | $SO_2$ | VOC | $NH_3$ | $CO_{2e}$ |
| **Stationary OCS Source** | | | | | | | | |
| *Discoverer* Drillship | 20.90 | 2.53 | 2.53 | 6.47 | 0.22 | 3.16 | 0.509[2] | 12,805 |
| Ice Management | 37.20 | 6.15 | 6.35 | 29.15 | 0.27 | 6.83 | | 16,676 |
| Anchor Handlers | 37.80 | 6.27 | 6.47 | 29.52 | 0.27 | 6.92 | | 16,620 |
| OSV Transit Mode | 16.90 | 0.50 | 0.50 | 3.60 | 0.01 | 1.30 | | 1,896 |
| OSV Dynamic Positioning Mode | 33.80 | 0.90 | 0.90 | 7.30 | 0.01 | 2.70 | | |
| OSR Vessels | 98.10 | 1.04 | 1.44 | 27.61 | 0.27 | 9.74 | | 5,561 |
| OSR Work Boats | 14.40 | 1.00 | 1.00 | 3.10 | 0.01 | 1.10 | | |
| ***Subtotal Stationary OCS Source*** | ***259.10*** | ***18.39*** | ***19.19*** | ***106.75*** | ***1.06*** | ***31.75*** | ***0.509*** | ***53,558*** |
| *Major Source Threshold* | 250 | 250 | 250 | 250 | 250 | 250 | 250 | None |
| **Mobile Sources** | | | | | | | | |
| Auxiliary Marine Vessels | 158.00 | 11.00 | 11.00 | 28.00 | 0.00 | 5.00 | 0.00 | 6,598 |
| Aircraft | 0.17 | NA | NA | 3.48 | 0.08 | 1.47 | | 204 |
| Surface Vehicles | 0.003 | 0.00003 | 0.00006 | 0.033 | 0.00003 | 0.0016 | | NA |
| ***Subtotal Mobile Sources*** | ***158.17*** | ***11.00*** | ***11.00*** | ***31.51*** | ***0.08*** | ***6.47*** | ***0.00*** | ***6,802*** |
| Total Project Emissions | 417.27 | 29.39 | 30.19 | 138.26 | 1.14 | 38.22 | 0.509 | 60,360 |

Note: $CO_{2e}$ is the carbon dioxide equivalent, and represents greenhouse gas (GHG) emissions.
Annual refers to one total drilling season, approximately 120 days.
NA is not available.
Values of 0.00 are not zero, rather the values are less than 0.005 tons/year.

[1] Emissions are calculated with BACT.

[2] Emissions of NH3 were calculated from MLC and well-drilling, and from cementing/logging using the drillship *Discoverer*.

Source: Shell (2011a), Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea, Alaska. Table 7.a-3, Annual Potentials to Emit for Emission Units on the *Discoverer* and Associated Support Fleet. RFAI 2 and 4-*Discoverer*_EI_Chukchi_20110602_D.xls [BOEMRETables], [SCR-NH3 Emis], & [GHG Only].
Federal Aviation Administration (FAA). 2011. Emissions and Dispersion Modeling System (EDMS v. 5.1.3). Washington, D.C.:FAA Office of Environment and Energy.

The emission inventory reflects the worst-case scenario for annual emissions because in the analysis the drillship *Discoverer* is assumed to operate the entire 120-day drilling season, regardless of how many wells are actually drilled. For instance, drilling three wells would require approximately 102 days, not 120 days. As such, the inventory reflects the highest possible emissions for one drilling season. The type and level of impacts to air quality are not expected to vary if Shell exits the drilling area sometime prior to late October. Impacts described under Alternative 2 are the worst-case possible impacts and would not be greater or more substantial in the event of a shorter drilling schedule.

The emission inventory for the OCS stationary source presented in Table 27 was translated into pollutant concentrations through computer dispersion modeling (ambient air analysis). A summary of the projected potential pollutant concentrations is provided in Table 28 and Table 29.

**Table 28. Projected ambient air analysis of $NO_2$ and $SO_2$ emissions.**

| Pollutants and Averaging Periods | Projected Pollution Concentrations (μg /m³) $NO_2$ | | $SO_2$ | | | |
|---|---|---|---|---|---|---|
| | 1-hr | Annual | 1-hr | 3-hr | 24-hr | Annual |
| **NAAQS** | 188 | 100 | 196 | 1,300 | 365 | 80 |
| **Max Allowable Increase (MAI)** | --[1] | 25 | --[1] | 512 | 91 | 20 |
| **Project-Only Impact (not including background concentrations)** | | | | | | |
| **Point Lay** | 11.8 | 0.05 | 2.2 | 1.2 | 0.7 | 0.2 |
| Percent of NAAQS | 6.3% | 0.1% | 1.1% | 0.1% | 0.2% | 0.3% |
| Percent of MAI | --[1] | 0.2% | --[1] | 0.2% | 0.8% | 1.0% |
| Exceeds 50% | No | No | No | No | No | No |
| **Wainwright** | 4.9 | 0.03 | 2.2 | 1.2 | 0.7 | 0.2 |
| Percent of NAAQS | 2.6% | 0.03% | 1.1% | 0.1% | 0.2% | 0.3% |
| Percent of MAI | --[1] | 7.0% | --[1] | 0.2% | 0.8% | 1.0% |
| Exceeds 50% | No | No | No | No | No | No |
| **Total Impact (design concentrations added to background concentrations for total impact)** | | | | | | |
| **Point Lay** | 11.8 | 0.05 | 2.2 | 1.2 | 0.7 | 0.2 |
| Background Concentrations | 41.0 | 2.0 | 14.0 | 14.0 | 14.0 | 0.4 |
| *Sum of Total Impact* | *52.80* | *2.05* | *16.20* | *15.20* | *14.70* | *0.60* |
| Exceeds NAAQS | No | No | No | No | No | No |
| **Wainwright** | 4.9 | 0.03 | 2.2 | 1.2 | 0.7 | 0.2 |
| Background Concentrations | 38.0 | 2.0 | 12.0 | 14.0 | 5.0 | 0.4 |
| *Sum of Total Impact* | *42.9* | *2.03* | *14.2* | *15.2* | *5.7* | *0.6* |
| Exceeds NAAQS | No | No | No | No | No | No |
| **Air Impact Boundary[2]** | 160.8 | 3.3 | 17.3 | 13.6 | 8.1 | 1.4 |
| Background Concentrations | 13.2 | 2.0 | 23.0 | 14.0 | 5.0 | 0.4 |
| *Sum of Total Impact* | *174.0* | *5.3* | *40.3* | *27.6* | *13.1* | *1.8* |
| Exceeds NAAQS | No | No | No | No | No | No |

[1] Maximum allowable increases (MAI) are not established for these pollutants or averaging periods.
[2] Air Impact Boundary is defined as 500 meters from the hull of the drillship *Discoverer*.

Sources: 40 CFR Part 52.21(c). Ambient Air Increments, Maximum Allowable Increases for a Class II Area.
CAA Section 163(b)(2). Class II Area Maximum Allowable Increases.
71 FR 61144 10/17/2006. National Ambient Air Quality Standards for Particulate Matter, Final Rule. (revokes PM10 annual standard)
EPA. July 6, 2011. Supplemental Statement of Basis for Proposed Outer Continental Shelf Prevention of Significant Deterioration Permits Nobel *Discoverer* Drillship. Table 6, 1-Hour $NO_2$ Modeled Impacts at Various Locations, Table 7, 1-Hour $SO_2$ Modeled Impacts at Various Locations, and Table 9, Maximum Modeled Impacts in the Chukchi Sea.
Shell. AERMOD Air Quality Impact Analysis of $NO_2$, $SO_2$, $PM_{2.5}$, $PM_{10}$, CO, and $NH_3$ - *Discoverer* Drillship. Table 6 Summary of Maximum Impacts at the Nearest Villages on the Chukchi Coast - Chukchi Sea. Prepared by Air Sciences.

**Table 29. Projected ambient air analysis of $PM_{10}$, $PM_{2.5}$, and CO emissions.**

| Projected Pollution Concentrations ($\mu g/m^3$) | | | | | |
|---|---|---|---|---|---|
| Pollutants and Averaging Periods | $PM_{2.5}$ | | $PM_{10}$[1] | CO | |
| | 24-hr | Annual | 24-hr | 1-hr | 8-hr |
| **NAAQS** | 35 | 15 | 150 | 40,000 | 10,000 |
| **Max Allowable Increase (MAI)** | 9[2] | 4[2] | 30 | --[3] | --[3] |
| **Project-Only Impact (not including background concentrations)** | | | | | |
| **Point Lay** | 0.2 | 0.003 | 0.2 | 298 | 132 |
| Percent of NAAQS | 0.6% | 0.02% | 0.13% | 0.% | 1.3% |
| Percent of MAI | 2.22% | 0.075% | 0.67% | --[2] | --[2] |
| Exceeds 50% | No | No | No | No | No |
| **Wainwright** | 0.3 | 0.003 | 0.2 | 298 | 132 |
| Percent of NAAQS | 0.9% | 0.02% | 0.1% | 0.8% | 1.3% |
| Percent of MAI | 3.3% | 0.08% | 0.7% | --[2] | --[2] |
| Exceeds 50% | No | No | No | No | No |
| **Total Impact (design concentrations that includes background concentrations)** | | | | | |
| **Point Lay** | 0.2 | 0.003 | 0.2 | 298 | 132 |
| Background Concentrations | 7.0 | 2.0 | 65.0 | 1029 | 1029 |
| *Sum of Total Impact* | *7.20* | *2.00* | *65.20* | *1,327* | *1,161* |
| Exceeds NAAQS | No | No | No | No | No |
| **Wainwright** | 0.3 | 0.003 | 0.2 | 298 | 132 |
| Background Concentrations | 13.0 | 2.0 | 114.0 | 959.0 | 945.0 |
| *Sum of Total Impact* | *13.3* | *2.003* | *114* | *1257* | *1077* |
| Exceeds NAAQS | No | No | No | No | No |
| **Air Impact Boundary** [3] | 12.4 | 0.4 | 11.5 | 562 | 329 |
| Background Concentrations | 11.0 | 2.0 | 79.0 | 959 | 945 |
| *Sum of Total Impact* | *23.4* | *2.4* | *90.5* | *1,521* | *1,274* |
| Exceeds NAAQS | No | No | No | No | No |

[1] The NAAQS for annual PM10 averaging period standard has been revoked; the averaging period was not analyzed.
[2] Maximum allowable increases (MAI) are established only for federal rules for these pollutants; not established for Alaska.
[3] Maximum allowable increases are not established for these pollutants or averaging periods under federal rules or for Alaska.
[4] Air Impact Boundary is defined as 500 meters from the hull of the drillship *Discoverer*.

Sources: 40 CFR Part 52.21(c). Ambient Air Increments for a Class II Area
CAA Section 163(b)(2). Class II Area Maximum Allowable Increase.
71 FR 61144 10/17/2006. National Ambient Air Quality Standards for Particulate Matter, Final Rule. (revokes PM10 annual standard)
EPA. July 6, 2011. Supplemental Statement of Basis for Proposed Outer Continental Shelf Prevention of Significant Deterioration Permits Nobel *Discoverer* Drillship. Table 6, 1-Hour NO2 Modeled Impacts at Various Locations, Table 7, 1-Hour SO2 Modeled Impacts at Various Locations, and Table 9, Maximum Modeled Impacts in the Chukchi Sea.
Shell. AERMOD Air Quality Impact Analysis of NO2, SO2, PM2.5, PM10, CO, and NH3 - *Discoverer* Drillship. Table 6 Summary of Maximum Impacts at the Nearest Villages on the Chukchi Coast - Chukchi Sea. Prepared by Air Sciences.

The data in Table 28 reflects the results of the ambient air analysis for the pollutants $NO_2$ and $SO_2$; whereas Table 29 provides results for the remaining pollutants $PM_{2.5}$, $PM_{10}$, and CO. Pollutant concentrations were modeled at three locations - along the air impact boundary (defined as 500 meters beyond the hull of the drillship *Discoverer*), at the nearest onshore location at Wainwright, and at the next nearest community at Point Lay. The modeling results at these locations are presented in the tables using two methods (1) concentrations resulting only from the project-related emissions (project-only impact), and (2) the design concentrations, which are the project-only impacts added to existing background concentrations (total impact). The tables show the comparison of the results to the maximum allowable increases and the NAAQS, indicating whether the project-only impacts exceed 50 percent of either threshold. The tables also compare the design concentrations to the NAAQS, indicating whether the standards are exceeded (excluding ozone). These comparisons are the basis of the BOEM determination of the significant level of effect for air quality.

During actual drilling, the drillship *Discoverer* and support vessels operating within 25 miles of the drillship are collectively defined as a stationary OCS source. All other marine vessels operating in support of the exploration plan are considered mobile sources. The assessment of emissions from the stationary OCS source is based on the air quality technical analysis provided in the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), which includes an EIA in Appendix F. The air quality assessment in the Shell EIA focuses on the analysis supporting the application for the PSD air quality operating permit. The Revised EP and the permit application, together with all subsequent supporting documentation, include all drillship emission information and emission reduction measures required for a NEPA analysis of the stationary source (30 CFR Part 550.224 and Part 550.225). These documents also contained the required dispersion analysis necessary to determine air quality impacts at communities on the North Slope.

In the assessment of air quality impacts associated with the Proposed Action, the stationary OCS source inventory included emissions of greenhouse gases (GHG) and carbon dioxide equivalent emissions ($CO_2e$). In a June 2010 ruling by the EPA, referred to as the Tailoring Rule, the agency established a schedule for the applicability criteria that determine which new stationary sources are required to report GHG emissions from federal actions (75 FR 31514, June 3, 2010). The Tailoring Rule states that as of July 1, 2011, a new stationary source is not subject to GHG regulations unless the federal action emits or has the potential to emit 100,000 tons per year or more of $CO_2e$. The inventory shows potential emissions of $CO_2e$ from both direct and indirect sources would be less than 61,000 tons per year. As such, the requirement for further analysis of GHG emissions would not apply to the Proposed Action.

Other emission sources would include auxiliary marine vessels, aircraft, and surface vehicles not directly involved in drilling activities and not part of the stationary OCS source during actual drilling. Rather, the sources are used to support the operation of the exploration plan, and include shallow water landing craft, barges, and tugs; and include helicopters and surface vehicles for the transportation of personnel. Helicopters were assumed to operate from the airport in Barrow, Alaska, where personnel are housed.

### Black Carbon

Black carbon, commonly referred to as soot, is a pollutant with high radiative forcing that supports warming trends in the Arctic. Radiative forcing is the result of the difference between the expected amount of incoming and outgoing solar energy, where radiative forcing is measured in watts per square meter. The analysis required to find the actual value of this ratio is complicated, and involves not only black carbon but other factors such as natural deforestation and volcanic activity (Chandler, 2010). Soot emissions from diesel engines have a tendency to decrease the albedo, or reflectivity, of sea ice. The decrease in albedo contributes to warming and loss of sea ice. The drillship and other marine vessels proposed for the exploration plan use diesel engines for propulsion and drilling and would be the largest source of black carbon attributable to the exploration plan. However, the loss of sea ice is not affected solely by black carbon deposits, but depends on snow cover, ice age, ice thickness, and state of melting as well (Dorn, Dethloff, and Rinke, 2009). Also, the magnitude of Arctic snow albedo effects is seasonal, and the effect is not measurable in the dark Arctic winter (Kopp and Mauzerall, 2010). A mitigation strategy to decrease the emissions of particulate matter, the main source of black carbon from a diesel engine, is the use of ULSD fuel. Sulfur is emitted directly as a component of burning crude oil and is found in both gasoline and diesel. Using ULSD fuel controls emissions of $NO_X$ and PM, which lowers the emissions of black carbon. Particulate filters on engines using ULSD fuel reduce PM emissions by 50 percent to near 100 percent. The State of

Alaska finalized a rule making the use of ULSD fuel mandatory in all highway, non-road, locomotive, and marine diesel engines (71 FR 32450, June 6, 2006). The drillship would be equipped with other emission reduction equipment, as required in the air quality permit for the drillship *Discoverer*. Thus, emissions of black carbon would be reduced to the greatest extent possible.

### Small Fuel Spill

An oil spill, even a small spill of less than 1,000 barrels (bbl), would cause an increase in the concentrations of gaseous hydrocarbons (VOC) which could affect onshore air quality. Although effects would be localized and temporary, concentrations of criteria pollutants may exceed the federal and Alaska ambient air quality standards during the initial phases, particularly offshore in the vicinity of the event. However, major impacts at the spill-site may cause only minor impacts onshore, depending on how far from shore the spill occurs; impacts onshore would go down with increasing distance from the coastline. As surface oil evaporates or is removed, as any fires are extinguished, and as the use of additional clean-up equipment lessens, impacts would eventually decrease to a minor level. Accordingly, while initial impacts are estimated to be major at the spill site, the emissions from the oil spill at most onshore locations would be minor to moderate.

Emissions from the occurrence and clean-up of a large oil spill would consist primarily of VOCs created from oil on the surface of the water. However, in the event of an initial explosion of gas and oil, the result would be a large black plume of smoke causing short-term emissions of PM and the other products of combustion, such as $NO_X$, $SO_X$, CO, VOC, and $CO_2$. The fire could also produce polycyclic aromatic hydrocarbons (PAHs), which are known to be hazardous to human health. The severity of impacts would decrease following the initial event and emissions would be limited to mostly VOCs from the surface oil and emissions associated with engines from vessels and other equipment used for the clean-up process. By the time the oil reaches the shoreline, emissions from the surface oil would decrease due to weathering and decreased thickness of the oil layer. During the clean-up process, the impact to onshore air quality may increase slightly due to the combination of in situ burning, use of dispersants, and the use of vessels, surface vehicles, and aircraft to support the clean up. Eventually, the continuing decrease in surface oil, lessening use of clean-up equipment, and the effect of Arctic winds would be expected to decrease any onshore air quality impacts to minor levels of effect.

### Large and Very Large Oil Spills

The potential effects of a large oil spill (≥ 1,000 bbl) in the Chukchi Sea were analyzed in the Sale 193 Final EIS (MMS, 2007), which found moderate to major effects on air quality during the initial event and during the response and cleanup process. Effects of evaporative hydrocarbon emissions would diminish with time because most of the surface oil would evaporate with time before reaching the shoreline. The potential effects of a very large oil spill (≥ 150,000 bbl) in the Chukchi Sea were analyzed in the Sale 193 Final SEIS (BOEMRE, 2011), which again found moderate to major effects on air quality during the initial event and during the response and cleanup process. As above, effects would diminish with time because most of the surface oil would evaporate before reaching the shoreline (where effects would be minor).

### Level of Effect

Upon reviewing the relevant documents, and after evaluating the results of the emission inventory and ambient air analysis presented Table 28 and Table 29, BOEM expects much the same level of effect from the Proposed Action as characterized in the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a). BOEM considers the Proposed Action to be compliant with the federal air quality standards and without potential to cause or contribute to any violation of the NAAQS, which define healthful outside air quality. Emission sources onshore would produce emissions far below the negligible level of 100 tons per year defined by BOEM. Accordingly, the Proposed Action is found to be compliant with the relevant provisions of the CAA and the federal OCS Air Regulations (40 CFR Part 55). As such, the level of effect on air quality caused by the Proposed Action is considered minor for the exploration plan using the drillship *Discoverer*. A thorough description of the levels of effect relevant to air quality impacts are provided in Appendix D - Air Quality. The effects would occur each season that Shell conducts exploratory drilling operations under this exploration plan. The minor effects, however, are temporally limited and consecutive years of activity would not have any greater effect than described under this project alternative.

### 4.1.3 Alternative 3 – One Well per Season

The analysis of Alternative 2, the Proposed Action, reflected the maximum possible emissions from an exploration plan with actual drilling occurring for the maximum period of 120 days. Under this alternative only one well would be drilled per summer season, which would require drilling for fewer days than evaluated under Alternative 2 – Proposed Action. Therefore, impacts to air quality under Alternative 3 would not be greater, and would likely be much less, than the impacts described under Alternative 2. Overall, the level of effect on air quality that could occur under Alternative 3 is considered negligible to minor for the exploration plan using the drillship *Discoverer*. The annual effects of each season, while Shell conducts exploratory drilling operations under this Revised EP, will not be greater than the effects described under Alternative 2 – Proposed Action, and would be temporally limited. The type and level of impacts to air quality are not expected to vary if Shell exits the drilling area sometime prior to late October. Impacts described under Alternative 2 are the worst-case possible impacts and would not be any greater or more substantial in the event of a shorter drilling season. Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

### 4.1.4 Cumulative Effects

The Proposed Action includes the temporary use of marine vessels, aircraft, and surface vehicles, which are pollutant sources that could contribute to the emission budget within the North Slope Borough. Pollution from Alternative 2 or 3 could add to pollution from other activities in the region to have an adverse cumulative effect on air quality. Specifically, any additional activities occurring during the same time period and in the same general area requiring the use of large marine vessels may cause emissions to build up in the atmosphere to levels harmful to human health or wildlife, particularly when combined with existing emissions in the area. However, in consideration of the prevailing wind conditions over the open sea, the few emission sources onshore, and the distance of the proposed drilling sites from the shoreline, emissions from the Proposed Action—when combined with other operations in the Chukchi Sea—would likely be diluted and dispersed resulting in pollutant concentrations far below the air quality standards at the shoreline. The reasonably foreseeable cumulative effects would occur at nearly the same level each season that Shell conducts exploratory drilling operations under this exploration plan. For the life of the project, impacts to air quality from the Proposed Action and from reasonably foreseeable cumulative activities would amount to a minor level of effect. A thorough description of the relevant additional activities that are recent, ongoing, or reasonably foreseeable, and that could result in measurable adverse cumulative air quality impacts, is provided in Appendix C. The level of air quality effect when considered together with the emissions from the Proposed Action would be minor and would not result in adverse cumulative impacts to air quality.

## 4.2 Water Quality

### 4.2.1 Alternative 1 – No Action

Under this alternative, the proposed exploration drilling would not be approved, and no impacts to water quality would result.

### 4.2.2 Alternative 2 – Proposed Action

The proposed exploration activities would entail several types of discharges authorized by National Pollutant Discharge Elimination System (NPDES) General Permit AK280000 (Offshore Oil and Gas Exploration Facilities in Alaska), including drilling wastes (cuttings and water-based drilling fluids), excess cement, oil-free deck drainage, treated sanitary waste, blow-out preventer fluids, domestic waste, desalination waters, non-contact cooling water, bilge water, and ballast water. Non-hazardous solid waste, hazardous waste and used oil would be stored and taken to an approved onshore waste facility. Support vessels would discharge domestic wastewater and treated sanitary waste into the sea according to applicable NPDES Vessel General Permit regulations.

The type and degree of effects on water quality from discharges into the marine environment are influenced by several physical factors including: rate of discharge, depth of discharge, concentration of contaminants, currents, bathymetry, density layers, oxygen concentration and water temperature. These factors are considered by EPA under its NPDES permitting process. The paragraphs below describe the types of discharges and potential effects on water quality associated with the Proposed Action.

**Drill Cuttings:** An estimated 5,800 barrels of drill cuttings would be generated from each exploration well for a maximum of 17,400 barrels of drill cuttings discharged in a given season (an estimated total of 34,800 barrels of cuttings over the entire proposed program) and up to 35,800 barrels of drill cuttings overall. Discharged cuttings (occurring over 30-45 days for each well) would settle out of the water column, the rate of deposit depending on sediment mineralogy and grain size. It is estimated, based on volume excavated, that cuttings would settle out on the seafloor within approximately 276 horizontal feet down-current from the drill site. Near the drill site, the thickness of the deposition is estimated to be up to approximately 6 ft deep; the depth of the deposition decreases to 0.4 in at a distance of 276 horizontal feet from the drill site.

Discharge of drill cuttings would increase suspended sediment and turbidity in the water column in the vicinity of the drill sites, causing decreased light transmitivity and visibility. The newly deposited cuttings on the seafloor could resuspend into the water column as a result of currents and severe storm events. Hydrocarbon concentrations, including polycyclic aromatic hydrocarbons (PAH) and some metals could become elevated in the lower water column and seafloor sediments at the drill site from discharge of drill cuttings.

**Drilling Fluid:** An estimated 3,200 barrels of drilling fluids would be discharged to the sea from each exploration well. Under this alternative, that would be up to approximately 9,600 barrels in a given drilling season. Fluids would cause increased suspended material and would settle on the seafloor (estimates of seafloor coverage are included in the cuttings estimations above). Barium from discharge of drilling fluids would cause elevated concentrations in the lower water column and in seafloor sediments. These concentrations may persist for years in the sediments.

**Mudline Cellars:** Seafloor material would be excavated to construct up to four mud cellars in a season. Each well would disturb 1,018 $ft^2$ of seafloor for 3,053 $ft^2$ in each of two drilling seasons (6,107 $ft^2$ over the entire drilling program). Each mud cellar would excavate 619 $yd^3$ of seafloor for a maximum of 2,476 $ft^3$ per drilling season and 3,714 $yd^3$ total for the entire drilling program. Cuttings from the mud cellar excavations would be deposited on the seafloor below the temperature and salinity stratification layer. It is estimated that the maximum thickness of the sediment deposition onto the seafloor would be 10.4 ft; the deposition would continue out to a horizontal distance of 449 ft from the excavation sites where it would be 0.4 in thick.

The excavation of four mud cellars in a season would increase sediment, suspended solids, and turbidity in the lower water column above background levels, dependent upon the mineralogy and grain size of the sediments excavated. Currents and severe storm events could resuspend and transport these newly deposited seafloor sediments.

**Anchoring:** Anchoring the drillship would disturb the seafloor area where each of the eight anchors is set. If re-positioning occurs, the estimated total number of anchors set per drill ship could be 16 per season or 64 over the entire program. Each anchor and chain would disturb 2027 $ft^2$; under this scenario, 34,432 $ft^2$ would be disturbed for each well for a total disturbance of up to 97,297 $ft^2$ of seafloor per year. The process of anchoring would introduce suspended sediment and turbidity into the lower water column. Sediment would then be deposited on to the seafloor down-current from the anchoring.

**Wastewater Discharge:** Non-contact cooling water would be discharged from the drillship at a rate of approximately 45,000 bbl of per day. The cooling water would be discharged above the salinity and temperature stratification layer and would mix in the surface waters. It is estimated that the discharge would be to be 1.4 C above ambient sea temperature, and the effects would be reduced by 99% within 164 horizontal feet.

Desalination brine would be discharged above the salinity-temperature stratification layer with slightly higher salinity and other dissolved constituents than the ambient receiving water. Salinity would briefly increase in the area near the discharge before it mixed with surface water.

Domestic wastewater and treated sanitary waste will be discharged from the drillship and support vessels. Organic materials in the wastes could cause temporary biological oxygen demand and increased suspended solids in the immediate area of the discharge. Residual chlorine would also be part of the waste discharge, which would mix and transport from the immediate area.

**Small Spill:** There is a potential for a small fuel spill (estimated at 48 bbl of diesel fuel) during fuel transfers between vessels. A fuel spill would introduce hydrocarbons and temporary toxicity to the surface water. The effects of a fuel spill would be limited by required deployment of booming equipment during fuel transfers and automatic shutdown of fuel lines triggered by decreased pressure. The effects would be localized and short-term.

**Large and Very Large Oil Spill.** Although very unlikely, it is possible that the Proposed Action could lead to a large or very large oil spill. For the purpose of analysis, BOEM estimates potential discharge volumes for this EA to be 1,555 bbl of diesel for a large spill and 750,000 bbl of crude oil for a very large spill. The Sale 193 Final EIS analyzed potential effects to water quality from large spills (≥ 1,000 bbl) and found that sustained degradation of water quality levels from hydrocarbon contamination would be unlikely. The Sale 193 Final SEIS analyzed potential effects to water quality from a very large spill (≥150,000 bbl) and found that a spill of this magnitude would lead to sustained degradation of water quality, violations of State and Federal criteria, and significant effects. These analyses remain sufficient to analyze the effects of large and very large spills in the Chukchi Sea, including potential spills of 1,555 bbl diesel and the 750,000 bbl crude oil estimated in this Environmental Assessment (EA).

### Mitigation

The following aspects of the Proposed Action would mitigate potential water quality effects:

- Operations conducted under NPDES permit as authorized and administered by EPA
- Booming fuel transfer activities

- Equipment for early warning of a potential well-control event
- Oil spill response vessels in the immediate vicinity of the drilling operations
- Adherence to the following plans: Critical Operations and Curtailment Plan; Ice Management Plan; Well Control Contingency Plan; and Fuel Transfer Plan

#### Summary of Effects – Alternative 2

The volume of sediment, cuttings, and wastewater released to the water column in the region of Burger Prospect would cause higher levels of suspended solids, turbidity, hydrocarbon, metals, salinities and temperatures in the water column in the areas of the discharges. This would occur for two or more open water seasons. The EPA has determined that the discharges described under the NPDES permit for this proposed offshore oil and gas operation would not result in unreasonable or substantial water quality degradation in the Chukchi Sea. Discharge of drill cuttings, drilling fluids, mudline celler sediments and wastewater would be highly localized around the drill site. Some low-level metal and hydrocarbon signatures may be long lasting in the sediments at the drill sites as a result of the deposition of the cuttings and drilling fluids. The Proposed Action is not expected to cause unreasonable degradation of the marine environment. The level of effects for Alternative 2 would be minor according to the definitions established for this environmental assessment.

### 4.2.3 Alternative 3 – One Well per Season

Under Alternative 3, BOEM would authorize Shell to drill one well to depth per season. Drilling cuttings, water-based drilling fluids, excess cement, oil-free deck drainage, treated sanitary waste, blow-out preventer fluids, domestic waste, desalination waters, non-contact cooling water, bilge water, and ballast water would be discharged in accordance with the applicable NPDES permit. The quantity of materials discharged per well would be the same as the "per well" quantities described above for Alternative 2. Points of discharge, applicable permitting requirements, and mitigation measures are the same as for Alternative 2.

The key difference between these alternatives is that under Alternative 3, discharges from six wells would be spread out over six drilling seasons.

#### Summary of Effects: Alternative 3

This alternative would cause elevated levels of suspended solids, turbidity, hydrocarbon, metals, and localized salinities and temperatures in the water column at an individual, localized site each year for six years. Compared with Alternative 2, the effects of the drilling activities and discharges in Alternative 3 would affect a smaller spatial area at a less intense level, but over a longer time frame (six seasons). The total volume of sediment, cuttings, and drilling fluids released to the water column in the region of the Burger Prospect would be the same between the two alternatives.

The EPA determined that the discharges described under the NPDES permit for this oil and gas operation would not result in unreasonable or substantial water quality degradation in the Chukchi Sea. The effects of Alternative 3 (1 well for each of six seasons) would not cause unreasonable degradation of the marine environment. Therefore, the effects of Alternative 3 would be minor according to the Level of Effects established for this environmental assessment. These effects are not expected to vary if Shell leaves the drilling area each year sometime prior to late October.

Under Alternative 3, the potential for a large or very large petroleum spill could be spread across additional seasons, but the potential environmental effects on water quality would be the same as was analyzed under Alternative 2.

### 4.2.4 Cumulative Effects

Cumulative effects are discussed in detail in the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a: pp. 297-313) and in Appendix C of the current document. The number of marine cargo, tourism and research vessels and barges in the Chukchi region is increasing as ice cover is reduced. This increases the risk of vessel accidents, vessel groundings, potential oil and cargo spills, permitted discharges, and introduction of marine invasive species.

These reasonably foreseeable activities would occur against the backdrop of climate change, which is anticipated to affect water quality in the future through warming of the sea surface, reduction in sea ice, and increased ocean acidity.

The incremental effects of the proposed exploratory drilling under Alternatives 2 and 3 would add a minor effect (through additional discharges to the sea) to the other ongoing activities. The discharges from this proposed project would be additive to the existing and future activities described here.

## 4.3 Lower Trophic Levels

### 4.3.1 Alternative 1 – No Action

Under the no action alternative, the proposed exploration activities would not be approved, and no effects to lower trophic resources would occur.

### 4.3.2 Alternative 2 – Proposed Action

Alternative 2 is the Proposed Action, wherein Shell intends to drill six exploratory wells on six separate sites within the Burger Prospect in the northeast Chukchi Sea. Up to three wells could be drilled to total depth (and an additional MLC constructed) in a given season, if conditions allow. But Shell's plan is flexible, and allows for the possibility of leaving the drilling area earlier than the proposed October 31$^{st}$ exit date.

Direct and indirect effects on the lower trophic resources could result from the following:

- Sediments displaced during anchoring of all vessels including drilling rigs.
- Construction of the MLCs and subsequent release of materials during drilling phases.
- Potential construction of accessory MLCs and partial wells beyond the six wells outlined in the proposed plan.
- The permitted discharges through the EPA NPDES permit.
- Potential of invasive species introduction.
- Potential liquid hydrocarbon spills during vessel refueling.

The effects on lower trophic populations would include the deposition of mercury, barium, and hydrogen sulfide on surface sediments due to sediment disruption, suspension, and deposition, and the perturbation of benthic environments due to ice gouging or advection of sediments from the Alaskan, Anadyr, Bering Sea, or Siberian Coastal currents. There are no known sensitive or unique biological communities within the leases of the proposed exploration drill sites that would be affected by these activities.

**Anchoring.** The *Discoverer* and its anchor handling vessel would deploy and retrieve eight anchors at each drill site during the proposed exploration period. There is also the potential that the drill ship could need to reposition the drill rig and re-anchor during drilling activities at any one exploration site. The total sediment displaced by the eight anchors used to moor the *Discoverer* during drilling operations, including anchor and chain scar volume during one deployment and retrieval event, is estimated at 3,122 $yd^3$ (2,387 $m^3$). Assuming eight deployments and retrievals of anchors--to account for two supplemental events where an MLC is constructed, or an adjustment of the drilling rig over one MLC that demands the anchors be repositioned at the site—the total sediment displaced, suspended, and deposited would be 24,979 $yd^3$ (19,908 $m^3$). A detailed discussion of anchor deployment, retrieval, and resulting discharges can be found in Section 2.3 of the Shell EIA (Shell, 2011a: Appendix F).

The process of anchoring vessels during drilling activities results in disturbed and suspended sediment within the pelagic water column. This sediment drifts with the current and is deposited over benthic environments, thus burying the underlying benthic communities. Recolonization of benthic communities would occur within one year, but growth of benthic organisms such as mollusks or polychaete to size ranges that would be utilized by benthic foragers such as walrus would take several years. However, the limited spatial coverage of these events, proposed to be no more than several hundred yards of coverage per well site, would result in a negligible level of effect.

**Drilling.** An MLC would be constructed at each drill site as preparation for the drilling operations. The MLC is a circular hole drilled into the hard mud under the surface of the benthic environment at the seafloor. For the *Discoverer*, the diameter will be at least 20 ft (6.1 m), with a depth of approximately 40 ft (12.2 m) below mudline. Estimated volume of displaced or disturbed sediment per MLC is approximately 2,976 bbl (619 $yd^3$, or 473 $m^3$). The effects of suspension of discharges and sediments from drilling operations would include a localized loss of some pelagic organisms. This would be the result of their inability to carry out metabolic functions caused by the temporary effects of sediment suspension in the water column. Loss of these organisms would be localized and they would likely be rapidly by the advection of water, which would carry organisms from downstream locations. Sediment displaced during creation of the MLC would result in a localized loss of pelagic organisms due to sediment suspension, and burial as a result of deposition of sediments. These would create a localized and temporary (approximately one year for the recolonization of affected areas) loss of benthic organisms pelagic and benthic communities directly affected by the suspension and deposition of the displaced sediments.

**Discharges.** Permitted NPDES discharges will include desalination brine waters, cooling waters, domestic wastewaters, spent drilling fluids, treated deck drainage, excess cement and blow-out preventer fluid. These will cause local and temporary effects to surface and pelagic environments and will be negligible.

**Invasive Species.** Several factors may potentially introduce invasive species during the Proposed Action. These include the use of equipment imported from other regions that may contain internal or surface viable life stages of invertebrate organisms, the presence of fouling organisms on hulls or propellers, and the release of ballast waters not properly discharged in transit. In conducting its proposed exploration activities, Shell would be responsible for preventing the introduction of invasive species through compliance with the National Invasive Species Act and policies of the USCG (refer to Appendix F). Therefore, the anticipated level of effect associated with the potential introduction of invasive species is negligible.

**Small Fuel Spill.** The effects of a small oil spill (<1,000 bbl)—estimated for this EA as a potential 48 bbl diesel spill—would be dependent upon sea conditions at the time of the spill. With high wind conditions and rough seas, the diesel would be rapidly diluted and dispersed and effects of the spill would be negligible. In calmer waters evaporation of the diesel would be rapid, and the area covered by dispersion of the remaining hydrocarbons would be dependent upon wind speed, wind direction, and water temperature. Loss of benthic organisms due to hydrocarbon poisoning would probably not occur due to dispersion of hydrocarbons before reaching benthic surface. Effects on pelagic organisms would be localized, and the levels of effect would be negligible.

**Summary of Anticipated Impacts.** In summary, all the above direct and indirect effects from Alternative 2-Proposed Action on pelagic, benthic, and epontic lower trophic organisms would be limited by the number of wells actually constructed per open water season. Drilling all six wells within two seasons would create displacement, suspension, and deposition of sediments at a higher annual level than any other alternative discussed. It would also increase the accumulations from release of discharges during drilling operations, and from drill and support ship discharges of NPDES permitted fluids, as described in Section 2 of the Shell EIA. The total effects of these activities would be minor. This determination is due to the potential of loss of benthic resources being compounded by the time required for resettlement and growth. These benthic lower trophic resources are important to trophic relationships in the region due to their capacity as bioturbators that increase the potential for regional productivity, and their potential as food resources for pelagic birds and marine mammals in the region. If the six-well drilling program extends beyond two seasons, the potential for effects on benthic invertebrate populations would decrease. The result would be negligible effects on the lower trophic resources. This would also result in reducing effects on productivity and, in turn, reduce indirect effects on upper level trophic resources such as pelagic bird and marine mammal populations.

**Large Oil Spill.** Effects of a large oil spill (≥ 1,000 bbl) on phytoplankton vary widely and are dependent on the concentration, type of oil or compounds used in the experiments, and the species being tested (Gonzalez, et al., 2009). Phytoplankton populations would be most affected during periods of spring and summer blooms that occur in early July through late August. Both laboratory and field studies have shown that hydrocarbons typically inhibit phytoplankton growth at higher concentrations (USDOI, MMS, 2007a). In cases where studies have been conducted following larger spills there was found to be little or no effects on phytoplankton populations (Diez, et al., 2009). This is thought to be due to the relatively rapid turnaround rate of phytoplankton generations (9-12 hours) and the influx of phytoplankton by advection from unaffected areas that replace population to pre-spill levels (National Research Council, 1985). Therefore, it is likely that the effects of a large oil spill on phytoplankton populations would be negligible.

The effects of petroleum based hydrocarbons on invertebrates have been observed by both field based observations and laboratory testing (Barron, 2007). Effects depend upon species tested, levels of exposure, and whether release of oil is at the surface (platform spill) or sub-surface (pipeline or wellhead). It is known that exposure to sunlight increases toxicity of petroleum by the enhanced creation of polcyclic aromatic hydrocarbons from raw crude (Duesterloh and Shirley, 2004). Effects of a large oil spill on zooplankton and benthic invertebrates would likely be minor due to the levels of oil released to the environment, with these effects being highly dependant upon the physical forcing mechanisms that move and break down the oil within the environment and resultant deposition of oil in the environment.

**Very Large Oil Spill.** Effects of a very large oil spill (≥ 150,000 bbl) are based on WCD calculations for the Burger Prospect of 750,000 bbl of crude oil. Potential for an oil spill of this magnitude is considered very low due to historical considerations discussed in Section 2.4.9 of this analysis. A very large oil spill analysis is provided in the Sale 193 Final SEIS, and although the magnitude of spill analyzed in that document is approximately 2.2 MMbbl, and the spill analyzed here is 750,000 bbl, the mechanics of spill response, the capacity of the physical environment to affect oil movement and weathering of hydrocarbons, and the ecology and biology of environmental degradation would be roughly similar in their potential to affect the environment of the Chukchi Sea planning area. The effects of a spill at this magnitude on lower trophic resources would be highly dependent upon season of year and resultant potential exposure of larval or other development stages of macroinvertebrates to crude oil byproducts, weather patterns, presence and classification of ice, residence time of oil within the water column or on the benthic surface, location of spill and spatial relationship to currents that could potentially advect the oil to other regions such as the Herald, Hanna, or Barrow Canyons and beyond into the Arctic Ocean, volume of oil reaching shore, and volume of oil in contact with benthic surfaces. Level of effects of a spill of this magnitude on pelagic lower trophic resources would likely be negligible on phytoplankton populations due to rapid recovery rate effected by advection of phytoplankton populations by way of regional currents and rapid (9-12 hours) generation time of phytoplankton resources. Zooplankton populations would be negligible to minor, based on potential effects of a culmination of factors as listed above and their potential effects on the slower reproductive biology of zooplankton populations. Level of effects on benthic resources would be minor to moderate, for the same rationale as given for the zooplankton lower trophic populations.

Additional analysis of potential impacts to lower tropic levels from large and very large oil spills is available in the Sale 193 Final EIS (USDOI, MMS, 2007) and the Sale 193 Final SEIS (USDOI, BOEMRE, 2011), respectively.

### 4.3.3 Alternative 3 – One Well per Season

Alternative 3 would limit Shell to one well per season, but would also extend the presence of the drill rig and support vessels and the resulting environmental effects to six seasons. Alternative 3 would limit Shell to one well per season. This reduction of activity within one season could lead Shell to conclude work and lead to an early departure from the drilling area (before the Oct. 31st deadline), thus creating a shorter total time spent in the Burger prospect during any single open water season. This alternative would also extend the presence of the drill rig and support vessels and the resulting environmental effects to six seasons.

The level of effect on these resources would remain negligible. Potential impacts associated with petroleum spills are the same as analyzed under Alternative 2.

### 4.3.4 Cumulative effects

Cumulative effects are discussed in detail in the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a: pp. 297-313) and in Appendix C of the current document, and are summarized below.

The cumulative effects on surface and pelagic resources of the lower trophics include climate change and warming of surface temperatures, changes in sea ice resulting in an increase in length of the open water season, potential increases in severe weather activities, and ocean acidification stemming from these changes. Anthropogenic effects include deposition of soot from air emissions, accidental spills of petroleum byproducts from vessel activities, release of effluents from drilling and support vessels, and surface disturbance from the passage of military, research, recreation, subsistence, and industry marine vessels and aircraft. These activities present a potential for adverse effects on trophic resources, but the advection of water masses through the proposed exploration drilling sites would probably prevent population effects on the pelagic lower trophic resources, and would make the cumulative effects negligible, localized, and temporary.

Natural effects specific to the benthic environment include ice gouging and ice melt from glaciers and winter snow cover. These contribute to the seasonal influx of nutrients and sediments to rivers and streams within drainages for waters of the Alaskan, Anadyr, Bering, Chukchi, and Siberian currents. Ultimately, such nutrients and sediments will be deposited over benthic environments. Anthropogenic effects include release of drilling fluids and other permitted discharges, anchor deployment and retrieval, and all subsequent release and deposition of permitted discharges and sediments during drilling activities. Anchoring activities will occur during deployment and retrieval of data collection buoys. Other ancillary activities are benthic sampling including fish trawls, van Veen grabs, vibracore, and cone penetration tests conducted for biological, chemical, and geological analysis. These activities present a potential for adverse environmental effects, but the sand, silt, and mud substrate of the benthic environments would make the cumulative effects negligible, local, and temporary.

The reasonably foreseeable cumulative effects are likely to occur at similar levels each season that Shell conducts exploratory drilling operations. If for any reason (e.g. any variations of the proposed mitigation measures or selection of Alternative 3 are chosen) Shell concludes work and exits the drilling area earlier than the October $31^{st}$ exit date, potential effects would be reduced due to the reduced time spent pursuing drilling activities. For the life of the project, the impacts to lower benthic resources from the Proposed Actions and from reasonably foreseeable activities amount to a negligible level of effect.

## 4.4 Fish and Essential Fish Habitat

### 4.4.1 Alternative 1 – No Action

Under Alternative 1, the proposed drilling program would not be approved, and no impacts to fish or Essential Fish Habitat would result.

### 4.4.2 Alternative 2 – Proposed Action

The effects under this alternative would result from drilling six exploration wells to depth in as few as two drilling seasons. Shell estimates that it can drill up to three wells to depth and excavate an MLC in a given season. The type of effects on fish and Essential Fish Fabitat (EFH) that could occur under this alternative include the following:

#### Sound from Operations

The proposed operations would expose fish to sound associated with vessel engines, excavating mud cellars, drilling, anchoring, ice management, aircraft traffic, and vertical seismic profiling.

Sound introduced into the environment through these activities could affect fish through interference with sensory orientation and navigation, decreased feeding efficiency, disorientation, scattering of fish away from a food source, and redistribution of fish schools and shoals (Fay, 2009; Radford et al., 2010; Simpson, 2010; Slabbekoorn, et al., 2010; Purser and Radford, 2011). Sound and visual cues from aircraft taking off and landing could also cause startle effects to epipelagic fish. Pelagic species in the area of drilling include adult Arctic cod, adult salmon, herring, capelin, and similar species. These pelagic species could startle and scatter as noise continues and, in theory, receive reduced levels of sound.

Sedentary, burrowing, territorial, benthic-obligated fish, shallower near-shore fish, fish eggs and fish larvae in the area of the drillship would be exposed to higher noise levels due to their limited swimming behaviors, obligate life history characteristics, behavioral traits, or spatial limitations. Fish in this category that are in the drilling area include sculpin species, yellowfin sole, Bering flounder, starry flounder and sand lance. Foraging and reproduction behaviors of these benthic-obligate fish could be affected negatively by noise from the proposed activities.

Under Alternative 2 the effects of sound on fish and EFH could all occur in a two year period. The level of sound in a given year would be greater, and would occur across a larger spatial area, if all exploration activities are concentrated within two seasons.

#### Bottom Disturbance and Deposition

Excavating mud cellars, drilling wells, and anchoring drill ships would directly disturb benthic habitat, introduce sediment into the water column, and cause deposition onto down-current benthic habitat. These discharges and disturbances are quantified in Tables 30 and 31.

**Table 30. Drill cuttings, drilling fluids, and mud cellar sediment discharged into water and on seafloor.**

| Alternative 2 -Discharge | 3 wells in first season | 3 wells in 2nd season | Total (6 wells) over drilling program of 2 seasons |
|---|---|---|---|
| Drill cuttings | 17,400 barrels (total for 3 wells) | 17,400 barrels (total for 3 wells) | 34,800 barrels (total for 6 wells) |
| Drilling fluids | 9,600 barrels (total for 3 wells) | 9,600 barrels (total for 3 wells) | 19,200 barrels (total for 6 wells) |
| Total for time period | 27,000 (total for 3 wells) | 27,000 (total for 3 wells) | 54,000 barrels (total for 6 wells) |

**Table 31. Potential surface area disturbed by excavating mud cellars and anchoring ships.**

| Alternative 2- Surface Area | 3 wells in first season | 3 wells in $2^{nd}$ season | Total (6 wells) |
|---|---|---|---|
| Mud cellar disturbance | 3,053 $ft^2$ (total for 3 wells) | 3,053 $ft^2$(total for 3 wells) | 6,106 $ft^2$ (total for 6 wells) |
| Anchoring | 97,297 $ft^2$ (total for 3 wells) | 97,297 $ft^2$ (total for 3 wells) | 194,594 $ft^2$ (total for 6 wells) |
| Total for time period | 100,350 $ft^2$ (total for 3 wells) | 100,350 $ft^2$ (total for 3 wells) | 200,700 $ft^2$ (total for 6 wells) |

The discharge of cuttings and drilling fluids would occur over 30-45 days for each well. During this time fish in the lower water column, including sculpin species, yellowfin sole, Bering flounder, starry flounder and sand lance, would be exposed to high suspended sediment and turbidity that could affect visibility (feeding ability), interrupt reproductive behaviors, smother benthic prey, and smother the fish themselves if they are not able to move from the area.

The newly deposited cuttings on the seafloor could resuspend into the water column via currents or severe storm events and have continuing effects. Hydrocarbon concentrations, including polycyclic aromatic hydrocarbons (PAH) and some metals, could become elevated in the lower water column and seafloor sediments from discharge of drill cuttings. This could expose benthic fish adults, eggs, and larvae in the immediate vicinity of the drill site to these concentrations and possibly cause physiological or toxicological effects.

Under Alternative 2, the effects of seafloor disturbance and sediment introduction and transport on fish and EFH could all occur in a two year period. Benthic habitat would be covered with excavated materials and drill cuttings and fish would be exposed to more extensive excavation and sedimentation effects for two or more open water seasons.

### Permitted Discharges

Fish in the area of drilling would be exposed in each drilling season to discharge of cooling water, desalination brine, domestic wastewater, treated sanitary wastewater, and drilling fluids. Wastewater would be discharged at 19.6 ft below the sea surface, above the temperature-salinity gradient, where it would mix with the surface waters.

Pelagic fish, such as Arctic cod, pink salmon, chum salmon, herring and would be particularly exposed to these discharges. Approximately 45,000 bbl of cooling water per day would be discharged from the drillship at 1.4 C above ambient sea temperature. The effect would dissipate within 164 horizontal feet. Desalination brine would be discharged with slightly higher salinity and other dissolved constituents than the ambient receiving water. Domestic wastewater and treated sanitary waste would introduce organic materials and could cause temporary localized biological oxygen demand and increased suspended solids. Pelagic fish near the point of discharge for these wastes would likely move away from the waste plume. Fish eggs and larval stages of fish would have continued exposure.

Under Alternative 2 the effects of wastewater discharges on fish and EFH could all occur in a two year period. Both benthic and pelagic fish of most species and life stages near the drill sites would be affected by these discharges during each drilling season.

### Shorebase Support Facilities

Shorebase support facilities (along with proposed runway improvements, fuel storage, boat ramp operations and field camp development referenced on pages 14-1 and 14-2 of the Revised EP) could affect nearshore and freshwater fish and EFH through wastewater discharges (permitted by the State), accidental discharges, vessel traffic, and noise. The fish that could be affected include Dolly Varden, rainbow smelt, cisco, Arctic char, Arctic grayling, pink salmon, and chum salmon.

### Small Fuel Spill

There is a potential for small fuel spills (<1,000 bbl) during fuel transfers between vessels. Section 2.4.9 estimates a potential spill size of 48 bbl of diesel fuel for the Proposed Action. A fuel spill of this size and type would introduce hydrocarbons and effects with respect to toxicity to the surface water. Pelagic fish adults, juveniles, eggs, and larvae would be exposed. Acute and chronic effects could occur to the various life stages of the fish species in the area.

### Large and Very Large Oil Spill

Although very unlikely, it is possible that the Proposed Action could lead to a large (≥ 1,000 bbl) or very large (≥150,000 bbl) oil spill. For the purpose of analysis, BOEM estimates potential discharge volumes for this EA to be 1,555 bbl of diesel for a large spill and 750,000 bbl of crude oil for a very large spill. The Sale 193 Final EIS (USDOI, MMS, 2007) analyzed potential effects to fish and EFH from large spills and found potential for immediate adverse impacts as well as changes in distribution and/or decrease in abundance of fish. The Sale 193 Final SEIS (USDOI, BOEMRE, 2011) analyzed potential effects to fish and EFH from a very large spill and identified direct and indirect effects to fish (which could become significant depending on the timing and trajectory of the spill) as well as significant impacts to EFH for Arctic cod, saffron cod, and all five species of Pacific salmon . These analyses remain sufficient to analyze the effects of large and very large spills in the Chukchi Sea, including potential discharges of 1,555 bbl and the 750,000 bbl, respectively, estimated for this EA.

### Mitigation

The following aspects of the Proposed Action would mitigate potential water quality effects:

- Operations conducted under NPDES permit authorized and administered by EPA
- Booming fuel transfer activities
- Shell policy prohibiting workers from fishing (Childs, 2009)
- Equipment for early warning of a potential well-control event
- Oil spill response vessels in the immediate vicinity of the drilling operations
- Adherence to the following plans: Critical Operations and Curtailment Plan (in the event hazards are identified in the vicinity of the drilling operations); Ice Management Plan; Well Control Contingency Plan; and Fuel Transfer Plan

### Summary of Effects of Alternative 2

Pelagic and benthic fish in the marine and nearshore environments would be affected for two or more seasons, and longer if their reproductive life cycle was disturbed, causing effects in later year classes. The effects of Alternative 2 on fish would be minor according to the Level of Effects established for this environmental assessment. The effects of Alternative 2 would occur over a larger spatial area per year as compared with Alternative 3, but the proposed action could be accomplished in fewer years. These effects are not expected to vary if Shell leaves the drilling area each year sometime prior to late October.

## 4.4.3 Alternative 3 – One Well per Season

The effects under this alternative would result from drilling one well to depth in the first open-water season and the same level of activity in five subsequent seasons.

The type of effects on fish and EFH that could occur under this alternative include the following:

### Sound from Operations

The proposed operations would expose fish to sound associated with vessel engines, excavating mud cellars, drilling, anchoring, ice management, and aircraft traffic over six open water drilling seasons.

Vertical seismic profiling would expose fish to seismic noise for 10-14 hours per season. Under Alternative 3 the environmental effects of sound on fish and fish habitat would be similar to Alternative 2. However, these impacts would be dispersed over additional drilling seasons, and the level of sound would be less each season and would occur across a smaller spatial area. Populations of fish in the Burger Prospect would be exposed to less extensive sound but recur over a longer period of time.

### Bottom Disturbance and Deposition

Excavating mud cellars, drilling wells, and anchoring drill ships would directly disturb benthic habitat, introduce sediment into the water column, and cause deposition onto down-current benthic habitat. Under Alternative 3 the effects of seafloor disturbance and sediment introduction and transport on fish and fish habitat would be similar to those effects under Alternative 2. The effects on fish and fish habitat, however, would recur over a longer time period (six open water seasons), and over a smaller spatial area each season.

### Permitted Discharges

Under Alternative 3, pelagic and benthic fish of most species and life stages near drill sites would be exposed to wastewater discharges and drilling fluids over six seasons. The environmental effects of wastewater on fish and fish habitat would be similar to the environmental effects in Alternative 2. However, the effects would recur over a longer time period and over a smaller spatial area each season. The volume of wastewater and drilling fluids would be less each season, but the absolute volume discharged over six seasons would be similar to the absolute volume discharged under Alternative 2.

### Shorebase Support Facilities

Under Alternative 3, shorebase support facilities could affect nearshore and freshwater fish and EFH through wastewater discharges (permitted by the State), accidental discharges, vessel traffic and noise. The fish that could be affected include Dolly Varden, rainbow smelt, cisco, Arctic char, Arctic grayling, pink salmon and chum salmon.

The effects on fish and fish habitat under Alternative 3 could be greater than the effects under Alternative 2 because the shorebase activities could continue for a longer period of time. Aircraft and vessel traffic may be less per season, but the worker activity would still affect nearshore and freshwater fish and fish habitat for six drilling seasons.

### Small Fuel Spill

Under Alternative 3, the potential for a small fuel spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

### Large and Very Large Oil Spill

Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

### Mitigation

The following are ways in which fish and fish habitat effects would be mitigated:

- Operations conducted under NPDES permit authorized and administered by EPA
- Booming fuel transfer activities
- Shell policy prohibiting workers from fishing (Childs, 2009)
- Alaska Department of Environmental Conservation water regulations onshore

- Equipment for early warning of a potential well-control event
- Oil spill response vessels in the immediate vicinity of the drilling operations
- Adherence to the following plans: Critical Operations and Curtailment Plan; Ice Management Plan; Well Control Contingency Plan; and Fuel Transfer Plan

**Summary of Effects of Alternative 3**

Pelagic and benthic fish in the marine and nearshore environments could be affected for six drilling seasons, and longer if their reproductive life cycle was disturbed, causing effects in later year classes. Alternative 3 would cause minor effects on fish populations in the area of the northeastern Chukchi Sea. Compared with Alternative 2, the effects of the drilling activities and onshore activities on fish and EFH described above would affect a smaller spatial area per year, but effects would continue over additional seasons. These effects are not expected to vary if Shell leaves the drilling area each year sometime prior to late October.

### 4.4.4 Cumulative Effects

Cumulative effects are discussed in detail in the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a: pp. 297-313) and in Appendix C of the current document. The number of marine cargo, tourism and research vessels and barges in the Chukchi region is increasing as ice cover is reduced. This increases the risk of vessel accidents, vessel groundings, potential oil and cargo spills, permitted discharges, and introduction of marine invasive species. Commercial fishing is prohibited in the U.S. Arctic (NPFMC, 2009) and would not have an effect in the near future. Subsistence fishing that occurs in coastal villages is likely to continue at a similar level. These ongoing effects would be the background in which Shell's proposed exploration activities would occur.

Climate change is having an effect on the Arctic environment now and is anticipated to have major effects in the future, including warming sea surface, reduction in sea ice and increased ocean water acidity. These factors are and will continue to affect fish and fish habitat in a substantive way in the Chukchi Sea.

Under Alternatives 2 and 3, the effects of the proposed exploration drilling would add a minor effect to the other ongoing activities described here. These effects would be additive and primarily related to benthic habitat alternation, noise disturbance to dish and water quality effects on fish and fish habitat. These effects are not expected to vary if Shell leaves the drilling area prior to late October in one or more of the drilling seasons.

## 4.5 Marine and Coastal Birds

Section 3.2.6 describes the status of marine and coastal birds in the project area. Recent site-specific information is consistent with previous descriptions, and existing information is sufficient to fully evaluate the potential effects of the Proposed Action.

As identified in the Sale 193 Final EIS (USDOI, MMS, 2007a) and the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a), there are several impact-producing factors associated with oil and gas exploration. The vertical seismic profiling component of the Proposed Action would occur in a localized area and be of short duration and no adverse effects from this activity are anticipated. Similarly, drilling noise would radiate from the site during active operation, but birds are not expected to approach the activity in ways that could harm them. Any displacement effects are anticipated to be extremely small, less so than those effects caused by the presence of the drilling structure.

The most important impact producing factors associated with the Proposed Action are:

- **Vessel presence and noise:** Some marine and coastal birds avoid close contact with vessels and can be temporarily displaced from localized areas when vessels transit through coastal and pelagic areas.
- **Aircraft presence and noise:** Some marine and coastal birds can be disturbed and/or temporarily displaced from localized areas when vessels transit through coastal and pelagic areas. Low-level flights are more likely to affect species that are sensitive to noise and vessel presence or are in a particular area because they are molting, broodrearing, or resting. Fewer disturbance events would result in less adverse effect than frequent or repeated disturbance events.
- **Avian Collisions:** Some seabirds, especially eiders, shearwaters, and auklets are more prone to collisions with structures and vessels than others because of their typical flight pattern or attraction to artificial light. Bird species that fly low over water have a greater potential to collide with offshore structures and ships, especially under conditions of poor visibility such as fog, precipitation, and darkness, and these can be injured or killed. Some birds can also be attracted to and can become disoriented by lights from vessels, which can increase the risk of collisions and result in injury or death.
- **Small Fuel Spills:** Small fuel spills can occur during vessel operations, such as fuel transfers. As explained in greater detail in the Lease Sale 193 EIS (USDOI, MMS, 2007a) and the SEIS (USDOI, BOEMRE, 2011a), spilled hydrocarbons can adversely affect marine and coastal birds because these species spend so much time on the water surface and are highly susceptible to mortality if contacted. BOEM assumes that any bird contacted by hydrocarbons would die.

Effects resulting from impact-producing factors are often similar among all marine and coastal bird groups described in section 3.2.6. Therefore effects are discussed generally below, with species-specific differences identified.

### 4.5.1 Alternative 1 – No Action

This alternative would not result in adverse effects to marine and coastal birds.

### 4.5.2 Alternative 2 – Proposed Action

This alternative would have a minor level of effect on marine and coastal birds.

Alternative 2 includes vessel and aircraft activities that could affect marine and coastal birds in the Chukchi Sea. Several species of marine and coastal birds could be subject to collisions with vessels and offshore structures. Also, a small spill (estimated at 48 bbl of diesel fuel) is anticipated to occur during the project period.

#### Threatened and Endangered Birds

**Vessel Presence and Noise.** Routine vessel support associated with the drilling operation is mitigated by these vessels using the shortest route between the shorebase and offshore drilling facility. Lease Stipulation 7 contains seasonal restrictions that will serve to prohibit vessels supporting Shell's drilling operations from transit into the LBCHU. Routine vessel traffic has limited potential to disturb birds and could temporarily move them a short distance to another location. Some marine and coastal birds have the potential to habituate to regular vessel traffic (Schwemmer et al., 2011). These small effects from the Proposed Action are not anticipated to persist from one year to another.

**Aircraft presence and noise.** Routine aircraft support associated with the drilling operation is mitigated by flight restrictions that minimize disturbance to marine and coastal birds while providing for aircraft safety. Aircraft would typically fly at >1,500 altitude along the shortest route between the shorebase and offshore drilling facility.

**Avian Collisions.** The spectacled and Steller's eiders are ESA-listed species that have some tendency to strike vessels and structures because they fly low and fast over the ocean and often do not or cannot react in time to avoid them. Birds have only a restricted range of flight speeds that can be used to adjust their rate of gain of visual information as their environment changes (Martin, 2011).

Studies in the North Sea indicated that different colored lights caused different responses. White lights caused attraction, red caused disorientation, and green and blue caused a weak response (Poot et al., 2008). White lights were replaced with lights that appeared green, and this resulted in 2 to 10 times fewer birds circling the offshore platforms (Poot et al., 2008).

A study on the effects of anti-collision lighting systems on Northstar Island for eiders and other birds found in the Beaufort Sea showed that there was a significant slowing of flight speeds at night and movement away from the island when strobe lights (40 flashes per minute) were used. The lights did not cause other bird species to avoid the island but caused attraction. Therefore, the effectiveness was not clear and was inconsistent (Day et al., 2003; Day, Prichard, and Rose, 2005). Nevertheless, Shell is required under Stipulation 7 of its lease to make efforts to reduce light radiating from their exploration vessels and structures.

Despite required efforts to reduce light radiated from exploration vessels and structures, mitigation measures for lighting cannot be assumed to be totally effective and there is still the potential for some bird collision mortality. To address the potential for spectacled and Steller's eiders to collide with structures in the Chukchi Sea, the FWS developed a collision rate. Collision data for common eiders at Northstar Island was compared to the population estimate for common eiders migrating across the Beaufort Sea to provide a strike rate of 0.0017%. This collision rate was used as a surrogate to assess potential impacts to Steller‘s and spectacled eiders, by converting it to a percentage and applying that to the estimated population sizes of listed eiders that may migrate past a structure.

The FWS BO (USDOI, FWS, 2009) calculated that for each drilling program in the Chukchi Sea, on average, an estimated 0.44 spectacled eiders and 0.02 Steller‘s eiders could be killed each year. Although yellow-billed loons and Kittlitz‘s murrelets may also be vulnerable to collisions, the FWS had no records upon which to base a comparable estimate of potential collisions, and there was no evidence to suggest population level impacts to these species would result. The BO issued to BOEM included an incidental take statement that includes the incidental lethal take of ESA-listed eiders:

> …even if seismic surveys and exploratory drilling activities intersect with listed and candidate species the impacts are limited to at most the death of a very low number of individuals through collisions (<1 Steller‘s eider and 12 spectacled eiders over a total of 12 years), and possibly although very unlikely the death of a few individuals in the event a small spill contacts these birds.

The FWS BO includes a requirement for bird strike reporting so that incidental takes of listed birds can be monitored and adaptive management would take place in the event of unanticipated mortality levels. Bird strike reporting would be a condition of BOEM approval of the Revised EP.

To date, no ESA-listed eiders have been reported to collide with exploration structures or vessels. However, there have been at least two reports of small flocks of common eiders colliding with structures on offshore islands/peninsulas in the Beaufort Sea in the past three years. The episodic nature of these events suggests that several birds in a flock could be killed at one time during any one year and an increasing number of years would correspond with an increase in the potential for avian collisions to occur. Using the FWS collision rate, three open water seasons using a single drilling operation could, on average, result in 1.32 spectacled eiders and 0.06 Steller's eiders colliding with offshore structures. Such mortality would be considered a minor level of effect.

**Small Fuel Spills.** Section 2.3.10 describes spill prevention and response. While there is some potential for a fuel spill during the proposed operations (section 2.3.9), few threatened or endangered birds are anticipated to occur in the project area and few could be exposed to an accidental spill. Many offshore birds would likely avoid spill response activities. The most likely outcome is an accidental small spill that is immediately contained and would have a negligible level of effect on threatened and endangered birds. The effects evaluated could occur each season that Shell conducts exploratory drilling operations under this exploration plan. Consecutive years of activity would not have an additive effect.

If a small accidental spill—potential discharge estimated at 48 bbl for this EA—were to escape containment or response measures, it would not persist very long (<3 days), resulting in few opportunities to contact many threatened and endangered birds. Spill response measures include immediate attention to the Ledyard Bay Critical Habitat Unit, located about halfway between the drilling sites and shore. Under most prevailing environmental conditions, the LBCHU would be contacted days before the Chukchi Sea shoreline. Spectacled eiders and other (flightless) molting birds in the LBCHU would be most vulnerable after mid-July. The vessel activity associated with spill response could have limited success in keeping keep molting seaducks away from a spill because the birds are flightless. That is why it is most important to focus on keeping spilled oil from reaching the LBCHU. Furthermore, later in the open-water season, new migrants could arrive in a spill area on a regular basis, making hazing more difficult. Limited mortality from a small spill would be considered a minor level of effect.

**Large and Very Large Oil Spill.** Although very unlikely, it is possible that the Proposed Action could lead to a large (≥1,000 bbl) or very large (≥150,000 bbl) oil spill. For the purpose of analysis, BOEM estimates potential discharge volumes for this EA to be 1,555 bbl of diesel for a large spill and 750,000 bbl of crude oil for a very large spill. The Sale 193 Final EIS (USDOI, MMS, 2007) analyzed potential effects to marine and coastal birds from large spills and found potential for sublethal or lethal effects to birds contacted by spilled oil. The Sale 193 Final SEIS (USDOI, BOEMRE, 2011) analyzed potential effects to marine and coastal birds from a very large spill and found potential for significant impacts were spilled oil to reach important habitat areas. These analyses remain sufficient to analyze the effects of large and very large spills in the Chukchi Sea, including the 1,555 bbl diesel spill and the 750,000 bbl oil spill estimated for this EA.

### Cliff-Nesting Seabirds

Mitigation measures intended to avoid or minimize adverse effects to threatened eiders also afford protection to cliff-nesting seabirds in those areas. Vessel and aircraft traffic are not anticipated to result in more than a negligible level of effect on cliff-nesting seabirds because they typically occur at low density in the area of exploration activity, and sensitive life stages are not subject to other than occasional vessel passage or aircraft overflight. Any adverse effects from a small spill would not be greater than those described for threatened or endangered birds. Few, if any, collisions by this species group are anticipated.

### Bering Sea Breeders and Summer Residents

Mitigation measures intended to avoid or minimize adverse effects to threatened eiders also afford protection to Bering Sea breeders and summer residents. Vessel and aircraft traffic are not anticipated to result in more than a negligible level of effect to Bering Sea breeders and summer residents because they typically occur at low density in the area of exploration activity are not subject to other than occasional vessel passage or aircraft overflight. Adverse effects from a small spill would not be greater than those described for threatened or endangered birds.

Lighting attraction and disorientation appears responsible for seabirds colliding with vessels and structures. For example, Dick and Donaldson (1978) reported collisions by crested auklets (*Aethia* *cristatella*) threatening to capsize an 86-ft long vessel when the vessel was using high-intensity lighting. Additional reports included in Dick and Donaldson (1978), Black (2005), and ADN (2006) suggest other similar occurrences by pelagic species such as shearwaters (*Puffinus* spp.), storm-petrels (Hydrobatidae), and whiskered auklets (*Aethia pygmaea*). Because several species of pelagic seabirds can occur in dense flocks in the Chukchi Sea and have the potential to be in the vicinity of or move past drilling structures and vessels engaged in exploration activities, it is likely that some birds will accidentally collide with exploration vessels and other structures and be injured or killed. Monitoring and reporting of bird strikes by drilling structure personnel is required and will allow the rapid detection of bird collision events before large-scale mortality occurs. Given that the pelagic seabird populations (especially shearwaters and auklets) in the Chukchi Sea are robust and number in the tens of thousands, a conservative estimate of collision mortality of fewer than 100 individual birds during the entire drilling program would not be considered more than a minor level of effect.

### High Arctic-Associated Seabirds

Mitigation measures intended to avoid or minimize adverse effects to threatened eiders also afford protection to high Arctic-associated seabirds in those areas. Vessel and aircraft traffic are not anticipated to result in more than a negligible level of effect to high Arctic-associated seabirds because they typically occur at low density in the area of exploration activity and are not subject to other than occasional vessel passage or aircraft overflight. Adverse effects from a small spill would not be greater than those described for threatened or endangered birds. Few, if any, collisions by this species group are anticipated.

### Tundra-Breeding Migrants

Mitigation measures intended to avoid or minimize adverse effects to threatened eiders also afford protection to tundra-breeding migrants in those areas. Vessel and aircraft traffic are not anticipated to result in more than a negligible level of effect to tundra-breeding migrants because they typically occur at low density in the area of exploration activity and are not subject to other than occasional vessel passage or aircraft overflight. Adverse effects from a small spill would not be greater than those described for threatened or endangered birds. Few, if any, collisions by this species group are anticipated.

### Waterfowl and Loons

Mitigation measures intended to avoid or minimize adverse effects to threatened eiders also afford protection to waterfowl and loons in those areas. Vessel traffic is not anticipated to result in more than a negligible level of effect to waterfowl and loons because they typically occur at low density in the area of exploration activity and are not subject to other than occasional vessel passage. Adverse effects from a small spill would not be greater than those described for threatened or endangered birds.

As with threatened eiders, similar waterfowl species (i.e., common and king eiders) are prone to collide with offshore vessels and structures. The episodic nature of these events suggests that several birds in a flock could be killed at one time during any one year. Given that common eider and king eider populations are robust, the level of bird strike mortality could be numerically larger, but proportionate to those calculated for threatened eiders. A minor level of effect on species in the waterfowl and loon group from avian collisions is anticipated.

### Shorebirds

Mitigation measures intended to avoid or minimize adverse effects to threatened eiders also afford protection to shorebirds in those areas. Vessel traffic is not anticipated to result in more than a negligible level of effect to shorebirds because they typically occur at low density in the area of exploration activity and are not subject to other than occasional vessel passage. Adverse effects from a small spill would not be greater than those described for threatened or endangered birds. Few, if any, collisions by this species group are anticipated.

### Raptors and Ravens

Activities associated with the Proposed Action are not anticipated to affect raptors and ravens.

## 4.5.3 Alternative 3 – One Well per Season

This alternative would result in a moderate level of effect to marine and coastal birds.

Unlike Alternative 2, the drilling program in Alternative 3 would be spread over 6 drilling seasons. The duration of each season's activity could be as long as specified for Alternative 2. There are no differences between the level of effects from vessel and aircraft presence and noise or small fuel spills resulting from this alternative as compared to Alternative 2; even though this alternative could more than double adverse effects on marine and coastal birds, these effects are not anticipated to persist from one year to the next.

As described under Alternative 2, however, eiders, shearwaters, and auklets are more prone to collisions with structures and vessels than other species. Despite the required efforts to reduce radiated light, mitigation measures for lighting cannot be assumed to be totally effective and there is still the potential for some bird collision mortality. While extending the drilling program to six years could more than double the estimated collision mortality (over 3 spectacled eiders and 0.14 Steller's eiders) compared to Alternative 2, such mortality would be considered a minor level of effect.

Some pelagic seabirds can occur in dense flocks in the Chukchi Sea and it is likely that some birds will accidentally collide with exploration vessels and other structures and be injured or killed. The more years a drilling operation occurs, the greater the potential that one of these large flocks could encounter a drilling structure, especially during periods of fog, rain, and/or darkness. Monitoring and reporting of bird strikes by drilling structure personnel is required and will allow the rapid detection of bird collision events before large-scale mortality (>100 individuals during one collision event) occurs. Given that the pelagic seabird populations (especially shearwaters and auklets) in the Chukchi Sea are measured in the tens of thousands, collision mortality over program duration (up to 7 years) could exceed hundreds of individuals. This collective mortality would be considered a moderate level of effect for this alternative.

Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

## 4.5.4 Cumulative Effects

Appendix C describes other past, present, and reasonably foreseeable future events that could occur in the project area and could affect bird populations. Activities associated with the action alternatives do not have a cause-effect relationship that would influence aspects of climate change discussed in Appendix C-3.4 (Climate Change).

Activities that impact marine and coastal birds include disturbances from vessel or low-level aircraft traffic, maritime spill accidents (i.e., bulk fuel deliveries to coastal villages), and bird collisions with vessels and structures in marine and coastal habitats would continue. Many of these activities include vessel and aircraft operations that are not subject to altitude or route restrictions and can affect marine and coastal birds.

Alternative 1 would not have an incremental contribution to the cumulative effect.

Alternative 2 would contribute to the collective impacts on bird populations in the project area. The reasonably foreseeable cumulative effects will occur at nearly the same level each season that exploratory drilling operations are conducted. Alternative 2 could result in short-term effects from vessels and aircraft, but these effects are localized and would not persist from one year to the next. The primary adverse effect, avian collisions, could result in annual mortality to ESA-listed and other bird species. The impacts to marine and coastal birds from Alternative 2 and from reasonably foreseeable activities would amount to no more than a minor level of cumulative effect.

Alternative 3 would contribute to the collective impacts on bird populations in the project area. The reasonably foreseeable cumulative effects will occur at nearly the same level each season that exploratory drilling operations are conducted, but collision mortality could accumulate over the project timeline to over double that described for Alternative 2. The impacts to marine and coastal birds from Alternative 3 and from reasonably foreseeable activities would amount to no more than a moderate level of cumulative effect.

## 4.6 Marine Mammals

This analysis tiers from the Sale 193 Final EIS (USDOI, MMS, 2007a) and Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) and applies the results of those analyses to the site specific information from the 2012 Shell Revised Chukchi Sea EP and Shell EIA. Relevant information from each of these documents in incorporated and summarized below. BOEM has identified the following effectors as having potential to affect marine mammals:

- Drilling
- Zero-offset Vertical Seismic Profile (ZVSP)
- Vessel Traffic
- Ice Management
- Aircraft Traffic
- Discharges
- Petroleum Spills

The greatest potential for the Proposed Action to impact marine mammals is through noise. Sounds are important to marine mammals because they use sound to navigate, communicate, find open water, avoid predators, and find food. Ambient or background sound levels in the Chukchi Sea have been measured at 80-100 dB under relatively calm seas (Brueggeman et al., 1990). Concern has focused on the intensity of impacts to marine mammals from sounds related to drilling, aircraft, and vessels, and its potential to cause deflection of whales from hunting and migration areas, masking of environmental sounds and intra-species communication, and physiological damage to marine mammal hearing. Avoidance behavior in response to sound energy noise by marine mammals such as temporary deflection from feeding areas or migration corridors is the most likely behavioral response expected as a result of Shell's exploration drilling activities in the Chukchi Sea. Extremely loud sounds could cause temporary or permanent damage to hearing ability (Kryter, 1985). Concerns that sound energy introduced into the environment of marine mammals could cause masking (the covering of sound that would otherwise have been heard) are present. Masking can interfere with the detection of important natural sounds. Underwater sound energy could possibly mask environmental sounds (Terhune, 1981) or communication between marine mammals (Perry and Renouf, 1987). The location of the proposed drill sites, more than 60 mi offshore and more than 25 mi from either Herald Shoal or Hanna Shoal, and the timing of the proposed activities (during the open-water period) decreases the likelihood of disturbance to large numbers of marine mammals from drilling noise.

Noise from aircraft traffic associated with proposed exploration activities may also cause some temporary behavioral disturbance, and possibly deflection away from the sound source. A marine mammal under water would typically only hear an aircraft at low altitude when it is within the area 13 degrees on either side of the vertical from where the animal is located (Richardson and Malme, 1993). According to Shell, aircraft other than marine mammal monitoring flights will not fly below an altitude of 1,500 ft (300 m), within 0.5 mi (800 m) of walrus or polar bears observed on land or ice, or within 500 yd (460 m) of whale groups. These flight restrictions are standard mitigation measures which are usually required by FWS and NMFS as part of the LOA and IHA process. Aircraft would follow flight corridors directly from shore at Wainwright to the drill site, and 5 mi inland when traveling from Wainwright to Barrow.

Vessel noise, vessel traffic, icebreaking, and ice-management could also have some level of effects on any pinnipeds or cetaceans visiting the vicinity of drilling or drilling support operations.

Discharges of wastewater, drill cuttings, and drilling fluids are unlikely to have any identifiable effects to marine mammals. The area disturbed or buried under sediments that precipitate out of the water column would only affect a relatively tiny portion of the sea floor. Additional analysis on the potential for the Proposed Action to affect lower trophic resources utilized by marine mammals is provided in Section 4.3.

### 4.6.1 Alternative 1 – No Action

If Alternative 1 is selected, the proposed exploration activities would not be approved, and there would be no effects on marine mammals.

### 4.6.2 Alternative 2 – Proposed Action

It is likely that some marine mammals will be present in the prospect area when the exploration drilling operations are ongoing. Potential adverse effects on marine mammals from the proposed exploration activities are organized first by species and then by mechanism of effect.

#### Seals

**Drilling.** Ringed seals have demonstrated very limited responses to drilling activities. While monitoring marine mammal distribution and reactions to drilling in the Beaufort Sea with the *Kulluk*, Brewer et al. (1993) observed ringed seals approaching within 33 ft (10 m) of the drilling vessel and concluded that seals were not disturbed by drilling activity. While monitoring marine mammals at another Beaufort Sea drill site, Gallagher, Brewer, and Hall (1992) observed seals within 115 ft (35 m) of the drillship *Northern Explorer II* indicating a high level of tolerance to such sounds and activities. Other studies of drilling activities in the Beaufort Sea have shown minor and temporary disturbance effects. Frost and Lowry (1988) concluded that local ringed seal populations were less dense within a 2-nautical mile buffer of manmade islands and offshore wells that were being constructed in 1985-1987. Moulton et al. (2003) found less marked differences in ringed seal densities on the same locations to be higher in years 2000 and 2001 after a period of habituation. Thus, it seems ringed seals may be somewhat disturbed by drilling operations for a period of time, until the activity has been completed. Adult ringed seals likely habituate to long-term effects of drilling, artificial island construction, and continuous operations that cumulatively created a much greater level of disturbance than what we expect from this project.

Concerns have been expressed that sound energy introduced into the environment of marine mammals could cause masking (covering of sounds that would otherwise have been heard) of other sounds that are present in the environment. Masking can interfere with the detection of important natural sound sources. Underwater drilling sounds could possibly mask some environmental sounds (Terhune, 1981) or communication between marine mammals (Perry and Renouf, 1987). However, in a study conducted by Cummings, Holliday, and Lee (1984), in which breeding ringed seals were subjected to recordings of industrial sounds, there were no documented effects on ringed seal vocalizations.

Because of the short duration of the proposed activities, unremarkable biological site characteristics, and the observed effects of offshore drilling on seals, we do not anticipate measureable population level effects to occur. Consequently drilling noise is expected to have a negligible level of effects on bearded, ribbon, ringed, and spotted seals in the vicinity of the prospects.

**ZVSP.** Seals do not echolocate as do odontocetes, and their use of sound mostly relates to intra-specific communication. Ringed seal reactions to seismic surveys are expected to be restricted to small distances and brief durations, with no long-term effects. Southall et al. (2007) proposed that auditory (PTS) injury could occur in seals exposed to single sound pulses at 218 dB re: 1 μPa in water; however, injury from most large seismic surveys would only occur if animals entered the zone immediately surrounding the source. The sounds levels produced by the airguns associated with proposed ZVSP activities are insufficient to elicit a TTS or PTS in any known seal species outside an area of a few meters at most.

Most ice seals spend greater than 80% of their time submerged in the water (Gordon et al., 2003); consequently, some could be exposed to sounds from ZVSP surveys that occur in their vicinity. Underwater audiograms for ice seals suggest that they have very low hearing sensitivity below 1 kHz, though they can hear underwater sounds at frequencies up to 60 kHz, making calls between 90 Hz and 16 kHz (Thomson and Richardson, 1995; Richardson et al., 1995b). The auditory bandwidth for pinnipeds in water is approximately 75 Hz to 75 kHz (Southall et al., 2007), and while seismic activity can contain sound up to 1 kHz, most of the emitted sound is less than 200 Hz, putting seismic noise at the very lowest end of the auditory spectrum for seals. Gordon et al. (2003) suggested that phocids may be susceptible to the masking of biologically important signals by low frequency sounds, such as those from seismic surveys, and while brief, small scale masking episodes might have few long term consequences.

Reported seal responses to seismic surveys have been variable and often contradictory, although they suggest ice seals often remain within a few hundred meters of large airgun arrays that are firing (Blees et al., 2010; Brueggeman et al., 1991; Harris, Miller, and Richardson, 2001; Miller and Davis, 2002).

Seismic surveying has limited potential to affect fishes and some invertebrate species that make up the ringed seal diet (USDOI, MMS, 2006). Potential impacts to prey species are analyzed in Section 4.4. If seismic surveys cause prey items to become scarce, either because they move out of an area or become more difficult to catch, seal distributions and feeding rates could be affected, especially those of newly weaned ringed seal pups (Gordon et al., 2003). It is also possible that damaged or disoriented prey could attract ice seals to seismic-survey areas, providing robust short-term feeding opportunities (Gordon et al., 2003).

Pinnipeds are unlikely to show a strong avoidance reaction to the moderately-sized airgun source that will be used for the ZVSP program. ZVSP operations are not expected to last beyond 10-14 hours at any drill site, greatly lessening the likelihood of a seal being exposed to noise from firing airguns. Visual monitoring from seismic vessels has shown only slight avoidance of large airgun arrays by pinnipeds, with small changes in behavior. Even if reactions of the species occurring in the proposed survey area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations. Furthermore the very brief duration of ZVSP operations and the smaller size of the airguns should greatly lessen the potential for and level of effects to seals. Consequently the ZVSP seismic activities are expected to have a negligible level of effects on seal species in the vicinity of any discharging airguns.

**Vessel Traffic.** Most likely some seals will be present in the prospect area when the exploration drilling operations are occurring. The most common seal species in order of occurrence should be ringed, spotted, and bearded seals, respectively, with very low ribbon seal occurrences. Seals appear to be fairly tolerant of vessel traffic.

Vessels underway will reduce speed and avoid multiple course changes when within 300 yd (275 m) of marine mammals in the water to avoid separating members from a group. Vessel speed will also be reduced during inclement weather conditions in order to avoid accidental collisions with marine mammals. No vessels will intentionally approach any marine mammal.

Vessel traffic may temporarily displace seals from preferred feeding areas, resting areas, or briefly alter travel routes of individual seals, resulting in small, immeasurable energetic costs. Richardson (1995c) found that vessel noise does not seem to strongly affect ice seals already in the water but seals on haulouts often respond more strongly to the presence of vessels by slipping into the water. Brewer et al. (1993) reported observations of ringed seals following ice management vessels in the Beaufort Sea, apparently feeding on fish and plankton in the disturbed waters.

During open water surveys in the Beaufort and Chukchi Seas (Harris, Miller, and Richardson, 2001; Blees et al., 2010; and Funk et al., 2010) ringed and bearded seals showed slight aversions to vessel activity. Funk et al. (2010) noted, among vessels operating in the Chukchi Sea where received sound levels were <120 dB, 40 percent of observed seals showed no response to a vessel's presence, slightly more than 40 percent swam away from the vessel, 5 percent swam towards the vessel, and the movements of 13 percent of the seals were unidentifiable. In the same Chukchi Sea surveys, 60 percent of the observed seals "…exhibited no reaction to vessels…", and 27 percent simply looked at the vessels. In the concurrent set of surveys conducted in the Beaufort Sea where sound levels were <120 dB, approximately 30 pecent of observed seals showed no reaction to vessel activity, 50 percent looked at the vessel, and 10 percent splashed in the water. Funk et al. (2010) concluded that bearded seals were more likely to occur near the pack ice margin than in open water, and that it is likely some individuals near the vessels were displaced to a limited extent. Brueggeman (2010) noted that in 2008 and 2009 ringed seal behavior was dominated by swimming (49 percent), diving (20 percent), and looking (18 percent) at the survey vessels.

Blees et al. (2010) reported a total of 16 ringed seals and 69 bearded seals were observed by monitoring vessels where the received noise levels were <120 dB during Statoil's 2010 seismic surveys in the Chukchi Sea. Of those observations the seals responded mainly by looking at the vessel (56.7%) or showed no reaction at all (32.8%). Blees et al. (2010) noted seals responded to the vessel by looking (37.5%) or simply did not respond to the vessel's presence (62.5%) when the M/V Geo Celtic was performing non-seismic activities. Summarily, the majority of seals encountered by Statoil's monitoring vessels reacted by looking at the vessel (51%) or by showing no obvious reaction (39%). Consequently ringed seals did not appear to be affected by vessel traffic with background noises below 120 dB in the 2006-2008 (Funk et al., 2010) or the 2010 (Blees et al., 2010) surveys, when they were in open water conditions and not hauled out on ice. However, in Blees et al. (2010) ringed, bearded, ribbon, and spotted seals were collectively grouped together in the analyses. Blees et al. (2010) noted seal observations by individual species; however, their analysis for sighting rates used the cumulative number of ice seal observations as a collective group rather than individual species, which would have been much lower.

It is possible that vessels could strike a small number of seals in open water conditions. Seals that closely approach larger vessels may potentially be drawn into bow-thrusters or ducted propellers. In recent years, gray and harbor seal carcasses have been found on beaches in eastern North America and Europe with injuries indicating the seals may have been drawn through ducted propellers (Thompson et al. 2010). However, adult seals are agile and should easily avoid vessels in open water conditions.

Considering most sea ice is absent from the prospect areas during the open water season, and the small impacts of vessel traffic on seals, the effects are expected to be brief and minor, mostly resulting in temporary avoidance responses by seals, such as slipping off of ice and into the water, diving, or briefly avoiding approaching vessels.

**Ice Management.** The Proposed Action includes ice management and the potential for icebreaking in certain limited circumstances. Bearded seals showed very limited reactions to icebreaking and have been observed approaching to within 656 ft (200 m) of ice breakers (Brewer et al., 1993). Reeves (1998) reported some ringed seals have been killed by icebreakers moving through fast-ice breeding areas, and that the passing icebreakers could have far-reaching effects on the stability of large areas of sea ice. However, this project would occur during the open-water season, long after sea ice retreats north of the prospect areas and after all of the fast-ice has melted way. The whelping and molting seasons for all four seal species will have ended before commencement of the Proposed Action. As few seals are expected to linger in the area after the sea ice has retreated north, no seals should be crushed by icebreaking activities. As a result, icebreaking and ice-management should have a negligible level of effect on seals, resulting only in temporary avoidance in the open water.

**Aircraft Traffic.** A study noting counts of ringed seal calls in water performed by Calvert and Stirling (1985) suggests seal abundance in an area subjected to low-flying aircraft and other disturbances was similar to what was observed in less disturbed areas. Concentrations of animals hauled out on land seem to react more severely than the scattered small groups found on the sea ice in spring, and in summer spotted seals haul out in large numbers on the sand bars near Kasegaluk Lagoon. Surveys by Rugh, Shelden, Withrow (1997) found spotted seals showed immediate reactions to the presence of survey aircraft at altitudes up to 4,500 ft (1,370 m) and up to 2 km away. Shell's flight routes would go directly from Barrow or Wainwright out to sea, or 5 mi inland between Barrow and Wainwright, so disturbances of spotted seals at terrestrial haul outs are not expected.

Any other disturbances of seals by Shell's aircraft would be temporary and localized to small numbers of seals hauled out on remnant ice floes or already in the water. The potential impacts on seals from aircraft traffic would be greatly mitigated by the proposed flight corridor (Shell 2011a: Figure 13.e-2), which minimizes the portion of flights over coastal waters. Flights between Barrow and Wainwright would occur along a corridor 5.0 mi inland to minimize effects on subsistence and subsistence resources including marine mammals.

Furthermore, Shell has incorporated other measures to reduce the chance of disturbing seals by restricting aircraft to altitudes above 1,500 ft (457 m), unless the aircraft is engaged in marine mammal monitoring, approaching, landing or taking off, or in cases where personal safety requires lower altitudes. Aircraft traffic and noise would have a negligible level of effect on ice seals.

**Discharges.** The Proposed Action entails the discharges of wastewater, drill cutting, and drilling fluids. As noted above, the areas affected by these discharges would be small, would recover quickly, and would be in the general proximity of activities causing enough noise to discourage visitation by seals. Identifiable impacts to seals from discharges are therefore unlikely.

**Small Fuel Spill.** After reviewing the potential effects of a 48 bbl oil (the amount estimated for a small spill in this EA) or fuel spill on seals, BOEM finds a negligible level of effects applies. Such a small spill would be insufficient to produce any population level effects on small or large groups of seals. Ice seals are believed to have the ability to detect and avoid oil spills (Geraci, 1990; St. Aubin, 1990). Moreover, the weathering process should act to quickly break up or dissipate oil/fuel through the local environment to harmless residual levels that would eventually become undetectable.

**Large and Very Large Oil Spill.** Although very unlikely, it is possible that the Proposed Action could lead to a large or very large oil spill. For the purpose of analysis, BOEM estimates potential discharge volumes for this EA to be 1,555 bbl of diesel for a large spill and 750,000 bbl of crude oil for a very large spill. The Sale 193 Final EIS (USDOI, MMS, 2007a) analyzed potential effects to seals from large spills and found that contact with oil could affect individual seals in a variety of negative ways. The Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) analyzed potential effects to seals from a very large spill and found that exposure to oil, long-term exposure to contaminants, and decreased availability of prey could lead to short-term population impacts. These analyses remain sufficient to analyze the effects of large and very large spills in the Chukchi Sea, including the 1,555 bbl diesel spill and the 750,000 bbl oil spill estimated for this EA

### Pacific Walrus

For management purposes, the Pacific walrus is considered a single stock, although there are some indications of separation between walrus from different breeding areas (Jay, Outridge, and Garlich-Miller, 2008). Exploration drilling on the Burger Prospect could impact walruses through disturbance, displacement, impacts to prey species, or accidental petroleum spills.

**Drilling.** The primary effects on walrus from exploration drilling are habitat loss and disturbance. Noise and activity associated with drilling may displace some walruses from the immediate area of the specific drill site (with ongoing operations). Walrus may be displaced from the immediate area of difference drill sites over the course of two or more open water seasons. The drill sites are located 60 miles or more from the coastline, and terrestrial haulouts are unlikely to be disturbed by exploration drilling activities. The proposed drill sites are in a central area near the Hanna and Herald Shoal areas, areas that are very productive for benthic invertebrates and may be important foraging areas for walrus in some years. Walrus would be displaced from specific drill site areas during active drilling; however, in recent years the sea ice has retreated too far northward for walrus to easily access these areas during the late summer and early fall open water season. The footprint of the drill ship and the activities associated with the drilling (crew change outs, re-supply vessels, possibly an icebreaker conducting ice management activities, spill response vessels on stand by) would likely displace walrus from the immediate area. Each drill site would have a mudline cellar (MLC) that would be approximately 30-40 ft deep and 325-350 $ft^2$ in size. In addition, approximately 17,000 $ft^2$ would be scarred by the anchors used to anchor the drill ship. These areas would not be available as foraging habitat until benthic invertebrates had time to re-colonize the area after the drill site had been abandoned. Dunton et al (2009) found healthy benthic communities in 2008 at sites in the Chukchi Sea that had exploration wells drilled in 1989. One drill rig active during the open water season would have a relatively small footprint when compared to the available habitat and is likely to have minor impacts to walrus in the Chukchi Sea. Shell may exit the drilling area prior to the end of October. The potential for large numbers of walrus to be displaced by ship traffic during the open water season is low.

**ZVSP.** One ZVSP will be conducted for each well. Walrus use sound for communication and spend a great deal of time foraging underwater. They may be exposed to sound from ZVSP. Temporary threshold shift (TTS) may occur after exposure to seismic pulses; however, this has not been documented for walrus. Walrus have good low-frequency hearing (Kastelein et al., 2002) and may be susceptible to masking of biologically significant signals by low frequency sounds, such as airgun pulses from seismic surveys (Gordon et al., 2003). ZVSPs would take place over a period of 10-14 hours at every well drilled. Walrus are likely to avoid remaining in the drill site area due to the noise and activity, which lessens the likelihood of their exposure. MMOs will be on watch during operations to avoid conducting ZVSP when walrus are present within the area ensonified at 180dB. Some walrus may move further away from the drilling operations if in the area when ZVSP occurs. Any impacts are likely to be limited to displacement of foraging walrus or of walrus swimming through the area.

ZVSPs will occur during the open water season when walrus densities are expected to be relatively low, and monitoring requirements and mitigation measures are expected to minimize interactions with large aggregations of walruses. Any impacts to walruses would be short in duration and would have a negligible overall impact on the Pacific walrus population.

**Vessel Traffic.** Documented reactions of walrus hauled out on ice to vessels include waking up, head raising, and entering the water (Richardson, 1995). Brueggeman et al. (1990, 1991) monitored the behavior of walrus, while on ice and in water, in response vessels associated with exploration drilling near Shell's prospects in 1989 and 1990. They reported that none of the observed groups of walrus exhibited escape behavior in response to anchored or drifting vessels. Responses of walrus to moving vessels varied depending in part upon the nearness of the vessels. The responses varied from no reaction, approaching the vessel, avoiding the vessel, abandoning the ice, and exhibiting escape behavior. The strongest reactions occurred when the vessel came within about 550 yd (500 m) of the walrus. Mitigation measures as described in Section 2.10 and in Shell's Polar Bear and Pacific Walrus Interaction and Avoidance Plan, which includes a 0.5 statute mi (800 m) exclusion zone around observed walrus for vessels in transit, will reduce contacts and avoid incidental takes of walrus during transit to and from the site.

The fleet associated with the proposed drilling operation could come into contact with individual or groups of walrus during transit or while at a drill site. Walrus may move through the drill site area while foraging or transiting between ice and shore. If pack ice remains in the area when drilling begins, walrus may be associated with the pack ice. In most cases, impacts to walrus would be limited to displacement from the area of activity. In the summer of 2010, a seismic operator in the Chukchi Sea operating near the proposed drill sites reported a large influx of walrus over several days as the walrus moved from the retreating pack ice to shore-based haul outs. The operator was directed to move operations to a different area until the walrus had moved through; disturbance to the walruses was minimized in this way.

**Ice Management.** Ice management operations are expected to have the greatest potential for disturbances to walrus. Brueggeman et al. (1991) reported that walrus moved 20-25 km from active icebreaking operations, where noise levels were near ambient. Icebreakers may assist vessels in transit to and from locations during ice conditions, and support drillship operations if ice moves into the operating theater or during late fall ice conditions. Ice management would occur at distances of 0.6 to 12 miles from the drill ship. Response distances of walrus to open water vessels and icebreakers are expected to vary, depending on the size of the ship, engine power, and mechanical characteristics of the icebreaker; vessel activities; noise-propagation conditions; the age and sex of individuals exposed; and the activities they are engaged in when exposed. Females with young calves are most vulnerable to disturbance events because the calves cannot remain in the water as long, cannot swim as far, and are more vulnerable to trampling when large groups of walrus stampede off of haulouts. Repeated disturbance from vessel traffic could cause walrus to abandon an area which would have energetic costs, and has the potential to separate calves from their mothers.

**Aircraft Traffic.** Sources of flights in the Proposed Action include industry crew changes and industry marine mammal surveys. Most offshore aircraft traffic in support of Shell's proposed drilling plan involves straight line flights for personnel transport and fixed-wing aircraft engaged in monitoring activities. The aircraft will primarily be flying over open water and are unlikely to disturb walrus that are in water. However, because of frequent low visibility due to fog, aircraft may not always be able to fly at heights that avoid disturbing walruses hauled out on the ice, or at coastal haul outs. Walrus may be displaced from ice floes or terrestrial haulouts temporarily by aircraft or may expend energy reserves avoiding aircraft. Females with calves react most readily to potential disturbance events. Walrus at terrestrial haul outs are vulnerable to injury or death during stampedes, with calves being the most vulnerable.

As walruses spend more time ashore due to receding sea ice, the potential for disturbance events increases. Increases in physiological stress of adults or juveniles may reduce fitness and have implications for productivity and survivorship over time. Requirements that industry flights stay at 1500 ft or more above ground level, and a minimum of ½ km from groups of walrus on ice or at terrestrial haul outs, have reduced the potential for disturbance. Flight corridors established from shore bases to offshore industry operation sites reduce the potential for disturbing walrus by limiting the spatial extent of the over-flights. OCS industry associated flights are directed away from concentrations of walrus and have negligible impacts to walrus and no population level effects.

**Discharges.** Exploration drilling could result in the disposal of drilling fluids or cuttings onto the seafloor under terms of an EPA NPDES permit. The accumulation of these sediments on the seafloor could result in a direct loss of walrus foraging habitat. Exploration drilling fluids and cuttings may cause localized contamination of the seafloor in the Chukchi Sea. Trefry, Trocine, and Cooper (2011) found higher mercury levels at three stations within 500m of the 1989 exploration wells at Burger and Klondike in the Chukchi Sea than at the other 106 stations tested in the Chukchi Sea. A similar study (Shell, 2009) in the Beaufort Sea did not find any residual contamination.

The discharge of drilling fluids and cuttings during exploration activities is not expected to cause population-level effects to walrus, either directly through contact or indirectly by affecting prey species. Any effects would be localized primarily around the exploration drilling site because of the rapid dilution/deposition of these materials. The effects from such discharges are expected to be localized to a small proportion of available marine mammal habitat. Pacific walruses are a long lived species that feed primarily on benthic invertebrates, some of which are known to concentrate contaminants (Doroff and Bodkin, 1994). Warburton and Seagers (1993) compared metal concentrations from 56 liver and kidney samples collected from 1986 to1989 with 57 samples collected in 1981 to 1984 (Taylor, Schliebe, and Metsker, 1989). While still low, trace levels of selenium, arsenic and lead increased significantly between the two time periods. Selenium was the highest at 17.6 parts per million (ppm.) Levels of cadmium and mercury did not increase; however, cadmium levels remained high (mean of 166.5 ppm.). Both cadmium and mercury appear to be naturally occurring in the Chukchi Sea. Available data on contaminant levels in walrus have not identified any health impacts to walrus. Authorized discharges from exploration drilling are anticipated to result in a negligible level of effect on Pacific walrus.

**Small Fuel Spill.** A small spill (estimated at potential 48 bbl of diesel fuel for this EA) would dissipate over a few days and impacts from a small spill would result in a minor impact to some walrus rather than a population level effect. Because walrus are likely to avoid and disperse from areas with lots of human activity (such as clean up crews or drilling operations), it is likely that those walrus that are not oiled immediately would avoid the area of the spill as long as clean up activities were ongoing.

**Large and Very Large Oil Spill.** The potential impacts of small, large, and very large oils spills have been analyzed in the Sale 193 Final EIS and the Sale 193 Final SEIS and are summarized here. Impacts from a spill originating at the proposed drill sites or from a vessel in transit to or from the proposed drill site do not differ from the previous analysis. Although a very large oil spill is a highly unlikely event, it could result in a major impact to the walrus population if it were to occur in the Chukchi Sea at an area with a large concentration of the walrus population. For example, if a very large oil spill originating at the drill site were carried northward by the currents and came into contact with the pack ice edge where walrus were gathered in large numbers, it could have moderate or major impact.

### Mysticete Whales

Mysticete whales include bowhead, gray, fin, humpback, and minke whales. Potential impacts to these species are analyzed below.

**Drilling.** Bowhead reaction to drillship-operation noise is variable. Individuals whose behavior appeared normal have been observed on several occasions within 10-20 km (6.2-12.4 mi) of operating drillships in the eastern Beaufort Sea, and there have been a number of reports of sightings within 0.2-5 km (0.12-3 mi) from drillships (Richardson et al., 1985a; Richardson and Malme, 1993). On several occasions, whales were well within the zone where drillship noise should be clearly detectable to them. In other cases, bowheads have avoided drillships and their support vessels by 10-20 km (Richardson et al., 1985; Richardson and Malme, 1993).

Richardson and Malme (1993) point out that the data suggest stationary, continuous noise sources, such as stationary drillships, elicit less dramatic reactions with bowheads than mobile noise sources. Most observations of bowheads tolerating noise from stationary operations are based on opportunistic sightings of whales near ongoing oil-industry operations. Other cetaceans seem to habituate somewhat to continuous or repeated noise exposure when the noise is not associated with harmful events, implying that bowheads may habituate to certain, non-threatening noises. Davis (1987) monitored the responses of bowhead whales to drilling operations at the Corona and Hammerhead wells in the U.S. Beaufort Sea, and concluded the sound generated by the drilling operations did not impede their migration since the only responses he observed were temporary avoidance behaviors in some whales. Likewise BOEM expects drilling operations would have the same effect on mysticete whales in the Chukchi Sea, eliciting temporary avoidance behavior in a few of the whales within the potential zone of effects from drilling noise.

The distance at which bowheads may react to drillships is difficult to gauge, because some bowheads would be expected to respond to noise from drilling units by changing their migration speed and swimming direction to avoid closely approaching these noise sources. For example, in the study by Koski and Johnson (1987), one whale appeared to adjust its course to maintain a distance of 23-27 km (14.3-16.8 mi) from the center of the drilling operation, and migrating whales avoided the drillship by 10 km (6.2 mi), passing to the north and south of drilling operations. In this study no bowheads were detected within 9.5 km (5.9 mi), and few were observed within 15 km (9.3 mi) of the drillship. The study concluded that bowheads appeared to avoid the offshore drilling operation during their 1986, fall migration.

Another study by Richardson et al. (1995) concluded:

> …migrating bowheads tolerated exposure to high levels of continuous drilling noise if it was necessary to continue their migration. Bowhead migration was not blocked by projected drilling sounds, and there was no evidence that bowheads avoided the projector by distances exceeding 1 kilometer (0.54 nautical miles). However, local movement patterns and various aspects of the behavior of these whales were affected by the noise exposure, sometimes at distances considerably exceeding the closest points of approach of bowheads to the operating projector.

The results from these two studies illustrate the variable responses of bowhead whales to drilling activities have been noted since at least 1987.

Richardson et al. (1995) reported that bowhead whale avoidance behavior has been observed in half of the animals when exposed to 115 dB re 1 μPa rms broadband drillship noises. However, reactions vary depending on the whale activity, noise characteristics, and the physical condition of individual animals (Olesiuk et al., 1995; Richardson, 1995b; Kraus et al., 1997; NRC, 2003, 2005). The study concluded that the demonstrated effects were localized and temporary, and playback effects of drilling noise on distribution, movements, and behavior were not biologically significant, leading the MMS to conclude that drilling activity should have a minor level of effects on bowhead whales. Moreover, offshore drilling operations have occurred in the Beaufort Sea over the past several decades. In this time, the Western Arctic Stock of bowhead whales has concurrently increased to a level that may approach the bowhead whale carrying capacity of the Beaufort and Chukchi seas (Allen and Angliss, 2011).

Richardson et al. (1985) projected recordings of the drillship *Explorer II* at summering bowheads in the Canadian Beaufort Sea. Changes in behavior in response to the sounds were observed, and some whales showed avoidance behavior; however, the deflection away from the noise was considered weak (Richardson et al. 1985). During this study the investigators observed whales between 2.5 mi and 12.4 mi (4 km and 20 km) from the drillship as drilling activity was occurring, and concluded the whales were undisturbed. In a similar study, Wartzok et al. (1989) projected recordings of the drilling vessel Kulluk, and no deflections were noted until sound pressure levels were ≥120 dB.

Gallagher, Brewer, and Hall (1992) monitored bowhead distribution during the drilling of the Galahad No. 1 well with the Explorer II in the Alaska Beaufort. They observed 96 bowheads during the monitoring effort, with the closest observation at 10.3 mi (16.5 km), and the average observation being 22 mi (34.8 km) from the drillship. Whales were noted farther offshore than historical trends suggested, and their routes took a more northerly bearing than expected as they approached the drill site, turning west after passing the drillship. These observations suggested a diversion effect due to drilling noise; however, the authors noted it was a heavy ice year and the whales were forced to migrate further offshore along a path aligned with the ice edge.

Brewer et al. (1993) observed 49 bowheads in the survey area while the *Kulluk* drilled the Kuvlum No. 1 well. The closest observed whale was 14 mi (23 km), and the average observation distance was 25 mi (40.3 km), from the drillship. The report noted drilling operations (drilling unit, icebreakers, and supply vessels) may have caused migrating bowhead whales to assume more clumped groupings, and shifted their distribution north, skirting around drilling operations. The start of the diversion was thought to begin about 19 mi (30 km) east of the drill site, but the authors noted the diversion was temporary as the whale distribution appeared to resume a typical track (uniform distribution and closer to shore). The investigators thought it unlikely that ice conditions were solely responsible for the changes in bowhead distribution.

Hall et al. (1994) observed the distribution of 373 bowhead whales around the Kuvlum No. 2 and No. 3 wells, which were also drilled by the Kulluk. They observed bowheads within 4.5 mi (7.2 km) of the drillship, and reported migrating bowheads much closer to shore than at a control area east of the drillship. A review of their plotted sightings indicated almost total avoidance of the area within 6.2 mi (10 km) of the drillship (Richardson et al., 1995b); however, the authors concluded the bowhead distribution patterns may have been due to sea ice, and that the distribution fell within the norms for fall distributions.

Few fin, humpback, and minke whales are expected to be in the vicinity of the Burger Prospect, and bowhead whales are expected to remain scarce at the Burger Prospect until their migration out of the Beaufort Sea begins in September. Gray whales are expected to occur throughout the eastern Chukchi Sea until their fall migration to Baja California begins (Funk et al. 2010; Blees et al. 2010; Brueggeman, 2010). Relatively few bowhead and gray whales, and fewer than 0-5 fin/humpback/minke whales are expected to be exposed to drilling noises from the Proposed Action. Based on the numbers reported by Shell (Shell, 2011a: Appendix C, Table 4.1.7-1) and this impacts analysis, the effects of sound energy generated by drilling on bowhead, and gray whales would be minor, while fin, humpback, and minke whales would be affected negligibly due to their low presence in the area.

**ZVSP.** An eight airgun array (4×40 $in^3$ airguns and 4×150 $in^3$ airguns, total volume of 760 $in^3$) would likely be used to perform ZVSP surveys at or near the end of each exploration well. Each ZVSP survey would last around 10-14 hours and include approximately 216 firings of the full airgun array, plus additional firing of a single 40-$in^3$ airgun to be used as a "mitigation airgun" while the geophones are relocated within the wellbore. The estimated source level used to model sound propagation from the airgun array is approximately 241 dB re 1µPa m rms, with most energy between 20 and 140 Hz (Shell 2011a: Appendix C: pp. 4-60).

From a behavioral perspective, seismic noise could mask whale vocalizations and interfere with their communications, and/or alter natural behaviors (i.e., displacement from migration routes or feeding areas; disruption of activities such as feeding, resting, or nursing) although it occurs at the lower end of the audible spectrum for mysticetes. Behavioral impacts may vary by gender, reproductive status, age, accumulated hearing damage, type of activity engaged in at the time, group size, and/or whether the animal has heard the sound previously (e.g., Olesiuk et al., 1995; Richardson, 1995b; Richardson et al., 1995; Kraus et al., 1997; NRC 2003, 2005). Mysticete females with calves have exhibited heightened behavioral responses to seismic noise (Henley and Ryback, 1995; McCauley et al., 2000), while in other studies some bowheads ceased feeding when exposed to seismic noise, though others continued feeding (Fraker, Richardson, and Würsig, 1995; Richardson, Wells, and Würsig, 1985).

Gray whales are low-frequency hearing specialists, with an auditory range starting at 10 Hz and possibly extending to 30 kHz (Ketten, 1998). Erbe (2002) (inferring from gray whale vocalizations) suggested they may be sensitive to frequencies between 20 Hz and 4.5 kHz, with their greatest sensitivity occurring in the 20 Hz–1.2 kHz range. 10 kHz clicks have been reported, with main frequencies between 1.4 and 4 kHz. The lowest response threshold reported was 82–95 dB at 800 Hz (Erbe, 2002). Minke whales appear most sensitive to sound between 100 and 200 Hz, with good sensitivity between 60 Hz–2 kHz. High-frequency clicks were analyzed in two studies, indicating they have some sensitivity between 4 and 7.5 kHz, up to 20 kHz (Erbe, 2002).

Based on previous studies (Table 20), few fin or humpback whales are expected to occur in the eastern Chukchi Sea, and even fewer are anticipated to occur in the proposed activity area. Few bowheads should occur in the eastern Chukchi Sea (Table 20) before the fall migration from the Beaufort Sea commences in September. Thus, gray whales are the only mysticete expected to regularly occur in the eastern Chukchi Sea for much of the open water season. The small chance of encountering bowhead, humpback, fin, or minke whales greatly lowers the potential impact of the Proposed Action on those species. In the unlikely event of an encounter with one of these species, the repetitive noise of discharging 150-$cm^3$, and 40-$cm^3$ airguns is expected to deflect the whale away from the area of effects before any injury can occur. BOEM anticipates the effects to be generally similar to those noted for other mysticete whales because of shared morphological characteristics and similar biological needs.

A maximum of three ZVSP surveys could be conducted within a single season; subsequently, any disturbances from ZVSP airguns discharging could occur for a maximum of 42 hours for the entire open water season. Whales begin diverting when received levels of noise reach approximately 150-180 dB (Richardson, 1995c), and so it is reasonable to expect avoidance behavior from mysticetes to begin before they approach to within 12,041 ft (2.28 mi) or 3,670 m (3.67 km) of ZVSP operations (160 dB zone in Table 9). By applying MMOs and ramp-up protocols as mitigation measures for ZVSP operations, TTS and PTS effects to the hearing of baleen whales should be avoided. Consequently, BOEM anticipates a minor level of effects from ZVSP activities on bowhead and gray whales with an estimated average of 25 bowheads and 21 gray whales being exposed to airgun noise during each season (Table 4.1.7-1: Shell 2011a: Appendix F). In addition, a negligible level of effects on fin, humpback, and minke whales are expected, since an average of zero individuals of those species should be affected by ZVSP airgun noise in any single season (Table 4.1.7-1: Shell 2011a: Appendix F). The rating of negligible for fin, humpback, and minke whales is mostly due to their scarcity in the prospect areas, which greatly lessens the likelihood of encountering or affecting them during the ZVSP phase of the Proposed Action.

**Vessel Traffic.** Bowhead whales react to the approach of vessels at greater distances than they react to most other activities. Most bowheads exhibit avoidance of vessel traffic, although reactions are less dramatic to slower moving vessels and vessels that are not approaching the animals directly (USDOC, NOAA, NMFS, 2008). In the Canadian Beaufort Sea, bowheads observed in vessel-disturbance experiments began to orient away from an oncoming vessel at a range of 2-4 km (1.2-2.5 mi) and to move away at increased speeds when approached closer than 2 km (1.2 mi) (Richardson and Malme, 1993). Vessel disturbance during these experimental conditions temporarily disrupted activities and sometimes disrupted social groups, when groups of whales scattered as a vessel approached.

According to Richardson and Malme (1993), most bowheads begin to swim rapidly away when vessels approach rapidly and directly. Received noise levels as low as 84 dB re 1 μPa or 6 dB above ambient may elicit strong avoidance of an approaching vessel at a distance of 4 km (2.5 mi) (USDOI, MMS, 2008, incorporated by reference). Richardson and Finely (1989) noted that bowheads tend to react most strongly to vessels when the vessels were moving quickly and directly toward the whale than if the vessel was moving more slowly or in any other direction than at the whale.

Richardson, Wells, and Wursig (1985) found that bowheads react more strongly to vessel traffic than other industrial disturbances such as aircraft overflights and drilling, and that most bowheads began to turn away when vessels approached within 0.6-2.5 mi (1-4 km) of the whale. The whales usually tried to outrun the boat, and when the vessel approached to within a few hundred yards, the whales diverted from the vessel path or dove. In comparison, groups of whales scattered during this study, though fleeing generally stopped within minutes after the vessel passed, but remaining scattered for perhaps an hour or more. Additional behavioral responses to vessel traffic also included changes in respiration rates. Similar responses to vessels have been observed in fin (Ray et al., 1978 as cited in Richardson et al., 1985) and humpback whales (Baker et al., 1983 in Richardson, Wells, and Wursig, 1985).

Koski and Johnson (1987) made similar observations of bowheads in the Alaskan Beaufort where strong responses by feeding bowheads to large icebreakers and supply vessels were observed. Changes in whale behavior were temporary, with feeding often resuming while the moving vessel was still within 3.7- 6.0 mi (6.0-10.0 km). At least some of the whales were observed back at the same area the next day, indicating there were little if any effects on bowhead whales use of that area.

Wartzok et al. (1989) reported that bowheads generally ignored a small ship at distances greater than 547 yd (500 m). Over 180 whales voluntarily approached within 547 yd (500 m) of the vessel. Little response was noted unless there was a sudden change in sound level due to ship acceleration. These studies indicate that some bowheads will react more strongly than others to vessel traffic associated with Shell's exploration drilling program. Bowheads may alter their behavior and avoid the area within 0.6-2.5 mi (1-4 km) of the vessel. Any changes in behavior such as swimming speed and orientation, respiration rate, surface-dive cycles will be temporary and lasting only minutes or hours. Similarly, any consequent displacement of bowheads will be of a similar length of time and be restricted to a distance of a few miles (kilometers) from the vessel.

Gailey et al. (2007 citing Bogoslovskaya et al., 1981) noted eastern gray whales on summer feeding grounds, fled when Soviet catcher vessels approached within 350-550 m, but usually paid no attention to vessels at distances > 550m. Richardson (1995c: p. 264 - reporting from Schulberg, Show, and Van Schoik, 1989) noted many gray whales may show no deflection or change in their behavior until vessels approach to within 49-98 ft (15-30 m) of the whale. Underwater sound also may cause whales to avoid vessels moving within their immediate area, and gray whales are expected to exhibit avoidance of vessels in close proximity (USDOI, MMS, 2007a). However, any avoidance responses due to vessel traffic are expected to be minimal and temporary.

The most common baleen whale occurrences will likely be gray whales, along with small numbers of bowhead, and smaller numbers of minke whales. Fin and humpback whales most likely will not be encountered during the proposed activities if past observations are any indication of their presence at the leases; however, possible sightings cannot presently be ruled out. The reactions of fin, humpback, and minke whales to vessel traffic are expected to approximate those of bowheads and gray whales due to their morphological similarities.

The drillship and support vessels will not enter the Chukchi Sea earlier than July 1 when most of the spring bowhead migration is complete. Consequently few bowheads are expected to be encountered during the drilling operations, until the fall migration out of the Beaufort Sea. As a mitigation measure, vessels associated with the drilling program that are underway will reduce speed, avoid separating members from a group of whales and avoid multiple course changes when within 300 yd (275 m) of marine mammals, including whales. Vessel speed also will be reduced during inclement weather conditions in order to avoid collisions with whales and other marine mammals. These mitigations should prevent any measureable disruptions to mysticete whales at the prospect areas. Consequently, BOEM concludes that vessel traffic and noise from the Proposed Action are expected to result in negligible effects on mysticete whales in the project area.

**Ice Management.** The Proposed Action would entail ice management activities, with some potential for icebreaking. Brewer et al. (1993) reported that in fall 1992, migrating bowhead whales avoided an icebreaker accompanied drillship by 25+ km. The ship was icebreaking almost daily. Richardson et al. (1995) noted that in 1987, bowheads also avoided another drillship with little icebreaking. Response distances vary, depending on icebreaker activities and sound-propagation conditions. Based on models in earlier studies, Miles, Malme, and Richardson (1987) predicted bowhead whales should respond to the sound of icebreakers at distances of 2-25 km (1.24-15.53 mi) from active icebreakers. The same study predicts about half of the bowhead whales in an area can be expected to show an avoidance response to an icebreaker underway in open water conditions at 2-12 km (1.25-7.46 mi) distance, or to an icebreaker pushing ice at 4.6-20 km (2.86-12.4 mi) distance, when the sound-to-noise ratio is 30 dB.

Richardson et al. (1995) concluded that exposure to a single playback of variable icebreaker sounds can cause statistically, but probably not biologically, significant effects on movements and behavior of migrating whales in lead systems during the spring migration east of Point Barrow. The study indicated the predicted response distances for bowheads around an actual icebreaker may be highly variable; but typically detectable effects on the movements and behavior of traveling bowheads are predicted to extend in a of 10-30 km (6.2-18.6 mi) radius, and sometimes to 50+ km (31.1 mi) radius. It should be noted that these predictions were based on reactions of whales to playbacks of icebreaker sounds in a lead system during the spring migration, and are subject to a number of factors that would not apply to the Proposed Action which would occur during the open water season. Infrasounds (sound at a range of frequencies below that of human hearing) that may be associated with icebreakers were not adequately represented in playback transmissions. Bowhead whales likely can hear or detect infrasounds (Richardson et al., 1995b).

Richardson et al. (1995: p.322) summarized:

> The predicted typical radius of responsiveness around an icebreaker like the Robert Lemeur is quite variable, because propagation conditions and ambient noise vary with time and with location. In addition, icebreakers vary widely in engine power and thus noise output, with the Robert Lemeur being a relatively low-powered icebreaker. Furthermore, the reaction thresholds of individual whales vary by at least ±10 dB around the "typical" threshold, with commensurate variability in predicted reaction radius.

Richardson et al. (1995) stated:

> If bowheads react to an actual icebreaker at source to noise and RL values similar to thosefound during this study, they might commonly react at distances up to 10-50 km from the actual icebreaker, depending on many variables. Predicted reaction distances around an actual icebreaker far exceed those around an actual drillsite…because of (a) the high source levels of icebreakers and (b) the better propagation of sound from an icebreaker operating in water depths 40+ m than from a bottom-founded platform in shallower water.

In order to limit the close contact between the whales and ice-management vessels and support-vessel operations, MMOs would be stationed on all support vessels to survey inside the exclusion zone (areas within isopleths of certain sound levels for different species) for marine mammals. If a marine mammal is sighted from a vessel within its relative safety radius, the vessel would reduce activity (reduce ice-management activities or speed if in transit) and sound level to ensure that the animal is not exposed to sound energy above their relative safety levels. Full activity would not be resumed until all marine mammals are outside of the exclusion zone.

Although bowhead whales react to icebreaking and ice-management activities, these activities are expected to have a minor level of effect on the bowhead whale population in the Chukchi Sea for the following reasons: the timing of this project during the open-water season; the low likelihood of the presence of large amounts of sea ice; a scarcity of bowhead whales during the July-August segment of this project; and the short duration of this project. The reactions of gray, fin, humpback, and minke whales to icebreaking and ice-management activities are expected to be similar to that of bowhead whales. However, considering the observed paucity of fin and humpback whales in the project areas, a negligible level of is expected for these whale species, since no detectable population-level effects could be measured for either. Minke whales are slightly more common; however, they generally do not associate with ice. Grey whales, which are the most common cetacean species in the area for much of the open water season, also generally do not associate with ice. Consequently, negligible effects are anticipated for minke, and gray whales from icebreaking and ice management.

**Aircraft Traffic.** For whales, the most common reaction to aircraft traffic is avoidance behavior, such as diving. Richardson et al. (1985) monitored the responses of summering bowhead to overflights with both fixed wing (Islander) aircraft and helicopter (Sikorsky S-76) in a set of planned experiments. Overflights of fixed-wing aircraft sometimes evoked responses at altitudes of less than 1,000 ft (305 m), infrequently at altitude of 1,500 ft (457 m), and virtually never at altitudes greater than 2,000 ft (610 m). The researchers concluded bowhead whale behavior is generally not disturbed by aircraft if an altitude of 1,500 ft (> 457 m) is maintained. The most common bowhead reactions to overflights were sudden or hasty dives, and changes in orientation, and dispersal or movement out of the area. Changes in activity were sometimes noted. Bowheads that were engaged in social activities or feeding were less sensitive than those that were not. Whales in shallow water < 33 ft (< 10 m) were often very sensitive. No overt responses were observed to helicopter overflights at an altitude of 500 ft (153 m); however, others (Richardson, 1995b) have reported disturbances such as hasty dives in response to low-level helicopter overflights. Richardson and Malme (1993) reported that most bowhead whales in their study did not show a response to helicopters flying at altitudes above 500 ft (150 m).

Gray whales may also show avoidance behavior in response to air traffic sound energy. Moore and Clarke (2002: citing Southwest Research Associates 1988) reported migrating gray whales did not react overtly to a Bell 212 helicopter at > 425m (1,394 ft) altitude, but they occasionally reacted when helicopters were at altitudes of 305-365m (1,000-1,197 ft), and usually reacted when helicopters were below 250m (820 ft). Clarke, Moore, and Ljungblad (1989) found gray whale mothers with calves appear to be particularly sensitive to air traffic. Some gray whales have been observed reacting to sound energy generated by helicopters flying within 328 ft (100 m) of the whales (Richardson, 1998). As a mitigation measure Shell helicopters will be prohibited from flying at altitudes below 1,500 ft (457 m) except during take-offs, landings, marine mammal monitoring, and when conditions force an altitude reduction for personal safety reasons. Shell helicopter flights should therefore have little or no effect on gray or bowhead whales. Any changes in gray whale behavior due to aircraft traffic associated with Shell's exploration drilling program will be minor and temporary, lasting only minutes or hours.

Summarily, the most likely response of baleen whales to aircraft operations in support of the Proposed Action would be very brief and minor alterations in their swimming and diving behavior until the aircraft noise becomes inaudible. Consequently, the effects of aircraft presence and noise on bowhead, fin, gray, humpback, and minke whales are expected to be minor due to mitigations applicable to the Proposed Action.

**Discharges.** The Proposed Action entails the discharges of wastewater, drill cutting, and drilling fluids. As explained above, the areas affected by these discharges would be small, would recover quickly, and would be in the general proximity of activities causing enough noise to discourage visitation by mysticetes. Identifiable impacts to these whales from discharges are therefore unlikely.

**Small Fuel Spill.** After reviewing the potential effects of a 48 bbl oil or fuel spill on baleen whales, BOEM finds a negligible level of effects applies. Such a small spill would be insufficient to produce any population level effects on whales in the Chukchi Sea. Oil generally poorly adheres to the skin of mysticete whales, and cetaceans are believed to have the ability to detect and avoid oil spills (Geraci, 1990; St. Aubin, 1990). Moreover, the weathering process should act to quickly break up or dissipate oil/fuel through the local environment to harmless residual levels that would eventually become undetectable.

**Large and Very Large Oil Spills.** Although very unlikely, it is possible that the Proposed Action could lead to a large or very large oil spill. For the purpose of analysis, BOEM estimates potential discharge volumes for this EA to be 1,555 bbl of diesel for a large spill and 750,000 bbl of crude oil for a very large spill. The Sale 193 Final EIS (USDOI, MMS, 2007a) analyzed potential effects to mysticete whales from large spills and found potential for adverse impacts through direct contact, reduction of prey availability, toxic exposure, and disturbance from cleanup operations. The Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) analyzed potential effects to mysticete whales from a very large spill and identified a variety of potential direct and indirect effects, some of which could become significant under certain circumstances. These analyses remain sufficient to analyze the effects of large and very large spills in the Chukchi Sea, including the 1,555 bbl diesel spill and the 750,000 bbl oil spill estimated for this EA

### Odontocetes: Beluga, Harbor Porpoise and Killer Whales

This section summarizes and incorporates the analysis of potential impacts from drilling operations found in Sale 193 Final EIS (USDOI, MMS, 2007a), Sale 193 Final SEIS (USDOI, BOEMRE, 2011a), Shell's (Shell, 2011a: Appendix F), and NMFS' proposed IHA for the proposed exploration drilling (76 FR 69958, November 9, 2011). Densities of odontocetes are anticipated to be very low in the project area and few beluga, harbor porpoise, or killer whales are expected to come into contact with proposed exploration activities on or near the Burger Prospect. Since impacts to all three species would be similar, they are grouped for this analysis.

**Drilling.** Impacts to Odontocetes from drilling operations are primarily impacts from exposure to sound. Sound propagation from the drill ship *Discoverer* is anticipated to decrease below 120db at less than 2km from the drill ship. Based on a variety of marine mammal surveys of the drill site area and the northeastern Chukchi Sea, NMFS and Shell have estimated that zero beluga, harbor porpoise or killer whales will be exposed to drilling sound above 120dB. Negligible impacts to odontocetes are anticipated from exploration drilling in the vicinity of the Burger Prospect in the Chukchi Sea.

**ZVSP.** The proposed ZVSP airgun array has been estimated to reach 160 dB, but to decrease below that level at less than 4 km from the *Discoverer*. NMFS estimates that 4 beluga, 0 harbor porpoises, and 0 killer whales may be exposed to sound levels exceeding 160dB. Negligible impacts to odontocetes are anticipated from the planned vertical seismic profiling.

**Vessel Traffic and Ice Management.** Some odontocetes may be encountered during transit to or from the drill site, or as they move through the drilling area. This is the case regardless of whether Shell exits the drilling area in late October or sometime prior. In general, beluga, harbor porpoise, and killer whales react to vessels and to icebreaking by moving away from the source of the activity. Some may therefore be displaced during feeding or may have increased energetic costs during rapid avoidance of vessel traffic. NMFS and Shell have estimated that for this operation, ice breaking noise decreases below 120dB at a maximum distance of about 10 km. NMFS estimates that fewer than 5 individuals of each species would be exposed to sound levels exceeding 120dB. Vessel traffic and icebreaking are expected to have a negligible level of effect for beluga, harbor porpoise, or killer whales.

**Aircraft Traffic.** Aircraft have minimal impacts on beluga, harbor porpoise, and killer whales. Because sound doesn't pass through the air-water surface very well, odontocetes are not typically affected by flights that pass briefly overhead at elevations of 1500 ft or above along offshore straight line transit routes. Shell's proposed aircraft flights along predetermined routes and during marine mammal surveys are not anticipated to have more than a negligible impact to odontocetes.

**Discharges.** Discharges of fluids and cuttings from the proposed wells are unlikely to have direct effects to odontocetes. Under EPA guidelines, concentrations of drilling fluids drop below levels that would affect marine mammals within a few minutes, and are diluted within a few hundred meters. Impacts to the fish they prey upon or a significant decrease in water quality could result in an indirect effect on odontocetes, but this is not anticipated given the small scale of the habitat disturbance. Impacts to fish and water quality are fully discussed in those sections.

**Small Fuel Spill.** A small spill (estimated at a potential 48 bbl for this EA) of diesel fuel would dissipate over a few days. Impacts to odontocetes from a small spill are unlikely because odontocetes are unlikely to be in the vicinity of the drillship or associated vessels due to noise. Because odontocetes are likely to avoid and disperse from areas with lots of human activity (such as clean up crews or drilling operations), it is likely that odontocetes would avoid the area of the spill as long as clean up activities were ongoing.

**Large and Very Large Oil Spill.** The potential impacts of small, large, and very large oils spills have been analyzed in the Sale 193 Final EIS (USDOI, MMS, 2007a) and Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) and are summarized here. Impacts from a spill originating at the proposed drill sites or from a vessel in transit to or from the proposed drill site do not differ from the previous analysis. A very large oil spill is a highly unlikely event, but could result in exposure to oil for odontocetes: through skin, inhalation, or ingestion of contaminated prey. Affects from this exposure in open water are likely to be limited to short term non-lethal effects such as skin irritation. A large or very large oil spill could result in moderate impacts to odontocetes.

### Polar Bear

This section refers to the Chukchi Bering seas (CBS) stock of polar bears and the Southern Beaufort Sea (SBS) stock of polar bears, and the critical habitat established for polar bears within the U.S. and U.S. waters. There is a substantial area of overlap between the two stocks, and activities in the northern Chukchi Sea would have the potential to impact both populations. In general, polar bears are widely dispersed when on sea ice and few polar bears transit through the open water as far offshore as the project area is located (+60 miles). Polar bears have been observed in the northeastern Chukchi Sea during the open water season, primarily when the pack ice is in the immediate vicinity.

Exploratory drilling projects have the potential to disturb polar bears that are swimming between the pack ice and shore. Swimming can be energetically expensive for polar bears, particularly for bears that engage in long-distance travel between the leading ice edge and land. Bears that encounter open water exploratory drilling operations may be temporarily deflected from their chosen path, and some may choose to return to where they came from. However, bears swimming to shore are most likely heading for reliable food sources (i.e., areas where ringed seal concentrations are high or Native-harvested marine mammal carcasses are on shore), for which they have a strong incentive to continue their chosen course. Therefore, although some bears may be temporarily deflected and/or inhibited from continuing toward land due to exploratory drilling operations, this interruption likely would be brief in duration. Due to the vast area over which polar bears travel and their dispersed distribution, the number of bears affected in this manner likely would be very small.

**Drilling.** Polar bears are closely tied to the presence of the sea-ice platform for the majority of their life functions, including hunting (Amstrup, 2003). It is unlikely that open-water exploration drilling in the northeastern Chukchi Sea will impact polar bears or the abundance and availability of ringed and bearded seals, which are the primary prey of polar bears. Exploration drilling operations have a localized footprint of a few thousand square feet per well; in this case, more than 60 miles offshore. The drillship and associated vessels will move out of the Chukchi Sea towards the end of the open water season. Impacts to polar bears from the drilling noise are negligible and no adverse impacts to critical habitat are anticipated.

**ZVSP.** The proposed ZVSP airgun array has been estimated to reach 160dB, but to decrease below that level at less than 4 km from the *Discoverer*. Polar bears normally keep their heads above or at the water's surface when swimming, where underwater noise is weak or undetectable (Richardson et al., 1995a). The sound level of the ZVSP is not anticipated to reach the 190 dB level identified as the level of "take" for polar bears. Negligible impacts to polar bears are anticipated from the planned vertical seismic profiling and no adverse impacts to critical habitat are anticipated.

**Vessel Traffic.** Most vessel operations associated with the proposed exploration drilling plan will take place far offshore and in open water and are not expected to encounter polar bears. Polar bears may approach or avoid ice breakers. Brueggeman et al. (1991) observed polar bears in the Chukchi Sea during previous drilling operations and recorded their response to an icebreaker. While bears did respond (walking toward, stopping and watching, walking/swimming away) to the vessel, their responses were brief. Impacts to bears from vessels are likely to be limited to short-term disturbance and displacement from the immediate area of activity, resulting in some expenditure of energy. In general, impacts are anticipated to be negligible.

**Ice Management.** If icebreaking is needed to transit in or out of the Chukchi Sea, or if icebreakers need to manage ice that has approached the drill ship during active drilling, then polar bears may be encountered. Shell's ice management plan is to avoid pack ice by moving the drillship offsite if necessary. Although this is for the safety of the ship and crew, it also reduces the likelihood of a need for icebreaking or encounters with polar bears. Shell's intention is to wait to enter the Chukchi Sea until after July 1 when the ice has receded north of the drill site. During transit into the Chukchi Sea, Shell may encounter some broken melting ice. During transit out of the Chukchi Sea, Shell may encounter some first year ice. While at the drill site, ice management may involve nudging floes of ice away from the drill ship. This is usually done by using propwash to push the ice floe into a different part of the current so that it will flow past the drillship rather than into the drillship. No adverse impacts to critical habitat are anticipated.

**Aircraft Traffic.** Sources of flights in the Proposed Action include industry crew changes and industry marine mammal surveys. Flights during crew change outs will follow a fixed route from Wainwright to the drill site over open water and are unlikely to disturb polar bears. Polar bears may be displaced from ice floes or terrestrial sites temporarily during marine mammal surveys, which will follow a sawtooth pattern nearshore. Impacts from these short term temporary disturbances are limited to some expenditure of energy for individual bears.

As polar bears spend more time fasting onshore due to receding sea ice the potential for small repeated energetic costs to have health impacts increases. Increases in physiological stress of adult or juveniles may reduce fitness and have implications for productivity and survivorship over time. Requirements that industry flights stay at 1500 ft or above ground level and a minimum of ½ km from polar bears helps to reduce the potential for disturbance. Flight corridors established from shore bases to offshore industry operation sites reduce the potential for disturbances by limiting the spatial extent of the over-flights. Aircraft flights associated with Shell's offshore drilling plan are likely to have a negligible impact to polar bears and no adverse impacts to critical habitat

**Discharges.** The discharge of drilling fluids and cuttings during exploration activities is not expected to cause impacts to polar bears or critical habitat, either directly through contact or indirectly by affecting prey species. Any effects would be localized primarily around the exploration drilling site because of the rapid dilution/deposition of these materials. The effects from such discharges are expected to be localized to a small proportion of available marine mammal habitat.

**Small Fuel Spill.** For the purpose of analysis, it is estimated for this EA that a 48 bbl spill of diesel fuel could occur. Given the dispersed distribution of polar bears, it is likely that a small spill persisting for less than 2-30 days would affect few polar bears, resulting in a minor level of effect on polar bears and no adverse impacts to critical habitat.

**Large and Very Large Oil Spill.** The potential impacts of small, large, and very large oils spills have been analyzed in the Sale 193 Final EIS (USDOI, MMS, 2007a) and the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a), respectively, and are summarized here.

In the unlikely event that a large (estimated at a potential discharge of 1,555 bbl for this EA) or very large spill (estimated at a potential discharge of 750,000 bbl) occurred at the drill site, it would likely be carried northward by the currents. If the oil came into contact with the pack ice, or became entrained in the ice, it could impact polar bears. If Polar bears come into contact with spilled fuel from a small spill or oil from a large or very large spill in water or on ice, their coats could become fouled. Polar bears rely on their thick fur to avoid hypothermia, and a heavily oiled bear would likely not survive. Polar bears could also ingest toxins while grooming or by foraging on seals that had become oiled (Amstrup et al, 2000; Amstrup et al, 1989; Durner and Amstrup, 2000). A large or very large spill that came ashore or fouled a large area of sea ice could impact polar bears directly (and indirectly through their prey) and could result in moderate or major impacts to polar bears as well as adverse impacts to critical habitat.

Cleanup operations following a large oil spill would involve multiple marine vessels operating in the spill area for extended periods of time, perhaps over multiple years. After a large spill, there typically are helicopter and fixed-wing aircraft over flights to track the spill and to determine distributions of wildlife that may be at risk from the spill. In the event of a large spill, both FWS and NMFS personnel would be on hand to conduct marine mammal surveys and to determine the best course of action to limit the potential impacts to marine mammals as much as possible. This may include prioritizing clean up to particularly sensitive areas, hazing animals away from spilled oil and clean up activities, and capturing oiled animals for transfer to rehabilitation facilities. The effects from cleanup activities on pinniped species would be largely the effects of disturbance from vessels, the effects of disturbance from aircraft, and the effects of the spilled oil itself.

### 4.6.3 Alternative 3 – One Well per Season

If Alternative 3 is selected, a maximum of one exploration well would be drilled in any season. Drilling six wells to total depth would require at least six seasons. The annual impacts from Alternative 3 would be slightly less than those described under Alternative 2, because there would be less disturbance from a single event compared with two or possibly three drilling events under Alternative 2. A shorter period of disturbance could reduce the probability of impacts and the number of animals impacted and would result in a smaller level of effects per season. The fleet would likely operate in the drill site area for a shorter time period each year, which would decrease the time period during which impacts could occur at the drill site in any one year. If drilling operations occur when there is the most open water and the least ice, the likelihood of encounters with walrus or polar bears, and possibly beluga, would decrease (although the likelihood of encountering polar bears or beluga is already very low).

However, this Alternative could have a greater total adverse effect on marine mammals. Whereas under Alternative 2 the drilling program could be completed in as few as two seasons, under

Alternative 3 the drillship and support vessels would enter, operate in, and exit the Chukchi Sea six or more times. Adverse effects could thus recur for a much longer (i.e. over twice as long) time period, becoming chronic. Consequently marine mammals might experience chronic exposures to the effects of exploration drilling under Alternative 3, which might lead to long-term direct and indirect effects that have yet to be observed or studied elsewhere in the Arctic, such as repeated vessel and aircraft traffic, drilling, and ZVSP seismic.

Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects of such spills would be the same as was analyzed under Alternative 2.

### 4.6.4 Cumulative Effects

Past, present, and reasonably foreseeable future activities relevant to potential cumulative effects are described in Appendix C. Marine mammals in the Chukchi Sea could be adversely affected by predation and subsistence activities, climate change, and marine vessel and aircraft traffic.

**Predation and Subsistence.** Predation and subsistence hunting continue to have the greatest impact on certain marine mammal species in the northeastern Chukchi Sea. Shell's proposed action would not contribute to these impacts.

**Climate Change.** Decreasing sea ice may be changing patterns of habitat use for marine mammals, increasing the available range of some whales, but decreasing available habitat for ice seals, polar bear, and walrus. Changes in sea ice extent related to climate change are altering the behavior and foraging opportunities of both walrus and polar bears, and shoreline and barrier islands along the Chukchi Sea coastline are increasing in importance as habitat for these species. While major shifts in their productivity or migrations have yet to be measured to date, bowhead whales are expected to be adversely affected if sea ice losses continue. These changes are likewise anticipated to have a growing impact over the long term for ice seals. However, climate change effects are difficult to predict, and no marked effects from climate change are anticipated over the small number of years necessary to complete the proposed action. The incremental increase to effects caused by the proposed action would be negligible and would not change the overall level of cumulative impacts to marine mammals from other past, present, and reasonably foreseeable future actions.

**Disturbance.** Activities entailing the use of marine vessels and aircraft can impact marine mammals by temporarily altering their behavior. Potential behavior changes include deflections away from vessels or aircraft, cessation of calling, masking of received sounds, temporary separations of mother/calf pairs and interruptions of foraging, and resting or other behaviors, all of which have energetic costs. Temporary disturbances resulting from exploration activities associated with Alternatives 2 and 3 could add incrementally to temporary disturbances resulting from other activities in the region to have an adverse cumulative effect on marine mammals. Specifically, any additional activities occurring during the same time period and in the same general area, and requiring the use of large marine vessels or aircraft, may cause additional disturbances to these species. Appendix C describes the potential for ongoing aerial and vessel based wildlife surveys, routine vessel passage through the area for cargo transport, aerial wildlife surveys, and routine aerial transport of cargo and passengers. Vessel traffic may increase over the course of the lifetime of this project as more cargo ships and tourist cruises take advantage of the increase in open water in the Arctic. The incremental impacts of the proposed alternatives in conjunction with the ongoing activities in the region are expected to have a negligible level of cumulative effect on these species over the lifetime of this project.

Analysis of the likely range of adverse behavioral effects supports a conclusion that the activities would result in no more than temporary negligible to minor effects. No significant effects to mysticete whales in the Chukchi Sea have been observed with respect to shipping and commercial air traffic, though the situation may change in the future. Due to their low numbers in the area, ribbon seals, minke, fin, and humpback whales are much less likely to be affected than are gray whales, ringed seals, spotted seals, and ribbon seals. Bowhead whales and beluga whales are highly unlikely to be affected by the proposed activities until the fall migration period out of the Beaufort Sea. Due to the fact that individual bowheads are migrating to Chukotka at this time, any impacts from the proposed actions would amount to individual bowheads skirting around the noise envelope before resuming their original route to their destination.

**Conclusion.** The effects of Alternatives 2 and 3 would have minute long-term detrimental effects on the marine mammals and their populations in the Chukchi Sea and should add little to the larger cumulative effects that are already occurring.

## 4.7 Terrestrial Mammals

For more in-depth analysis of the effects of drilling, seismic, and offshore exploration activities on terrestrial mammal species, populations, and their environment please review the Lease Sale 193 Final EIS (USDOI, MMS, 2007a) and Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011a). The effects on terrestrial mammals of the exploration drilling proposed here would be the same as was described in these documents, which are summarized and incorporated below.

The Western Arctic (WAH) and Teshekpuk Lake Caribou Herds (TCH), one or possibly two grizzly bears or moose, a few muskoxen, and Arctic foxes could be affected by aircraft travel along the proposed flight path between Barrow and Wainwright, Alaska. The flight path lies approximately five miles inland from the coast (Shell, 2011a, Appenidx F: Figure 2.2-1) and without mitigations, could disturb or drive caribou away from potential insect relief areas during July and August, or elicit escape reactions that could be injurious to individual animals. The proposed minimum flight altitude of 1,500 ft (457 m) (except for safety reasons) would mitigate the effects of air travel between Barrow and Wainwright. As discussed in Section V.II, page II-231 of the Arctic Multiple Sale Draft EIS, observation of caribou, muskox, moose, and grizzly bears have shown that flights above 1,000 ft have little effect upon them (USDOI, MMS, 2008).

No other impacts to terrestrial mammals are anticipated. Air and water quality effects are too small to be detected along the Chukchi coastal areas, vessel traffic will be far offshore, and any noise or other activities associated with the Proposed Action would be to far from the coast to have any effect. Consequently, aircraft presence and noise should have a negligible effect on terrestrial mammals within a few miles of the inland flight corridor between Barrow and Wainwright Alaska. Aircraft presence and noise beyond the Barrow-Wainwright flight path would have no effects on terrestrial mammals, since no other air travel is proposed for Alternatives 2 and 3. All other effectors would have no effect on terrestrial mammals in the region.

Small oil/fuel spills, discharges, and any air/water quality effects would be extremely small, if detectable at all, along the Alaskan coast, and vessel traffic will be far offshore preventing any noise or other activities from having effects on terrestrial mammal resources. A large spill is very unlikely to contact the coast since 1,555 bbl—the estimated potential discharge for a large spill in this EA—would weather before making landfall. As explained in the Sale 193 Final EIS (USDOI, MMS, 2007a) and the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a), the potential for adverse effects to terrestrial mammals in the event of a large or very large oil spill is low. Therefore, negligible effects are anticipated for terrestrial mammals from small, large, or very large oil spills resulting from the Proposed Action.

Under Alternatives 2 and 3 there would be a negligible level of effects on some terrestrial species as a result of aircraft traffic and noise, while under Alternative 1 there would be no effects. Alternative 3 would only allow one well to be drilled per annum, which could potentially protract the effects beyond the estimated time to project completion under Alternative 2. Consequently, the cumulative effects from aircraft traffic and noise under Alternative 3 could exceed what would otherwise occur under Alternative 2. However, the level of effects would still remain negligible under either alternative. All other determinations of no effect are consistent between the three different alternatives.

Caribou from the WAH and TCH would continue to experience annual mortality to predation, injuries, stress, subsistence hunting, and sport hunting. Climate change is expected to have profound detrimental effects to some species such as caribou, but beneficial effects on others, including shrinkage in winter range for the WAH (Murphy et al. 2010). For the duration of Alternatives 2 and 3, no major effects from climate change are anticipated so mortalities are expected to remain within what typically occurs per annum. By comparison the effects from the Proposed Action are expected to occur rarely, and as mitigated, have a negligible level of effect on any terrestrial mammal species in the area. Consequently BOEM does not expect the effects of Alternatives 2 or 3 to add appreciably to the cumulative effects over the duration of the proposed activities, or to long-term cumulative effects.

## 4.8 Subsistence Activities

This section describes the direct and indirect effects on subsistence activities that may result from the no action alternative and Proposed Action described in Section 2.

### 4.8.1 Alternative 1 – No Action

Under Alternative 1, the proposed exploration activities would not be approved, and no effects to subsistence activities would occur.

### 4.8.2 Alternative 2 – Proposed Action

Subsistence use by the communities of Barrow, Wainwright, Point Lay, and Point Hope and the place and time that each species is hunted and harvested are discussed in Section 3.2.10 above and in Tables 23, 24, 25, and 26. Direct adverse effects would result when activities described in the Proposed Action cause interference or disruption of subsistence activities. An example of a direct effect is when the physical presence of a drill ship prevents harvest activity from occurring in the area around a drill ship. Indirect adverse effects would result when the subsistence resource, the target species, is adversely affected, and therefore not available, available in reduced numbers, or is otherwise made undesirable for harvest. An example of an indirect effect is if noise from a drillship causes bowhead whales to divert from an area where hunting and harvest usually occur. In order for the effect to be realized, the exploration activities or their residual effects have to overlap in space and time with subsistence resources.

Potential direct and indirect effects will primarily result from vessel presence and vessel traffic interacting with subsistence activities, vessel and air traffic noise causing diversion of the resource away from the location of subsistence activities, and the increased level of activities offshore and onshore being incompatible with subsistence activities. The activities described under the Proposed Action would be completed within two years after commencement of exploration drilling.

An important consideration in assessing potential effects on subsistence activities is that most of Shell's proposed activities would occur in the summer and fall, from early July to late October. This is the time during which the Iñupiat from Barrow, Wainwright, Point Lay, and Point Hope have completed the spring bowhead whale hunt and other activities described in Section 3.2.10 and in Tables 23, 24, 25, and 26, such as the beluga whale hunt at Point Lay.

Table 32 (below) indicates for each village, the exploration activities that do or do not overlap in the space or time that the resource is normally hunted and harvested. For example, drilling activities on the Burger Prospect are not expected to disrupt subsistence activities. No documented subsistence activities have occurred at the proposed offshore drill sites, so the activities do not overlap in space. Similarly, activities associated with the exploration occur before or after the time when the animals are normally hunted or harvested. For example, Shell will not begin activities until after the spring bowhead whale hunt is completed in the Chukchi Sea, so there is no overlap in time between exploration and harvest.

Most of the effects from the proposed activities result from avoidance behavior by the animal being hunted, which may divert the animal away from the location of subsistence activities. These typical behaviors, described in greater detail in the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008: Section 4.4.1.8, 4.4.1.9, and 4.4.1.12) are:

- Bowhead whales may exhibit temporary avoidance behavior if approached by vessels at a distance of 1-4 km (0.62 to 2.5 mi), with behavioral changes lasting a few minutes in the case of vessels and up to 30 to 60 minutes in the case of seismic activity. No obvious response to helicopter overflights above 150 m (500 ft), avoidance behavior for other air traffic could persist up to 12 hours.
- Beluga whales, seals, walruses, and polar bears may be startled, annoyed, or flee intense noise with vessel traffic temporarily displacing (within 1-3 km [0.62 to 1.9 mi] ) or interfering with marine mammal migration, and change local distribution for a few hours to a few days. Aircraft effects expected to be local and transient for seals. Walrus exhibit little reaction to aircraft above 305 m (1000 feet) but traffic may disturb walrus and seals from haulouts and cause them to enter the water.
- Caribou reaction to aircraft flying below 305 m (1,000 feet) include startle forcing herds and individuals to scatter, separating cows from calves, and possibly causing injury during panic.
- Reaction of birds to vessel traffic could displace birds from the area where the activity is occurring with little direct mortality. Aircraft noise could disturb birds, causing them to flush or move away from noise and approaching low-flying aircraft.

**Table 32. Potential for the proposed activities to affect subsistence resources for Chukchi Sea Communities.**

| Subsistence Resource | Point Hope | Point Lay | Wainwright | Barrow |
|---|---|---|---|---|
| Bowhead Whale Spring Hunt | Completed prior to start of exploration activities. No overlap in space or time. Therefore, no effect. | Completed prior to start of activities. No overlap in space or time. Therefore, no effect. | Completed prior to start of activities. No overlap in space or time. Therefore, no effect. | Completed prior to start of activities. No overlap in space or time. Therefore, no effect. |
| Bowhead Whale Fall Hunt | Not traditionally undertaken. In addition, no overlap in space. Therefore, no effect | Not traditionally undertaken. In addition, however, no overlap in space. Therefore, no effect. | Potential direct and indirect effect from vessel and aircraft transit. | Potential direct and indirect effect from aircraft transit |
| Beluga | Overlap in time, no overlap in space. Therefore, no effect. | Overlap in time, no overlap in space. Therefore, no effect. | Potential effect from vessel and aircraft transit. | Potential effect from aircraft transit |
| Caribou | Overlap in time, no overlap in space. Therefore, no effect. | Overlap in time, no overlap in space. Therefore, no effect. | Potential effect from vessel and aircraft transit. | Potential effect from aircraft transit |
| Pacific Walrus | Overlap in time, no overlap in space. Therefore, no effect. | Overlap in time, no overlap in space. Therefore, no effect. | Potential effect from vessel and aircraft transit. | Potential effect from aircraft transit |
| Bearded Seal | No overlap in time or space. Therefore, no effect. | No overlap in time or space. Therefore, no effect. | Potential effect from vessel and aircraft transit. | Potential effect from aircraft transit |
| Ringed Seal | No overlap in time or space. Therefore, no effect. | No overlap in time or space. Therefore, no effect. | Potential effect from vessel and aircraft transit. | Potential effect from aircraft transit |

| Subsistence Resource | Point Hope | Point Lay | Wainwright | Barrow |
|---|---|---|---|---|
| Spotted Seal | No overlap in time or space. Therefore, no effect. | Overlap in time, no overlap in space. Therefore, no effect. | Potential effect from vessel and aircraft transit. | Potential effect from aircraft transit |
| Ribbon Seal | No overlap in time or space. Therefore, no effect. | No overlap in time or space. Therefore, no effect. | Potential effect from vessel and aircraft transit. | Potential effect from aircraft transit |

Mitigation measures incorporated into proposed activities to minimize vessel and marine mammal interaction and subsistence activities include:

- The *Discoverer* and support vessels will enter the Chukchi Sea through the Bering Strait on or after July 1, minimizing effects on marine mammals and birds that frequent open leads and minimizing effects on spring and early summer bowhead whale hunting.
- Drillship and support vessel transit routes will avoid known fragile ecosystems and the Ledyard Bay Critical Habitat Unit, and will include coordination through Communication Centers (Com Centers).
- To minimize impacts on marine mammals and subsistence hunting activities, the drillship and support fleet will transit through the Chukchi Sea along a route that lies offshore of the polynya zone. In the event the transit outside of the polynya zone results in Shell having to break ice (as opposed to managing ice by pushing it out of the way), the drillship and support vessels will enter into the polynya zone far enough so that ice breaking is not necessary. If it is necessary to move into the polynya zone, Shell will notify the local communities of the change in the transit route through the Com Centers. As soon as the fleet transits past the ice, it will exit the polynya zone and continue a path in the open sea toward the drill sites.
- MMOs will be aboard the *Discoverer* and all support vessels.
- Vessels will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on land or ice.
- When within 900 ft (274 m) of marine mammals, vessels will reduce speed, avoid separating members from a group and avoid multiple changes of direction.
- Vessel speed is to be reduced during inclement weather conditions in order to avoid collisions with marine mammals.
- Shell will communicate and coordinate with the Com Centers regarding all vessel transit.

As shown on marine vessel routes (Shell, 2011a: Figure 13.e-1) and flight corridors (Shell, 2011a: Figure 13.e-2), Point Hope and Point Lay summer and fall subsistence resource populations and harvests of bowhead whales, beluga, walrus, seals, and caribou would be out of range of any potential disturbance or disruption from Shell's activities or the residual effects of those activities. Provisions of Lease Stipulation No. 7—which directs surface vessels associated with exploration and delineation drilling operations to avoid travel within Ledyard Bay Critical Habitat Unit and directs aircraft to avoid operating below 1,500 feet above sea level over the Unit between July 1 and November 15—should eliminate effects from vessels and aircraft on subsistence activities that occur in the unit. The Proposed Action's mitigation measures put into place for Point Lay and Point Hope, such as the Com Centers and subsistence advisor program, would help ensure that communities and harvesters are informed as to Shell's activities offshore. Impacts to Point Hope and Point Lay subsistence activities are not expected but would be considered negligible. Although no effects are expected, subsistence resources could be rarely but periodically affected, but there would be no apparent effect on subsistence harvests. Impact to Barrow and Wainwright subsistence activities are expected to be minor because the few potential effects would be accidental or incidental and would be very short term.

Using the proposed primary and alternate flight corridors (Shell, 2011a: Figure 13.e-2), the primary helicopter route between the shorebase and the Burger Prospect is from the Barrow airport where the helicopters are stationed, directly offshore to the Burger Prospect. Helicopters would alternatively travel between Wainwright and the Burger Prospect under special circumstances. The proposed alternative overland flight corridor between Barrow and Wainwright crosses an area that is recognized as being subsistence territory used by the Iñupiat of Barrow, Atqasuk, and Wainwright. Past use has been prolonged and consistent, as evidenced by the numerous house sites, camps, and other cultural features that dot the landscape (SRB&A, 1989a, 1989b; USDOI, MMS, 2010).

Active harvesters have expressed concerns about disruption or displacement of caribou and other wildlife by noise, with noise from helicopters being one source of particular concern (S.R. Braund and Assocs., 2009: p.18-30, 39-40). For example, Point Hope hunters report that while preparing to hunt "the caribou would be spooked by a small airplane flying around. Hunters reported that the caribou are taking a difficult route and they believe it is because of an airplane flying low near the mountains" (Umiak LLC, 2011). Point Lay hunters have expressed concerns that helicopter traffic is scaring caribou farther away from traditional hunting areas (ASRC Energy Services, 2009). Similarly, the Wildlife Director for the Native Village of Barrow, raised a concern in a meeting regarding affects from helicopter traffic, suggesting that there be no flying overland between Barrow and Wainwright because of observations that the caribou are being disturbed (Umiak LLC, 2011). Mitigation suggested by active harvesters to reduce the effects of overflights on subsistence resources includes (SRB&A, 2009):

- Planning ahead of time and locating activities to minimize exposure of wildlife to noise.
- Learn from locals, areas and times that are most sensitive for wildlife.
- Set altitude minimums by activity.
- Put in place a real-time monitoring and response communication system so harvesters out on the land and water can communicate directly with dispatchers.
- Alert harvesters to planned activities.
- Provide means so that harvesters and pilots can learn from each other and exchange ideas to minimize impacts.
- Conduct and annual survey of harvesters to monitor harvest success and reports of impacts to activities. Hold and annual workshop to discuss and respond to results.

Many of these suggested measures are included in the mitigations that have been incorporated into the Proposed Action to minimize effects from aircraft on subsistence activities and ensure communications with subsistence hunters, which include:

- Aircraft shall not operate below 1,500 ft (457 m) unless the aircraft is engaged in marine mammal monitoring, approaching, landing, or taking off, in poor weather (fog or low ceilings), or in an emergency situation, while over land or sea to minimize disturbance to mammals and birds.
- Aircraft engaged in marine mammal monitoring shall not operate below 1,500 ft (457 m) in areas of active whaling; such areas to be identified through communications with the Com Centers.
- Aircraft will not operate within 0.5 mi (0.8 km) of walrus or polar bears when observed on land or ice.
- Shell will also implement non-MMO flight restrictions prohibiting aircraft from flying within 1,000 ft (300 m) of marine mammals or below 1,500 ft (457 m) altitude (except

during takeoffs and landings or in emergency situations) while over land or sea. This flight will also help avoid disturbance of and collisions with birds.

- Implementation of a Communication Plan and will implement this plan before initiating exploration drilling operations to coordinate activities with local subsistence users, as well as Village Whaling Captains' Associations, to minimize the risk of interfering with subsistence hunting activities, and keep current as to the timing and status of the bowhead whale hunt and other subsistence hunts. The Communication Plan includes procedures for coordination with Com Centers to be located in coastal villages along the Chukchi and Beaufort Seas during Shell's proposed exploration drilling activities.
- Shell will employ local subsistence advisors (SAs) from the Chukchi Sea villages that are potentially impacted by Shell's exploration drilling activities. The SAs will provide consultation and guidance regarding the whale migration and subsistence activities.

Subsistence harvesters have expressed concerns about more outsiders present in hunting areas, making it difficult to hunt safely and without fear of misrepresenting subsistence hunting (SBR&A, 2009). The BOEM-approved Shell Cultural Awareness Program developed in response to BOEM Stipulation No. 2, Orientation Program, is "designed to increase sensitivity and understanding by Shell and its contractors of community values, customs, and lifestyles in the area they will be working, and how to avoid conflicts with subsistence activities" (Shell, 2011a: pp. 5–6). This measure should mitigate the concerns expressed by subsistence harvesters.

Wainwright would be 90 mi away and Barrow would be 150 miles away from drilling activities, respectively, and most summer and fall subsistence resource populations and harvests would be out of range of any potential disturbance from drilling activities. If the alternative aircraft route is used, helicopter traffic originating in Barrow will fly down the coast to Wainwright before proceeding offshore in a route intended to minimize effects to subsistence harvest activities. Vessel traffic to and from Wainwright would traverse marine subsistence areas.

Wainwright's bowhead and beluga whale hunts that occur in June would be completed prior to the start of exploration activities. Subsistence hunts for polar bear, bearded seal (*ugruk*), hair seals, fish, and birds would occur either in nearshore coastal areas at least 40 mi from activities or in the spring and winter seasons when drilling and vessel and helicopter traffic would not be present. In Wainwright, walrus hunting during August can occur up 40 mi from shore, still 20 mi from proposed activities. Walrus present within the vessel/flight corridor potentially could be disrupted by these activities, but IHA and LOA monitoring requirements, minimum flight elevations of 1,500 ft, and coordination with community Com Centers and subsistence advisors would likely mitigate potential disturbance to walrus so that the resulting impacts would be no more than negligible. Caribou hunting occurs in late summer and fall and caribou congregate nearshore between Barrow and Wainwright at this time. It is expected that the inland flight corridor and maintaining 1,500 ft while transiting between the two communities would not disrupt caribou movements or the subsistence hunt.

Wainwright's nascent fall bowhead whale hunt could be affected by aircraft and vessel traffic associated with exploration activities. While the location of the past harvest is northeast of Wainwright and close to shore, away from the vessel and aircraft route to the Burger Prospect, hunting in future years could be closer to the community. Adherence to the mitigation measures would ameliorate the effects of exploration-related air and vessel traffic on the bowhead whale harvest.

The effects described above could occur on an annual basis but do not persist past the end of each year's activities. If exploration activities terminate prior to the end of October in any year the types and level of impacts would be as described above because of the location and timing of subsistence activities. If the exploration activities continue past two years, the effects for each additional year would be the same as described above. Effects to subsistence activities for Barrow and Wainwright could occur from incidental or accidental interactions between exploration drilling activities and subsistence activities because mitigation measures eliminate or practically reduce effects from routine activities. In addition, the effects to subsistence activities that occur are short term and are not expected to persist past the end of each year's drilling season. However, with adaptive management, effects that accidentally or incidentally occur in one year would be recognized and measures would be applied to activities where necessary to prevent recurrence in subsequent years.

The oil-spill analysis has determined that there is a low chance for an accidental small oil spill that likely would be operational in nature. For the purpose of this analysis, a 48 bbl fuel transfer spill was chosen. A 48 bbl diesel spill (the estimated potential discharge for this EA) would evaporate and disperse in less than 3 days before contacting critical nearshore subsistence areas. As required by Lease Stipulation 6, oil-spill containment booms would be deployed during any refueling activity, and would contain a small oil spill if one should occur.

The perception that an oil-spill could contaminate subsistence foods, particularly marine mammals or fish, might be of concern to the Iñupiat at Barrow, Wainwright, Point Lay, and Point Hope in terms of potential effects on health. Because subsistence activities do not occur in the vicinity of proposed drilling and any associated spill source, and because no fuel transfer is expected during transit between the Beaufort and Chukchi seas, the short-term effects of the analyzed small spill on subsistence activities are expected to be negligible to minor. No long-term effects are anticipated as effects are not expected to persist past the end of the drilling season.

A large spill of 1,555 barrels (the estimated potential discharge for this EA) or very large oil spill of up to 750,000 (the estimated potential discharge for this EA) would have similar effects to those described in detail in other lease sale EIS's for subsistence resources (USDOI, MMS, 2007a; USDOI, MMS 2008; USDOI, BOEMRE, 2011a). General effects from a large oil spill could be expected from the oil spill itself, actual or perceived tainting, and the cleanup disturbance that could occur after such a spill event. A spill affecting any part of the habitat used by the bowhead whale, other marine mammals (seals, walrus, beluga, polar bears), or caribou could taint the resource, so that (even if available for harvest) it could leave the species less than desirable and alter or stop the subsistence activity. Oil-spill-cleanup activities could produce additional effects on subsistence activities, potentially causing displacement of subsistence resources and subsistence hunters. All areas directly oiled, areas to some extent surrounding them, and areas used for staging and transportation corridors for spill response would not be used by subsistence hunters for some time following a spill. Oil contamination of beaches would have a profound impact on whaling because even if bowhead whales were not contaminated, Iñupiat subsistence whalers would not be able to bring them ashore and butcher them on a contaminated shoreline. The duration of avoidance by subsistence users would vary depending on the volume of the spill, the persistence of oil in the environment, the degree of impact on resources, the time necessary for recovery, and the confidence in assurances that subsistence harvest resources were safe to eat.

#### Summary – Alternative 2

With Shell's adherence to proposed mitigation, monitoring, communication, and response plans, short-term effects from drilling and air and vessel traffic on subsistence resources range from no effect to minor.

### 4.8.3 Alternative 3 – One Well per Season

Potential direct and indirect effects will primarily result from vessel presence and vessel traffic interacting with subsistence activities, vessel and air traffic noise causing diversion of the resource away from the location of subsistence activities, and the increased level of activities offshore and onshore being incompatible with subsistence activities. The activities described under this alternative would require at least six drilling seasons.

The effect of activities would be the similar to those effects described under Alternative 2, the Proposed Action, except that the effects may occur annually in each additional year of exploration activity. Point Hope and Point Lay summer and fall subsistence resource populations and harvests of bowhead whales, beluga, walrus, seals, and caribou would be out of range of any potential disturbance or disruption from Shell's activities or the residual effects of those activities. Effects on subsistence activities for Barrow and Wainwright could occur from incidental or accidental interactions between exploration drilling activities and subsistence activities because mitigation measures eliminate or practically reduce effects from routine activities. In addition, the effects to subsistence activities that occur are short term and are not expected to persist past the end of the each year's drilling season. Furthermore, with adaptive management, effects that accidentally or incidentally occur in one year would be recognized and measures taken to prevent recurrence in subsequent years.

Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2

#### Summary – Alternative 3

With Shell's adherence to proposed mitigation, monitoring, communication, and response plans, short-term effects from drilling and air and vessel traffic on subsistence resources range from no effect to minor.

### 4.8.4 Cumulative Effects

This section discusses the effect on subsistence resources which results from known past, present and reasonably foreseeable future activities and the incremental contribution of the Proposed Action and alternatives to the Proposed Action. The past, present, and reasonably foreseeable future activities have been identified in Appendix C.

This environmental analysis has identified vessel traffic, specifically marine vessel traffic, as an important impact source of anthropogenic sound introduced to the Chukchi Sea during the timeframe of the proposed activities.

Other vessel traffic is not controlled by the proposed project, and should be assumed to continue through the period of the exploration activities, including the fall whaling hunt at Barrow and Wainwright. These vessels could be icebreakers, USCG vessels, cargo vessels, other supply ships and tugs and barges, cruise ships, and vessels associated with scientific endeavors. The USCG estimates that from 2008 to 2010 the number of vessels in the Arctic increased from more than 100 to more than 130, and the number of transits through the Bering Strait increased from more than 245 to more than 325 (USCG, 2011). The estimated number of miles of non-seismic vessel traffic in the Chukchi Sea for July through October increased from approximately 2000 miles in 2006 to more than 11,500 miles in 2010 (Shell, 2011a: Appendix F, Table 4.2-2). Vessel tracks from 2009 indicate vessel transits in the vicinity of Barrow and Wainwright are concentrated to the west and south of the communities along the coast (Marine Exchange of Alaska, 2011). This area corresponds to the subsistence use areas described in Section 3.2.10 for those communities.

Air traffic not associated with the proposed project may involve flight patterns at a lower altitude than the 1,500 ft level that will be industry's standard for this project. Other air traffic associated with basic village transportation, freight and mail, and scientific endeavors would continue unabated. Shell calculated that an average of 306 commercial flights per month occurred from Wainwright airport between July and October, 2000 to 2008 (Shell 2011a: Appendix F, Table 4.1.11-6). As noted in Section 4.8, Alaska Native hunters have expressed concern about marine mammal and caribou reaction to aircraft noise impacting subsistence harvest. The air traffic noise has the potential to disrupt and disturb subsistence hunters from Chukchi villages.

Previous environmental analyses have concluded that cumulative effects from shipping and other sources "would continue to have a moderate level of effect on subsistence resource and harvest practices. The greatest source of large noncrude oil spills would occur from bulk fuel deliveries to coastal villages. The anticipated increase in marine traffic from tourism, research, and other shipping vessels could dramatically increase the potential for marine accidents and large fuel spills, which could result in major adverse effects on subsistence resources and harvest practices in the Chukchi Sea region" (USDOI, MMS, 2008: p. 4-896).

Activities described in the exploration plan would incrementally increase the number of marine vessel transits in the Chukchi Sea from mobilization of the drilling fleet in July, logistic support of activities of the offshore supply vessel during the drilling season (between Dutch Harbor and the drillsite, approximately 17 round trips or 34 transits of the Bering Strait), and oil spill response work boats (between the Wainwright supply base and oil spill response barge, approximately 12 round trips per week for two months). The supply vessel transits represent an increase of approximately 10 percent over the cumulative total for 2010. OSR work boat traffic will increase the number of trips from Wainwright. All these vessels will observe the vessel travel mitigation measures designed to avoid or minimize effects on subsistence activities.

Shell estimates that exploration activities will require the support of approximately 4 round trips per week of a fixed wing aircraft between Anchorage and Wainwright, an increase of approximately 10 percent over the average number of flights per month under the no action alternative. Exploration activities will require 12 round trip helicopter flights per week between Barrow and the drillsite. All helicopter flights will observe the aircraft travel mitigation measures designed to avoid or minimize effects on subsistence activities.

The incremental impacts of the Proposed Action on subsistence resources would be negligible for routine activities such as vessel and aircraft operations, and negligible to minor for an oil spill from a vessel. The Proposed Action's contribution to cumulative effects would be negligible and would result in no change in the moderate to major level of effect for subsistence resources from past, present, and reasonable foreseeable future actions.

## 4.9 Sociocultural Systems

This section describes the direct and indirect effects on sociocultural systems that may result from the Proposed Action and alternatives described in Section 2.

### 4.9.1 Alternative 1 – No Action

Under Alternative 1, the proposed exploration activities would not be approved, and no effects on sociocultural systems would occur.

### 4.9.2 Alternative 2 – Proposed Action

BOEM will only permit offshore oil and gas activities if disruption to subsistence harvest of resources can be minimized in such a manner that the disruption is short term and the result of incidental or accidental encounters. Under the Proposed Action, these encounters would come primarily from vessel traffic and aircraft traffic associated with the project. Because of the negligible to minor subsistence effects described in Section 4.8 from vessel traffic interacting with subsistence activities, vessel and air traffic noise causing diversion of the resource away from the location of subsistence activities, and the increased level of activities offshore and onshore being incompatible with subsistence activities, negligible effects on social organization and institutional arrangement are not expected to occur. Offshore activities are likely to cause some concern already present in North Slope communities regarding the potential effects of oil spills from the activities. Onshore supply base operations using existing facilities could result in concern over encroachment of oil facilities on the community, but these would be negligible at most and could be offset by the benefits of increased opportunity from direct and indirect employment in the communities. The effects will occur each season that Shell conducts exploratory drilling operations under this exploration plan. The negligible effects, however, are temporally limited and consecutive years of activity would not have an additive effect.

The oil-spill analysis has determined that there is a low chance for an accidental small oil spill that likely would be operational in nature. For the purpose of this analysis, a 48 bbl fuel transfer spill was estimated. A 48 bbl diesel spill (the potential discharge estimated for this EA) would evaporate and disperse in less than 3 days before contacting critical nearshore subsistence areas. As required by Lease Stipulation 6, oil-spill containment booms would be deployed during any refueling activity, and would contain a small oil spill if one occurred.

A large spill of up to 1,555 barrels (the potential discharge estimated for this EA) or very large oil spill of up to 750,000 barrels (the potential discharge estimated for this EA) would have similar effects to those described in detail in other lease sale EIS's for sociocultural resources (USDOI, MMS, 2007a; USDOI, MMS, 2008; USDOI, BOEMRE, 2011a). The sociocultural impacts of a large or very large oil spill on Alaskan Native communities are interconnected with the subsistence lifestyle of these communities. Subsistence embodies the traditions of Alaskan Native culture with overlapping connections to other cultural, social, and economic institutions. Longer term disruptions to subsistence resources and practices would impact sharing networks, subsistence task groups, and crew structures, as well as cause disruptions of the central Iñupiat cultural value: subsistence as a way of life. These disruptions could cause breakdowns in family ties, a community's sense of well-being, and damage sharing linkages with other communities, and could curtail community activities and traditional practices for harvesting, sharing, and processing subsistence resources—a major impact on sociocultural systems. The effects of disruption to sociocultural systems would last beyond the period of oil-spill cleanup and could lapse into a chronic disruption of social organization, cultural values, and institutional organization.

BOEM views very large oil spills as having the potential to cause long-term significant effects that would disrupt or nearly eliminate subsistence harvests. Oil spills are never permitted and are always in violation of the law. Operators would be held accountable and responsible for mitigation and monitoring, loss or reduction of subsistence species, and effects on the local subsistence harvesters and the linked social organizations and institutions.

### 4.9.3 Alternative 3 – One Well per Season

Potential direct and indirect effects will primarily result from the potential of the proposed activities to interfere or disrupt sociocultural practices associated with subsistence. As described in Section 4.8, these effects result from vessel traffic interacting with subsistence activities, vessel and air traffic noise causing diversion of the resource away from the location of subsistence activities, and the increased level of activities offshore and onshore being incompatible with drilling seasons.

The effect of activities would be the similar to those effects described under Alternative 2-Proposed Action, except that the effects may occur annually in each additional year of exploration activity. Point Hope and Point Lay summer and fall subsistence resource populations and harvests of bowhead whales, beluga, walrus, seals, and caribou, discussed in the affected environment section, would be out of range of any potential disturbance or disruption from Shell's activities or the residual effects of those activities. Effects on subsistence activities for Barrow and Wainwright could occur only from incidental or accidental interactions between exploration drilling activities (such as vessel and air traffic) and subsistence activities because mitigation measures eliminate or practically reduce effects from routine activities. In addition, the effects on subsistence activities that occur are short term and are not expected to persist past the end of the each year's drilling season. Furthermore, with adaptive management, effects that accidentally or incidentally occur in one year would be recognized and measures taken to prevent recurrence in subsequent years.

### 4.9.4 Cumulative Effects

This section discusses the effects on sociocultural systems which result from known past, present, and reasonably foreseeable future activities, and the incremental contribution of the Proposed Action. Relevant past, present, and reasonably foreseeable future activities have been identified in Appendix C. The potential for the Proposed Action and alternatives to contribute to cumulative effects is assessed below.

Direct, indirect, and synergistic cumulative effects on sociocultural systems have been discussed in previous analyses (USDOI, MMS, 2007a; USDOI, MMS, 2008; USDOI, MMS, 2009; USDOI, BOEMRE, 2011a; SRB&A, 2009; Ristroph, 2010). These ongoing effects include the following trends:

- Adaptation to introduction of new technology, pressures, and legal/regulatory actions introduced through successive waves of contact between Natives and non-Natives, starting with whaling in the 19th century through oil and gas development in the 21st century.
- Changes in settlement patterns with greater centralization into larger communities.
- Continuation of pattern of centralized leadership of whaling captains and their families, cultural and nutritional dependence on subsistence foods, reliance on sharing and kinship, connection to family camps and traditional use areas, and a desire to control destination of their communities.
- Stress to sociocultural systems that result from the encroachment of oil-production facilities into areas used for subsistence.
- Population growth and employment and an influx of non-Native workers can cause long-term disruption to social organization and place increased demands on institutions that provide public service and health care.
- Problems North Slope communities are experiencing in social health and well being that could be exacerbated by additional development.
- Stress created by fear of an oil spill, a predevelopment impact-producing agent that is distinct from potential effects from routine operations.
- Response of institutions to strengthen Iñupiat traditions and culture in the face of these stresses.
- Positive effects from higher income and community infrastructure and services made possible from oil and gas activity.
- Continued adaptation of the communities to changing conditions brought about by changing climatic conditions in the Arctic.

These trends will continue over the period covered by the exploration plan. Overall, the effect of these trends constitutes a major effect on sociocultural systems, as recognized in the previous analyses.

Activities described in the exploration plan would incrementally contribute to some of the trends described above. For example, offshore activity contributes to the fear of an oil spill and there will be some population growth as a result of the influx of project workers into the communities. However, the effects on sociocultural systems would be very short term, not expected to persist beyond the end of the exploration drilling program. Mitigation measures, such as the orientation program, the plan of cooperation, and measures to minimize or avoid effects on subsistence, reduce the project's effects to a negligible level. Some positive effects, such as project-level employment of North Slope residents and increased economic activity for Native corporations will occur. These effects would occur over the life of the exploration program.

The incremental cumulative effect of the Proposed Action on sociocultural resources would be negligible and would result in no change in the major level of effect for sociocultural systems from past, present, and reasonably foreseeable future actions.

The perception of contamination to subsistence foods, particularly marine mammals or fish, might be of concern to the Iñupiat at Barrow, Wainwright, Point Lay, and Point Hope in terms of potential effects on health. Because subsistence activities do not occur in the vicinity of proposed drilling or any associated spill source, and because no fuel transfer is expected during transit between the Beaufort and Chukchi seas, the short-term effects of the analyzed small spill on subsistence activities are expected to be negligible to minor. No long-term effects are anticipated, as effects are not expected to persist past the end of the drilling season.

The activities that occur under this Alternative 3 would incrementally contribute to some of the trends described above, and would have approximately the same effect as the Proposed Action, except that the effects would occur over a period of six drilling seasons after the commencement of activities.

The incremental cumulative effect of Alternative 3 on sociocultural resources would be negligible. Incremental contributions from Alternative 3 would result in no change in the major level of effect for sociocultural systems from past, present, and reasonable foreseeable future actions.  Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

## 4.10 Economy

The description and analysis of effects on the economy below focuses on the economy of the NSB, as the location, timing, and scale of the activities described in the 2012 Shell Revised Chukchi Sea EP are not expected to generate economic effects at the State or Federal level.

### 4.10.1 Alternative 1 – No Action

Under the No Action Alternative, the proposed exploration activities would not be approved, and no effects on the economy would occur.

### 4.10.2 Alternative 2 – Proposed Action

Descriptions of the NSB economy in the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a) are incorporated by reference, and salient points are included below. Additional information on the NSB economy is also provided.

**Employment and Personal Income.** Shell’s offshore exploration plan promises to provide specific benefits to some local residents in and around Barrow, Wainwright, Point Hope, and Point lay. Shell’s proposed exploration drilling would offer employment to a relatively small number of local NSB residents, but more than previously proposed projects in the area. The MMO program would employ local Iñupiat residents to monitor and document marine mammals in the project area. The Subsistence Advisor program would recruit a local resident from each village to communicate local concerns and subsistence issues from residents to Shell. Shell’s Com Center program would involve hiring individuals from Chukchi Sea villages. In total, Shell estimates that 196 direct jobs could be created annually for North Slope residents by Shell’s exploration drilling program, spread out among job types including MMOs, subsistence advisors, community liaisons, communication and call centers, village OSR responders, contingency responders, and shorebase staff (Shell, 2011c). A more detailed discussion of local hire can be found in section 2.3.8.

Even with the potential employment and related personal income associated with the proposed activities, it appears that employment opportunities for local residents, especially Alaskan Natives, would remain comparatively low in oil industry-related jobs on the North Slope. Goods and services would be obtained from local village contractors, when available, during the duration of the project. The proposed activities are short term and temporary and are expected to have a negligible effect on the economy of the NSB or communities of Barrow, Wainwright, Point Hope, and Point Lay. These effects do not constitute a significant change in the impacts previously identified and evaluated in the approved with conditions 2010 Chukchi Sea EP (USDOI, MMS, 2009a).

**Revenues.** The proposed exploration activities will not require development of additional onshore oil and gas infrastructure that the NSB and State of Alaska would receive property tax revenues from, and so the direct and indirect effects on revenues are expected to be negligible.

**Small Fuel Spill**. It is reasonably likely that the Proposed Action could result in a small oil spill. For the purpose of analysis, a 48 bbl fuel transfer spill was estimated for this EA. A 48 bbl diesel spill would disperse and evaporate within 3 days, generating minimal additional employment and personal income during that time.

**Large and Very Large Oil Spill.** Although very unlikely, it is possible that the Proposed Action could lead to a large or very large oil spill. For the purpose of analysis, BOEM estimates potential discharge volumes for this EA to be 1,555 bbl of diesel for a large spill and 750,000 bbl of crude oil for a very large spill. The Sale 193 Final EIS (USDOI, MMS, 2007a) analyzed potential effects to the economy from large spills and found that likely effects to the local economy include creating additional employment of 60-190 jobs with associated personal incomes for up to six months. The Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) analyzed potential effects to the economy from a very large oil spill and found that a very large oil spill would generate thousands of direct, indirect, and induced jobs and millions of dollars in personal income associated with oil spill response and cleanup in the short run. In addition, revenue impacts from a hypothetical very large oil spill include additional property tax revenues accruing to NSB from any additional onshore oil spill response infrastructure, and any potential decline in Federal, State, and local government revenues from displacement of other oil and gas production. These analyses remain sufficient to analyze the effects of large and very large spills in the Chukchi Sea, including the 1,555 bbl diesel spill and the 750,000 bbl oil spill estimated for this EA.

### 4.10.3 Alternative 3 – One Well per Season

Under Alternative 3, exploration drilling activities will be less intensive in any single drilling season but more prolonged overall. Spreading out exploration drilling activities over additional drilling seasons would also prolong the potential direct and indirect impacts to employment and personal income, as described above, though the economic impacts would be lower in any single drilling season. As is the case with Alternative 2, these impacts would still be considered negligible, and would not constitute a significant change in the impacts to employment and personal income previously identified and evaluated in the approved with conditions 2010 Chukchi Sea EP (USDOI, MMS, 2009a). Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

### 4.10.4 Cumulative Effects

A thorough discussion of past, present, and reasonably foreseeable future actions affecting the Chukchi Sea environment is provided in Appendix C.

Activities associated with the Proposed Action are short term and temporary, involving relatively low levels of new employment and associated income, and no generation of property tax revenues accruing to the NSB or State of Alaska, and are therefore expected to have a negligible cumulative effect on employment, income, and revenue levels of the NSB.

Under Alternative 3, exploration drilling activities will be less intensive in any single drilling season but more prolonged overall. Spreading out exploration drilling activities over additional drilling seasons would also prolong the potential cumulative impacts to employment and personal income, as described above, though the impacts would be less intense in any single drilling season. As is the case with Alternative 2, these impacts would still be considered negligible, and would not constitute a significant change in the impacts to employment and personal income previously identified and evaluated in the approved with conditions 2010 Chukchi Sea EP (USDOI, MMS, 2009b).

## 4.11 Public Health

### 4.11.1 Alternative 1 – No Action

Under the No Action Alternative 1, the proposed exploration activities would not be approved, and no effects to public health would occur.

### 4.11.2 Alternative 2 – Proposed Action

The activities associated with the 2012 Shell Revised Chukchi Sea EP would be staged out of the Barrow, Wainwright, Point Hope, and Point Lay communities. Goods and services would be obtained from local village contractors, when available, for the duration of this project. These business interactions are not expected to adversely affect public health. Personnel traveling to these communities in support of Shell's operations will receive a 'fitness to work' medical review to prevent the spread of communicable diseases between Shell personnel as well as any local residents with whom Shell personnel come into contact with. Findings regarding air quality, emissions, and water quality remain the same as those impacts previously identified and evaluated in the approved with conditions 2010 Chukchi Sea EP (USDOI, MMS, 2009a) and are incorporated by reference.

It is reasonably likely that the Proposed Action could result in a small oil spill. For the purpose of analysis, a 48 bbl fuel transfer spill was estimated for this EA. A spill of this size and type would disperse and evaporate within 3 days, prior to reaching onshore communities or nearshore subsistence areas, resulting in minimal impacts to public health.

Although very unlikely, it is possible that the Proposed Action could lead to a large or very large oil spill. For the purpose of analysis, BOEM estimates potential discharge volumes for this EA to be 1,555 bbl of diesel for a large spill and 750,000 bbl of crude oil for a very large spill. The Sale 193 Final EIS (USDOI, MMS, 2007a) and the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a) analyzed potential effects to public health from large and very large oil spills and found that effects to air quality, water quality, subsistence resources, and other environmental resources could cause impacts from the following: contact with contaminants, which could occur mainly through inhalation, skin contact, or intake of contaminated subsistence foods; reduced availability or acceptability of subsistence resources; periodic interference with subsistence-harvest patterns from oil spills and oil-spill cleanup; and stress due to fears of the long-term implications of a spill and the disruptions it would cause. These analyses remain sufficient to analyze the effects of large and very large spills in the Chukchi Sea, including the 1,555 bbl diesel spill and the 750,000 bbl oil spill estimated for this EA.

### 4.11.3 Alternative 3 – One Well per Season

Under Alternative 3, exploration drilling activities will be less intensive in any single drilling season but more prolonged overall. Spreading out exploration drilling activities over additional drilling seasons would also prolong the potential direct and indirect impacts to public health, as described above, though the impacts would be less intense in any single drilling season. As is the case with Alternative 2, these impacts would still be considered negligible, and would not constitute a significant change in the impacts to public previously identified and evaluated in the approved with conditions 2010 Chukchi Sea EP (USDOI, MMS, 2009a). Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

### 4.11.4 Cumulative Effects

A thorough discussion of past, present, and reasonably foreseeable future actions affecting the Chukchi Sea environment is provided in Appendix C.

With the implementation of the mitigation described in Section 3 and the subsections above, the cumulative effects from the Proposed Action of the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a) in combination with other 2012 survey activities described in Appendix C are considered to be negligible. These effects do not constitute a significant change in the impacts to public health previously identified and evaluated in the approved with conditions 2010 Chukchi Sea EP (USDOI, MMS, 2009a).

Under Alternative 3, exploration drilling activities will be less intensive in any single drilling season but more prolonged overall. Spreading out exploration drilling activities over additional drilling seasons would also prolong the potential cumulative impacts to public health, as described above, though the impacts would be less intense in any single drilling season. As is the case with Alternative 2, these impacts would still be considered negligible, and would not constitute a significant change in the impacts to public previously identified and evaluated in the approved with conditions 2010 Chukchi Sea EP (USDOI, MMS, 2009a).

## 4.12 Archaeological Resources

The NSB zoning ordinances ensure protection of archeological and cultural resources. NSB Municipal Code 19.70.050(E) states that development which is likely to disturb certain cultural or historic sites be required to avoid the sites or be required to consult with appropriate local, state, and federal agencies and survey and excavate the site prior to disturbance. NSB Municipal Code 19.70.050(F) requires that development not significantly interfere with traditional activities at cultural or historic sites. NSB Municipal Code 19.70.050(G) requires that development not cause surface disturbance of newly discovered historic or cultural sites prior to archaeological investigation.

Additional requirements pertaining to archaeological resources are contained in the NHPA and its implementing regulations, as well as in BOEM operational regulations at 30 CFR 550.194. The technical requirements for the archaeological resource surveys and reports that may be required under the regulations are detailed in the Alaska OCS Region Notice to Lessees NTL 05-A03. Under Section 106 of the National Historic Preservation Act, BOEMRE consults with the Alaska State Historic Preservation Office (SHPO) for OCS activities during the pre-lease process.

### 4.12.1 Alternative 1 – No Action

Under the No Action Alternative, the proposed exploration activities would not be approved, and no effects on archaeological resources would occur.

### 4.12.2 Alternative 2 – Proposed Action.

Exploration activities could impact offshore resources through vessel mooring, mudline cellar construction, discharge of drill cutting and drill fluids, and onshore construction activities.

Analysis for each drill site and anchor location (shown in the Revised EP on Figures 1.b-3 through 1-b.8, Bathymetry and Planned Drillship Anchor Locations) indicates that activities will avoid all sidescan sonar contacts and magnetic anomalies. Discharges of drilling fluids and cuttings would be dispersed before reaching the seafloor and would be deposited on top of the thin veneer of Holocene-age sediments that already cover any prehistoric cultural resources in the area. Drilling cuttings produced during mudline cellar construction and drilling of the uppermost well interval will also be discharged on the seafloor surface. Discharges could result in seafloor scouring at the site of the discharge, which could potentially impact archaeological resources on or just below the seafloor. However, site assessments of the drill site did not identify any potential cultural resources on or below the seafloor.

No impacts to onshore archaeological resources are expected since Shell plans to use existing facilities at Barrow and Wainwright.

The effects of activities would be on a site-by-site basis regardless of the year in which the activity occurs.

Analysis of the shallow hazards survey reports and archaeological assessments listed in the Revised EP Section 5 (Shell, 2011a) indicates the following:

- Numerous side scan sonar targets are distributed across the survey areas. None of the targets were deemed in the analysis to be archaeologically significant.
- Numerous magnetic anomalies are distributed across the survey areas. Many of the anomalies form linear strings which closely correspond to fault picks, may represent subsurface geological features, or are unattributed. None of the magnetic anomalies corresponded to side scan sonar targets. None of the anomalies are deemed to be archaeologically significant.
- The previous point not withstanding, a cluster of seven magnetic anomalies south of the Burger V drill site cannot be identified through geophysical data, are of unknown origin, and will avoided by all activities, such as anchoring, associated with exploration.
- Pleistocene buried channels were identified in the area of Burger A, F, and S. Channel levees, internal strata and overbank deposits have been eroded and removed during subsequent marine transgression and covered with a thin veneer of Holocene age material. There are no landforms identified by the surveys which would be considered high probability areas for prehistoric occupation.
- Comparison of the reports listed above with the Revised EP Figures 1.b-3 through 1.b-8 indicates that anchor locations will avoid sidescan sonar targets and magnetic anomalies.

Shell describes the shallow hazards and archaeological surveys in Section 5 of the Revised EP. The Revised EP states that “all of the side-scan sonar contacts and magnetic anomalies will be avoided during the exploration drilling operations” (Shell, 2011a: p. 5-3).

Based on the above information, no historic or prehistoric properties are likely to be affected by the activities proposed in the Revised EP. Therefore, the Proposed Action will have a negligible effect on archaeological resources. If exploration activities terminate prior to the end of October in any year the types and level of impact would be as described above.

The oil-spill analysis has determined that there is a low chance for an accidental small oil spill that likely would be operational in nature. For the purpose of this analysis, a 48 bbl fuel transfer spill was estimated. A 48 bbl diesel spill would evaporate and disperse in less than 3 days before contacting critical nearshore subsistence areas. As required by Lease Stipulation 6, oil-spill containment booms would be deployed during any refueling activity, and would contain a small oil spill if one should occur. As there are no identified archaeological resources in the area of any of the drill sites, effects on historic resources from the initial event and offshore spill are not likely to occur.

In a large oil spill of up to 1,555 bbl (estimated potential discharge for this EA) or a very large oil spill of up to 750,000 bbl (estimated potential discharge for this EA) various aspects of the oil spill, offshore and onshore response, and cleanup have some potential to adversely affect archaeological resources. Regardless of water depth, because oil is a hydrocarbon, heavy oiling could contaminate organic materials associated with archaeological sites, resulting in erroneous dates from standard radiometric dating techniques (e.g., 14C-dating). Interference with the accuracy of 14C-dating would result in the loss of valuable data necessary to understand and interpret the sites.

Offshore archaeological sites could be disturbed by vessel anchoring. The density of anchoring activity increases the potential to damage archaeological resources, although the use of dynamically-positioned response vessels would minimize the occurrence of anchoring. Onshore, oil-spill-cleanup activities that disturb soil or cause shallow permafrost to thaw have the potential to disturb archaeological resources. Contamination of archaeological resources through contact with oil would decrease data recovery. Onshore cleanup activity would introduce ground disturbing activities into remote areas and increase the likelihood of vandalism and pilferage of sites or structures. Measures such as orientation programs for clean-up workers, embedding of archaeologists in shoreline cleanup teams, and early identification of sites can mitigate some of these potential effects (USDOI, MMS, 2007a, 2008; USDOI, BOEMRE, 2011a).

Additional analysis of potential effects to archaeological resources from large and very large oil spills is provided in the Sale 193 Final EIS (USDOI, MMS, 2007a) and the Sale 193 Final SEIS (USDOI, BOEMRE, 2011a), respectively.

### 4.12.3 Alternative 3 – One Well per Season

Activities associated with Chukchi Sea exploration could impact the offshore resources through vessel mooring, mudline cellar construction, and discharge of drill cutting and drill fluids. The effects of activities would occur on a site-by-site basis regardless of the year in which the activity occurs. Effects would be the same as those effects described under Alternative 2, the Proposed Action, except that the potential for effects would be spread out amongst additional years of exploration activity.

Site assessments of the drill site did not identify any potential cultural resources on or below the seafloor or any potential cultural resources on shore affected by activities associated with the exploration plan. Therefore, Alternative 3 (like the Proposed Action) will have a negligible effect on archaeological resources.

Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2

### 4.12.4 Cumulative Effects

This section discusses the effect to the archeological resources which result from known past, present and reasonably foreseeable future activities and the incremental contribution of the Proposed Action and any alternatives to the Proposed Action.

Natural processes such as ice gouging, bottom scour, thermokarst erosion, and shoreline erosion have the greatest cumulative effect on archaeological resources in the Chukchi Sea area. These natural processes are ongoing and continue to have destructive effects on prehistoric and historic archaeological sites (USDOI, MMS, 2007a; USDOI, MMS, 2008).

Other OCS oil and gas activities in the Chukchi Sea could disturb the seafloor, but will have undergone a similar review to that for the Proposed Action. As such, cumulative effects on archaeological resources from these projects will be negligible. Similarly, construction of onshore infrastructure to support exploration activities will be limited and take place near population centers, most notably Wainwright. State and North Slope Borough policies on coastal development help ensure protection of archaeological resources similar to that afforded federally-authorized activities.

This Proposed Action would have a negligible effect on archaeological resources. The incremental contribution of the activities associated with this alternative result in no change in the negligible level of effect for this resource.

## 4.13 Environmental Justice

Significant effects with respect to environmental justice include impacts on human health or environment that cause disproportionate, high adverse effects on minority or low-income populations. This threshold would be reached in the event of significant impacts to subsistence harvest patterns, sociocultural systems, or public health. Tainting of subsistence foods from oil spills and contamination of subsistence foods from pollutants would contribute to potential adverse human health effects. Concerns that subsistence foods could be contaminated could also affect human health.

### 4.13.1 Alternative 1 – No Action

Under the No Action Alternative, the proposed exploration activities would not be approved, and no environmental justice issues would arise.

### 4.13.2 Alternative 2 – Proposed Action

This analysis considers the Proposed Action’s direct and indirect effects on subsistence, sociocultural systems and public health as factors that would most affect environmental justice. Because the analyses above conclude that the proposed project would result in negligible direct and indirect effects to these resources, it follows that the proposed project would have non-existent to negligible direct and indirect effects on environmental justice. The effects evaluated will occur each season that Shell conducts exploratory drilling operations under this exploration plan. The negligible effects, however, are temporally limited and consecutive years of activity would not have an additive effect.

This conclusion is supported by the environmental justice analysis conducted by EPA for the Clean Air Act permits related to the Proposed Action concluded that

> “the activities proposed to be authorized…will not cause or contribute to air quality levels in excess of health-based standards for SO2, CO, PM10, PM2.5, Ozone or NO2. Region 10 therefore concludes that there will not be disproportionately high and adverse human health or environmental effects with respect to these air pollutants on minority or low-income populations residing in the North Slope, including coastal communities closest to the proposed operations. In reaching this conclusion, Region 10 considered the impact on communities while engaging in subsistence activities in areas where such activities are regularly conducted” (EPA, 2011).

The oil-spill analysis has determined that there is a low chance for an accidental small oil spill that likely would be operational in nature. For the purpose of this analysis, a 48 bbl fuel transfer spill was estimated. A 48 bbl diesel spill would evaporate and disperse in less than 3 days before contacting critical nearshore subsistence areas. As required by Lease Stipulation 6, oil-spill containment booms would be deployed during any refueling activity, and would contain a small oil spill if one occurred.

The perception that subsistence foods might be contaminated, particularly marine mammals or fish, might be of concern to the Iñupiat at Barrow, Wainwright, Point Lay, and Point Hope in terms of potential effects on health. Because subsistence activities do not occur in the vicinity of proposed drilling and any associated spill source, and because no fuel transfer is expected during transit between the Beaufort and Chukchi seas, the short-term effects of the analyzed small spill on subsistence activities are expected to be negligible to minor. No long-term effects are anticipated as effects are not expected to persist past the end of the drilling season. Therefore, small oil spills would amount to a negligible to minor effect.

A large spill of up 1,555 bbl (estimated potential discharge for this EA) or very large oil spill of up to 750,000 bbl (estimated potential discharge for this EA) would have similar effects to those described in detail in other lease sale EIS's for environmental justice (USDOI, MMS, 2007a; USDOI, MMS 2008; USDOI, BOEMRE 2011a). The environmental justice impacts of a large or very large oil spill on Alaskan Native communities are interconnected with the subsistence lifestyle of these communities described in Section 4.8 and the attendant sociocultural systems effects described in Section 4.7. Given the overarching importance of subsistence resources to the indigenous populations—all defined minority populations—any major impacts to subsistence resources that create attendant major impacts on Alaska Native sociocultural systems would be expected to have consequent disproportionate, high adverse impacts on environmental justice.

BOEM views oil spills as having the potential to cause long term significant effects that would disrupt or nearly eliminate subsistence harvests. Oil spills are never permitted and are always in violation of the law. Operators would be held accountable and responsible for mitigation and monitoring, effects of loss or reduction of subsistence species on the local subsistence harvesters, and the linked social organizations and institutions.

### 4.13.3 Alternative 3 – One Well per Season

This analysis considers the proposed project direct and indirect effects on subsistence and public health as factors that would most affect environmental justice. Because the analyses above conclude that the proposed project would result in negligible direct and indirect effects to these resources, it follows that the proposed project would have non-existent to negligible direct and indirect effects on environmental justice. The effects evaluated will occur each season that Shell conducts exploratory drilling operations under this exploration plan. The negligible effects, however, are temporally limited and consecutive years of activity would not have an additive effect. Under Alternative 3, the potential for a large or very large petroleum spill would be spread across additional seasons, but the potential environmental effects would be the same as was analyzed under Alternative 2.

### 4.13.4 Cumulative Effects

This section discusses effects from known past, present, and reasonably foreseeable future activities and the incremental contribution of the Proposed Action.

Incidental or accidental short term encounters can be further eliminated through effective communication between the communities and BOEM and/or industry. The communication center operation and the subsistence advisor program are mitigation measures identified in the description of the Proposed Action and are examples of remedies for these types of disruptions.

This analysis considers that cumulative effects on subsistence, sociocultural, and public health are factors that would most affect environmental justice. Because the analysis concludes that cumulative effects on subsistence and local economic opportunities would be negligible, it follows that there will be negligible cumulative effects on environmental justice. The reasonably foreseeable cumulative effects would occur at nearly the same level each season that Shell conducts exploratory drilling operations under this exploration plan. For the life of the project, the impacts to environmental justice from the Proposed Action and from reasonably foreseeable cumulative activities would amount to a negligible level of effect.

# SECTION 5. Consultation and Coordination

The following subsections describe formal and informal consultations undertaken by BOEM with respect to the Proposed Action, as well as public involvement in the development of this Environmental Assessment (EA). Also provided is a list of EA reviewers and preparers.

## 5.1 Endangered Species Act Consultation

BOEM consults with NMFS and FWS regarding potential impacts to listed species and designated critical habitat under each Service's jurisdiction.

Consultation with NMFS for the proposed exploration program is covered by the July 17, 2008, BO for Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska and Authorization of Small Takes Under the Marine Mammal Protection Act (NMFS, 2008). In December 2010, NMFS proposed the ringed seal and the Beringia Distinct Population Segment of the bearded seal for listing under the ESA (75 FR 77476). In October 2011, BOEM concluded that the proposed exploration program would not jeopardize the continued existence of these ice-seals and conferencing under the ESA on the exploration plan was not required. While not required for the proposed exploration plan, on October 11, 2011, BOEM requested a programmatic conference opinion from the NMFS for the ice seals that could provide continuous ESA consultation coverage for the two ice seal species if they are listed in the near future.

BOEM last completed consultation with the FWS on September 3, 2009, a consultation that concluded with the BO for the Beaufort and Chukchi Sea Program Area Lease Sales and Associated Seismic Surveys and Exploratory Drilling (USDOI, FWS, 2009). Most of Shell's proposed exploration activities were covered by that consultation; however, on December 7, 2010, FWS finalized the designation of critical habitat for the polar bear (75 FR 76086). The designation identified the physical and biological features essential to the conservation of the polar bear. The FWS identified land-fast sea ice (sea ice that is frozen to the shoreline or to the seafloor and is relatively immobile) and pack ice (annual and multi-year ice that is in constant motion due to winds and currents) as critical sea ice habitats (75 FR 76086). Open water is not considered an essential feature for polar bears (75 FR 76086). BOEM has reinitiated section 7 consultation and, in September 2011, transmitted a Biological Evaluation to the FWS that assessed the potential effects of oil and gas exploration and development on the Arctic OCS Region for listed species and designated critical habitat. Any approval of the Proposed Action would be conditioned upon completion of this ESA consultation. This condition of approval will allow BOEM to incorporate any additional mitigation measures developed in ongoing section 7 consultations. BOEM has had ongoing communications with FWS regarding the Proposed Action and will continue to ensure compliance with the ESA.

## 5.2 Essential Fish Habitat Consultation

Pursuant to the Magnuson-Stevens Fisheries Conservation and Management Act, BOEM consulted with NMFS on the Sale 193 Final EIS (USDOI, MMS, 2007) regarding Pacific salmon EFH and on the Sale 193 Final SEIS (USDOI, BOEMRE, 2011) regarding Arctic cod, saffron cod and opilio crab. BOEM provided a determination of adverse effects in a consultation document sent to NMFS in July of 2011. NMFS replied with conservation recommendations in September of 2011. BOEM provided it reply to these conservation measures in October of 2011. BOEM would engage in additional EFH consultation prior to the commencement of the Proposed Action evaluated in the EA.

## 5.3 Marine Mammal Protection Act

To ensure compliance with the Marine Mammal Protection Act (MMPA), BOEM would require Shell to obtain an incidental harassment authorization (IHA) from NMFS and a letter of authorization

(LOA) from FWS before Shell commences BOEM-permitted exploration activities. Mitigation measures are included in the IHA and LOA to ensure the least practicable adverse impact on marine mammal species or stocks and to ensure that potential impacts to marine mammal populations will be negligible and have no unmitigable adverse impacts on the availability of marine mammals for subsistence uses. Shell is applying to NMFS for an IHA for the incidental take of whales and seals, and to FWS for an LOA for the take of polar bears and Pacific walrus.

## 5.4 National Historic Preservation Act Consultation

BOEM consulted with SHPO regarding Chukchi Sea issues in conjunction with the Sale 193 Final EIS (USDOI, MMS, 2007) and in conjunction with the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008). SHPO provided its concurrence with BOEM's consultation letter on September 24, 2008. More recently, BOEM reviewed site-specific geophysical data associated with the 2012 Shell Revised Chukchi Sea EP (or Revised EP)and identified no historic properties at the proposed drill sites. On November 29, 2011 BOEM wrote a letter informing the SHPO of its determination that drilling of the six wells and related activities will have no effect on historic properties.

## 5.5 Reviewers and Preparers

Table 33 identifies the persons responsible for reviewing the 2012 Shell Revised Chukchi Sea EP and preparing this EA.

**Table 33. Persons responsible for the preparation of this EA.**

| Name | Professional Position | Role in Preparation |
|---|---|---|
| Scott Blackburn | Technical Writer Editor | Technical Editor / Publisher (Primary) |
| Jerry Brian | Socioeconomic Specialist | Review & Analysis – Economy, Public Health |
| Mary Cody | Wildlife Biologist | Review & Analysis – Marine Mammals |
| Deborah Cranswick | Supervisory Environmental Protection Specialist | Project Manager |
| Chris Crews | Wildlife Biologist | Review & Analysis – Marine Mammals, Terrestrial Mammals |
| Nancy Deschu | Biologist | Review & Analysis – Water Quality, Fish & Essential Fish Habitat |
| Dan Holiday Ph.D. | Biological Oceanographer | Review & Analysis – Lower Trophic Levels, Cumulative Effects |
| Jim Lima, Ph.D. | Socioeconomic Specialist | Review & Analysis – Subsistence Activities, Sociocultural Systems, Environmental Justice, Archaeological Resources |
| Virginia Raps | Meteorologist | Review & Analysis – Air Quality, Climate Change, Meteorology |
| Mike Routhier | NEPA Coordinator | Project Coordinator |
| Mark Schroeder | Wildlife Biologist | Review & Analysis – Marine and Coastal Birds |
| Caryn Smith | Oceanographer | Review & Analysis – Petroleum Spills |
| Bill Swears | Technical Editor | Technical Editor / Publisher |
| Joe Talbott | NEPA Coordinator | Project Coordinator |

## 5.6 Public Involvement

BOEM has provided several opportunities for public involvement regarding the 2012 Shell Revised Chukchi Sea EP and the preparation of this EA. These opportunities include:

- Posting a May 2011 version of the 2012 Shell Revised Chukchi Sea EP to the BOEM website for public review.
- Soliciting public comments on the 2012 Shell Revised Chukchi Sea EP. When BOEM "deemed submitted" the Revised EP, BOEM initiated a 21-day public comment period, from November 16, 2011 to December 7, 2011, to solicit public input regarding the Revised EP.
- Soliciting public comments on the preparation of this EA. When BOEM "deemed submitted" the Revised EP, BOEM notified the public that the agency was preparing an Environmental Assessment and requested public input. The public had 10-days, from November 16, 2011 to November 26, 2011, to comment. Six public comments were received and considered in developing this EA.

Opportunities for public input regarding exploratory drilling in the Arctic OCS have also been provided during numerous prior NEPA processes

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# Appendix A

## Analysis of Accidental Oil Spills

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# Appendix A. Table of Contents

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# Appendix A. Analysis of Accidental Oil Spills

## A-1. Introduction

This Appendix describes the results of the oil-spill analysis and includes the supporting documentation for those results. The-oil-spill analysis considers the potential accidental oil spill discharges and their likelihood of occurrence, and then outlines the accidental oil spill scenario framework for the impact analysis of the alternatives in this EA. The vessel, drilling, and fuel-transfer activities are described in the 2012 Shell Revised Chukchi Sea Exploration Plan (Revised EP) for Alternative 2-The Proposed Action, and Alternative 3-One well per season, were evaluated for both routine operations and accident conditions. It is not anticipated that oil spills occur as a routine activity. Therefore, oil spills are not considered a routine impact-producing factor. Oil spills are considered accidental events, and the Clean Water Act and the Oil Pollution Act include both regulatory and liability provisions that are designed to reduce damage to natural resources from oil spills. Therefore oil spills are treated as an accidental impact-producing factor. An accident is an unplanned event or sequence of events that results in an undesirable consequence. In this analysis the undesirable consequence is an oil spill in the environment.

BOEM carefully and thoroughly analyzed a range of oil spill sizes (from small [<1,000 bbl] to very large [≥150,000 bbl]) and the likely consequences to environmental, social, and economic resources in the Sale 193 FEIS and FSEIS, from which this EA tiers. BOEM updated those small and large oil spill and impact analyses in the Arctic Multiple Sale Draft EIS. A small spill was analyzed again in the 2009 Chukchi Sea EA. Both the Arctic Multiple Sale DEIS and the 2009 Chukchi Sea EA are incorporated by reference. This Appendix also incorporates by reference the 2012 Shell Chukchi Sea EIA, which is Appendix F of the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a). Brief summaries, where relevant, are provided below, and the information is updated and augmented by new material as needed.

Section 1.1 below begins with the summary of estimated oil spill factors (number, size, source, oil type, duration, likelihood of occurrence, weathering characteristics) which collectively make up the oil spill scenario. The accidental oil spill scenario is used for impact analysis in Section 4.0 for Alternative 1-No Action, Alternative 2-The Proposed Action, and Alternative 3- One Well per Season in this EA. The remainder of this Appendix provides the information supporting the estimated oil spill factors.

## A-2. Summary: Potential Oil Spill Size Categories

There are three potential size categories of oil spills in connection with exploratory operations in Alternative 2-The Proposed Action and Alternative 3-One Well Per Season: (1) a large spill (≥1,000 bbl) from exploration operations; (2) a very large spill (≥150,000 bbl) from a well-control incident; and (3) a small spill (<1,000 bbl) from exploration operations. Historical and modeling oil spill data demonstrates that the frequency of a large spill occurring during exploration is low and, therefore, this EA does not analyze the impacts of large spills from exploration operations. The occurrence of a very large spill resulting from a well-control incident is similarly very low. Nonetheless, this EA tiers to the BOEM's prior analyses of the impacts of a large and very large oil spill in the Sale 193 FEIS and SFEIS. See further discussion in Section 4.0 of this EA.

For purposes of the oil spill analyses for Alternative 1-No Action, no small, large, or very large spills are estimated to occur in the project area. In Alternative 1, none of the exploration activities described in the proposed action occur in the project area.

For purposes of the oil spill analyses for Alternative 2-The Proposed Action proposed action and Alternative 3- One Well per Season, it is likely that a small spill could occur. BOEM estimates a 48-bbl diesel fuel-transfer spill for the volume and type of a small spill, as identified in the Shell Chukchi Sea Regional Oil Discharge Prevention and Contingency Plan-Revision 1 (Shell ODPCP) summary of potential discharges (Shell, 2011b: Table 2.3-1).

For purposes of the oil spill analyses for Alternative 2-The Proposed Action and Alternative 3- One Well per Season, no large or very large crude or diesel oil spills are estimated from exploration activities. This is based on a review of potential discharges, historical oil spill and modeling data, and likelihood of oil spill occurrence. This estimate is based on (1) the low rate of OCS exploratory drilling well-control incidents spilling fluids per well drilled; (2) since 1971 one OCS spill (large/very large) has occurred during temporary abandonment while drilling more than 15,000 exploratory wells; (3) the low number (six) of exploration wells being drilled from this proposed action; (4) no crude oil would be produced and the wells would be permanently plugged and abandoned; (5) the history of exploration spills on the Arctic OCS, all of which have been small, (6) the fact that no large spills occurred while drilling 35 wells in the Arctic OCS; and (7) pollution prevention and oil spill response regulations and methods, implemented by BOEMRE (now BOEM), Shell Offshore Inc., and Shell Gulf of Mexico Inc., since the Deepwater (USDOI, BOEM, 2011; Shell, 2011b, Shell, 2011a).

## 2.1 Summary: Small Spills (<1,000 bbl) from Exploration Activities

Historical Beaufort Sea and Chukchi Sea OCS exploration spill data suggest that a small spill is likely to occur. Thirty five exploration wells were drilled in the Arctic OCS from 1981-2003. During that time period 35 small spills have occurred spilling a total of 26.7 bbl (of which 24 bbl was recovered). The most likely cause of a small oil spill during exploration could be operational, such as a hose rupture. The largest Arctic OCS exploration spill was less than 20 bbl (Section 1.3.1). For purposes of analysis of the Alternative 2 and 3, a 48-bbl diesel fuel-transfer spill was estimated as the small spill volume and oil type. The spill is estimated to last less than 3 days on the surface of the water, based on oil weathering model calculations. Section 4.0 of this EA analyzes the impacts of such a small spill in each of the EA sections on oil spill impacts to specific resources. Lease Stipulation 6 and Shell's fuel transfer plan procedures require pre-booming during fuel transfers, which would reduce or negate adverse effects from a small diesel fuel-transfer spill.

## 2.2 Summary: Large Spills (≥1,000 bbl) from Exploration Activities

Historical OCS crude and condensate spill data demonstrates that a large spill is unlikely to occur as a result of Alternative 2-The Proposed Action or Alternative 3- One Well per Season. No oil will be produced. All wells will be permanently plugged and abandoned in accordance with BOEM requirements on completion of drilling. Since 1971, one OCS spill (large/very large) has occurred during temporary abandonment from a well-control incident while drilling approximately 15,000 OCS exploration wells. All fuel-storage tanks will be internal to the drillship and should an internal storage tank rupture, it is unlikely a large diesel fuel spill would reach water. A large spill from internal diesel fuel tanks or a well-control incident escalating into uncontrolled flow is unlikely in connection with the exploration activities set forth in Shell's Revised EP, and therefore, this EA does not analyze the impacts of such a large spill scenario, but tiers to previous analysis of large spills in Sale 193 FEIS and incorporates by reference Arctic Multiple Sale DEIS.

## 2.3 Summary: Very Large Oil Spills (≥150,000 bbl) from Exploration Activities

A very large oil spill (VLOS) from a well-control incident during OCS exploratory drilling is a similarly unlikely occurrence. There is abundant and reliable scientific data on the infrequency of an exploration well-control incident occurring and releasing fluids, and further support for this conclusion is set forth below. A very large spill from a well-control incident is unlikely in connection with the exploration activities set forth in Shell's Revised EP, and therefore, this EA does not analyze the impacts of such a scenario, but tiers to analysis of very large oil spills in the Sale 193 FSEIS.

BOEMRE (now BOEM) analyzed the potential impacts of a very large oil spill from a well-control incident escalating into a long duration flow (USDOI, BOEMRE, 2011: pp. 136–296). There are no site-specific anomalies that differentiate a very large oil spill release at Launch Area (LA) 11 from Shell's leases, and the oil-spill contacts are statistically similar. Thus, BOEM has analyzed the potential impacts from a very large well-control incident escalating into a loss of well control where fluids are released into the Chukchi Sea and tiers to that analysis. This impact analysis in USDOI, BOEMRE (2011) does not consider the mitigation of spill response. Shell's ODPCP response scenario addresses the potential immediate release of crude oil to the environment by a loss of well-control during drilling. Shell's ODPCP demonstrates the access to sufficient equipment and personnel needed to respond to a Worst Case Discharge flow rate of 25,000 barrels of oil per day (bopd) for 30 days.

# A-3. Oil-Spill Volume and Type Estimates

Oil spills are an issue of great public concern in relation to the offshore oil and gas industry. Etkin (2009) estimates that petroleum industry spillage has decreased over the last 40 years; 70 percent less oil is spilling since the 1970s and 54 percent less in the decade 1998-2007 from the previous. Although total oil spill volumes are decreasing, even with consumption of oil increasing, the Deepwater Horizon Event has heightened the industry's, regulator's and public's awareness of the potential impacts of very large oil spill events.

Using information from the Shell ODPCP and EIA, BOEM reviewed and evaluated available information regarding the small, large, and very large oil spill volume estimates, oil spill types and the likelihood of the potential discharges. Using this information BOEM, determined a reasonably foreseeable spill analysis scenario. The analysts used the reasonably foreseeable spill analysis scenario to evaluate the potential oil spill impacts on their resources in Section 4 of this EA for Alternative 2-The Proposed Action and Alternative 3- One Well per Season. No oil spills are estimated to occur for Alternative 1-No Action.

## 3.1 Oil Spill Potential Discharge Volume

BOEM verified and then used Shell's potential discharge volumes (summarized below in Table A-1) as the likely spill volume and oil type for each of BOEM's small (<1,000 bbl), large (≥1,000 bbl), and very large (≥150,000 bbls) spill size categories (Shell, 2011a: Table 2-1). Within each of BOEM's spill-size categories, the estimated potential discharge volume is considered the representative volume for that size category (without pollution prevention and oil spill response measures). A 48-bbl diesel-transfer spill is the estimated volume of a small spill; a 1,555-bbl diesel-fuel tank-rupture spill is the estimated volume of a large spill, and the blowout worst-case discharge of 750,000 bbl is the estimated volume of very large spill (without pollution prevention and oil spill response measures). Section 3.2 below describes why and how Shell Offshore, Inc. calculated the worst-case discharge (WCD) and BOEM's verification of the WCD.

**Table A-1. Summary of Potential Discharge Volumes and Relation to BOEM Spill Size Categories for Oil-Spill Analysis.**

| BOEM Spill-Size Categories | Type | Cause | Product | Size | Duration | Prevent Potential Discharge |
|---|---|---|---|---|---|---|
| Small <1,000 bbl | Transfer from fuel tanker to drill vessel | Hose rupture | Diesel | Approximately 2,000 gallons 48 bbl (Section 1.6) | 5.5 minutes (ODPCP Section 1.6) | Transfer procedures in place; minimized by the weather restrictions, during unfavorable wind or sea conditions. Transfers are announced in advance; and verbal communication, in combination with |

| BOEM Spill-Size Categories | Type | Cause | Product | Size | Duration | Prevent Potential Discharge |
|---|---|---|---|---|---|---|
| | | | | | | visual inspection, is the best method of discharge detection. Booming is in place during transfer. |
| Large ≥1,000 bbl | Diesel Tank | Tank rupture | Diesel | 1,555 bbl | Minutes to hours (ODPCP Section 2) | The diesel tanks are internal to each drilling vessel rather than deck-mounted, where the potential for marine spills is much greater. As a result, a scenario involving tank rupture has not been included in the oil-spill-response plan, but will be monitored as part of an ongoing tank inspection program. |
| Very Large ≥150,000 bbl | Blowout | Uncontrolled flow at the mudline | Crude oil | 750,000 bbl | 30 days (ODPCP Section 1) | Blowout prevention equipment and related procedures for well-control. Layer I includes proper well planning, risk identification, training, routine tests, and drills on the rig. Layer II includes early kick detection and timely implementation of kick-response procedures. Layer III involves the use of mechanical barriers, including, but not limited to, blowout preventers, casing, and cement. Testing and inspections are performed to ensure competency. Shell (2011b): ODPCP Section 2.3.1 |

Source: USDOI, BOEM, 2011.

## 3.2 Worst-Case Discharge Calculation for the Oil Spill Response Plan

The BOEM and BSEE regulations set forth how the volume for a WCD calculation is determined for an Exploration Plan and oil-spill-response planning scenario (30 CFR and 254.47(b) and 550.213(g)). The WCD volume and storage capacities are calculated to address BOEM and BSEE's need to determine the adequacy of the company's spill-response capabilities and are shown in Table A-2.

**Table A-2. Estimates of Cumulative WCD Volume by Citation and Source.**

| Citation | Source | Type and Location | Product | Size (bbl) | Duration |
|---|---|---|---|---|---|
| 30 CFR 254.47(b) | Shell (2011b) | Uncontrolled flow at the mudline | Crude oil | 750,000 | 30 days (ODPCP Section 1) |
| 30 CFR 550.213(g) and NTL 2010-N06 | Shell (2011b) | Uncontrolled flow at the mudline | Crude oil | <295,426-669,474[1] | Burger J, S, A, V, F, R. wells 34-38 days to drill a relief well |
| BOEM Verification | Wall (2011) | Uncontrolled flow at the mudline | Crude oil | 253,234-279,954 | Burger J well 34-38 days to drill relief well |

Note: 1. The size in bbls range is estimated from the lowest bopd rate multiplied by the shortest number of days to drill a relief well to the cumulative volume for Burger J.

BSEE requires the WCD to be based upon the daily volume possible from an uncontrolled blowout flowing for 30 days (30 CFR 254.47(b) Determining the volume of oil of your worst case discharge scenario). The Shell planning scenario considers a daily release of 25,000 bbl of crude oil for 30 days (750,000 bbl total). This volume exceeds Shell's WCD calculated for the Burger J, S, A, V, F, R. wells (Section 2(g) of the Revised EP). Shell's ODPCP demonstrates access to sufficient equipment and personnel needed to respond to a well blowout with a 25,000 barrels of oil per day flow rate and total volume of 750,000 bbl.

Other BOEM regulations (30 CFR 550.213(g)-Blowout scenario) require a scenario for a potential blowout that will have the highest volume and maximum duration for a given well. Shell's blowout scenario provides for transiting and drilling a relief well for Burger J, S, A, V, F, R wells in up to 34–

38 days. The resulting estimated daily spill volume for Burger J, S, A, V, F, R wells ranges from 8,689–23,100 bopd. Again, these oil spill volumes are calculated without factoring in any intervention or response. Burger J is the highest flowing well. The cumulative volume ranges from 603,564–669,479 bbl for 34 and 38 days, respectively (Shell, 2011a: Section 8, Table 8.d.2). These volumes are below the 750,000 bbl used for planning purposes in Shell's ODPCP (Shell, 2011b).

The daily flow rate for a loss of well control resulting in a blowout is based on the WCD estimate provided by Shell and verified by BOEM (Wall, 2011). The WCD estimate does not reduce the cumulative volume by including intervention or response in the calculation. BOEM, Resource Evaluation conducted a verification of the WCD model submitted by Shell and concurs that the Burger J well has the highest potential discharge volume in both daily rate and cumulative flow. BOEM WCD results find that the cumulative discharges are all less than the cumulative discharges forecast by the Shell's WCD model (Wall, 2011). BOEM estimates the cumulative oil discharge at 34 and 38 days for the Burger J well is 253,234 and 279,954, respectively. BOEM further estimates the cumulative discharge at the end of day 90 is 613,076 bbl (Wall, 2011).

## 3.3 Comparison of WCD to Very Large Oil Spill

BOEM reviewed the very large oil spill (VLOS) elements analyzed in the Sale 193 SFEIS (Table A-3) to determine if the WCD estimates provided in the Shell Revised EP are within the scope of the VLOS scenario. In calculating the flow rate, length of flow, and volume, the Sale 193 FSEIS analysis did not consider a reduced volume that may be achieved through the use of oil spill countermeasures.

**Table A-3. Comparison of Very Large Oil Spill Scenario Elements to Shell Worst Case Discharge Information.**

| Description | Chukchi Sea SFEIS | Burger J | Relative Change |
|---|---|---|---|
| Flow Rate | 61,000-20,479 bopd | 25,000 bopd[1] | Less than ½ the flow initially |
| Length of Flow | 39-74 days | 30 days | Shorter duration |
| Volume | 2.2 Million barrels[2] | 750,000 barrels | About 1/3 of the size |
| Oil Type | 35 °API | 30° API | Light versus medium crude |
| Location | Subsurface or Surface | Surface or Subsurface (subsurface modeled for WCD) | Subsurface likely will surface within 1000 m of the location of loss of well control |

Source: Shell (2011b) and Wall (2011).

Key: °API = American Petroleum Institute gravity (API)
Bopd = barrels of oil per day
[1]Provided as required by 30 CFR 550.213(g), 550.219(a)(2)(iv) and 254.47(b)

The Burger J well was selected as the basis for comparison as it has the highest calculated WCD of the six exploration wells proposed in the Revised EP (Shell, 2011a: p. 2-3). BOEM analysis (Wall, 2011) establishes an initial flow rate of 13,091 bopd which differs from that provided by Shell's estimate of 23,100 bopd (Wall, 2011). This EA considers mitigation measures incorporated into Shell's Revised EP including the use of a capping and containment system to stem the discharge of oil to the marine environment within 15 days of a loss of well control incident. It is important to note that the volume of a very large oil spill estimated from a loss of well control event at Burger J is within the range analyzed in the Sale 193 FSEIS for both BOEM's and Shell's WCD scenario.

BOEM determined that the low-probability, very large oil spill scenario and conclusions with respect to the effects analysis provided in the Sale 193 FSEIS remain valid. That analysis is sufficient to inform the decision maker of the effects of a low-probability, very large oil spill in the vicinity of the Proposed Action. In addition, the use of a capping stack and containment system could limit further the amount of oil reaching the sea surface and spreading

# A-4. Historical and Modeled Oil Spill Information

The following sections review the historical and modeled information on crude and condensate spills from exploration operations and well-control incidents during all drilling operations. The historical oil spill and model data indicate it is unlikely a large or very large oil spill will result from a well-control incident during drilling or other exploration operations. The Arctic OCS historical oil spill data indicate a small refined spill is likely to occur during exploration operations.

## 4.1 Historical Refined and Crude Spills from Exploration Operations on the Beaufort and Chukchi Outer Continental Shelf and Canadian Beaufort

BOEM estimates the chance of a large (≥1,000 bbl) oil spill from OCS exploratory activities to be very low. On the Beaufort Sea and Chukchi Sea OCS, the oil industry drilled 35 exploratory wells from 1981-2003. During the time of this exploratory drilling, industry has had 35 small spills totaling 26.7 bbl or 1,120 gallons (gal). Of the 26.7 bbl spilled, approximately 24 bbl (90%) were recovered or cleaned up. Table A-4 shows the exploration spills on the Beaufort Sea and Chukchi Sea OCS. All the explorations spills on the Beaufort Sea and Chukchi Sea OCS have been small, with the largest spill approximately 20 bbl. OCS spill data shows that 99.7% of all spills on the OCS are < 50 bbl in size (Anderson and LaBelle 2000, Table 13). Based on the historical OCS spill data and Arctic OCS exploration spill data, small spills of diesel, refined fuel, or crude oil may occur. Shell estimates a small spill size of 48 bbl for a transfer of diesel fuel during refueling operations in their potential discharge estimates. BOEM estimates a small

**Table A-4. Exploration Spills on the Beaufort Sea and Chukchi Sea OCS (1981-2003).**

| Lease No. | Sale Area | Operator | Date | Facility | Oil | Amt. (Gal) | Cause of Spill | Response Action | Rec. (gal) |
|---|---|---|---|---|---|---|---|---|---|
| 0344 | 71 | Sohio | 7/22/1981 | Mukluk Island | Diesel | 0.50 | Leaking line on portable fuel trailer | Sorbents used to remove spill. Contaminated gravel removed. | 0.05 |
| 0344 | 71 | Sohio | 7/22/1981 | Mukluk Island | Diesel | 1.00 | Overfilled fuel tank on equipment | Sorbents used to remove spill. Contaminated gravel removed. | 1.00 |
| 0280 | 71 | Exxon | 8/7/1981 | Beaufort Sea I | Hydraulic Fluid | 1.00 | Broken hydraulic line on ditch witch. | Fluid picked up with shovels. | 1.00 |
| 0280 | 71 | Exxon | 8/8/1981 | Beaufort Sea I | Trans. Fluid | 0.25 | Overfilling of transmission fluid. | Fluid picked up and placed in plastic bags. | 0.25 |
| 0280 | 71 | Exxon | 1/11/1982 | Beaufort Sea I | Hydraulic Fluid | 0.50 | Broken hydraulic line. | Fluid picked up and stored in plastic bags. | 0.50 |
| 0280 | 71 | Exxon | 1/11/1982 | Alaska Beaufort Sea I | Diesel | 3.00 | Overfilled catco 90-3 tank. | Fluid picked up. | 3.00 |
| 0280 | 71 | Exxon | 1/17/1982 | Beaufort Sea I | Diesel | 1.00 | Tank on catco 90-14 overfilled. | Fluid picked up and stored in plastic bags. | 1.00 |
| 0280 | 71 | Exxon | 1/21/1982 | Beaufort Sea I | Hydraulic Fluid | 0.25 | Broken hydraulic line on ditch witch. | Fluid picked up. | 0.25 |
| 0371 | 71 | Amoco | 3/16/1982 | Sandpiper Gravel Island | Unknown | 1.00 | Seeping from Gravel Island. | Sorbent pads. | Unknown |
| 0849 | 87 | Union Oil | 9/4/1982 | Canmar Explorer II | Unknown | 1.00 | Transfer of test tank from drillship to barge. | None | None |
| 0871 | 87 | Shell Western | 9/5/1982 | Canmar Explorer II | Light Oil | 0.50 | Washing down cement unit, drains not plumbed to oil/water separator. | None | None |
| N/A | 87 | Shell | 9/14/1982 | Canmar II Drillship | Diesel | 30.00 | Tank vent overflowed during fuel transfer. | Deployed sorbent pads and pump. | 30.00 |
| 0191 | BF | Exxon | 11/11/1982 | Beechey Pt. Gravel Is. | Lube Oil | 1.00 | Loader tipped over lube oil drum | Oil cleaned up with sorbents. Contaminated gravel removed | 1.00 |
| 0191 | BF | Exxon | 1/15/1983 | Beechey Pt. Gravel Is. | Diesel | 0.12 | Fuel truck spilled diesel as it climbed a 40 degree ramp to island | Sorbents used and contaminated gravel removed | 0.12 |
| 0191 | BF | Exxon | 1/23/1983 | Beechey Pt. Gravel Is. | Hydraulic Fluid | 2.50 | Hydraulic line on backhoe broke | 1 gallon in water. Boom deployed with sorbents, Contaminated gravel removed | 2.50 |
| 0191 | BF | Exxon | 8/29/1983 | Beechey Pt. Gravel Is. | Hydraulic Fluid | 0.20 | Hydraulic line on backhoe broke | Spill contained on island surface. Sorbents used and contaminated gravel removed. | 0.25 |
| 0196 | BF | Shell | 8/30/1983 | Ice Road to Tern Island | Hydraulic Fluid | 10.0 | Broken hydraulic line on rollogon | Unknown | Unknown |
| 0191 | BF | Exxon | 2/26/1985 | Beechey Pt. Gravel Is. | Hydraulic Fluid | 0.37 | Hydraulic line broke | Contaminated Snow Removed | 0.37 |

| Lease No. | Sale Area | Operator | Date | Facility | Oil | Amt. (Gal) | Cause of Spill | Response Action | Rec. (gal) |
|---|---|---|---|---|---|---|---|---|---|
| 0196 | BF | Shell | 3/1/1985 | Ice Road to Tern Island | Hydraulic Fluid | 3.00 | Hydraulic line broke | Unknown | 3.00 |
| 0191 | BF | Exxon | 3/2/1985 | Beechey Pt. Gravel Is. | Gasoline | 0.01 | Operational Spill | Snow shoved into plastic bag. | 0.01 |
| 0191 | BF | Exxon | 3/4/1985 | Beechey Pt. Gravel Is. | Waste Oil | 2.00 | Drum of waste oil punctured | Snow recovered | 2.00 |
| 0196 | BF | Shell | 3/4/1985 | Tern Gravel Island | Crude Oil | 1.00 | Well Separator overflowed, crude oil escaped | Line boom deployed | Unknown |
| 0196 | BF | Shell | 3/6/1985 | Tern Gravel Island | Crude Oil | 15.00 | Test burner was operating poorly | Containment Boom deployed | Unknown |
| 0196 | BF | Shell | 9/24/1985 | Tern Gravel Island | Crude Oil | 2.00 | Oil released from steam heat coil when Halliburton tank moved | Sorbents and hand shovel used | 2.00 |
| 0191 | BF | Shell | 10/4/1985 | Enroute to Tern Gravel Island | Jet fuel B | 800.00 | Wire sling broke during helicopter transport of fuel blivits | Contaminated Snow Removed. Test holes drilled with no fuel below snow. | Unknown |
| 0196 | BF | Shell | 10/29/1985 | Tern Gravel Island | Crude Oil | 2.00 | Test oil burner malfunction | Contaminated snow removed | 2.00 |
| 0196 | BF | Shell | 6/27/1986 | Tern Gravel Island | Crude Oil | 3.00 | Test oil burner malfunction | Spray picked up with sorbents. Bladed up dirty snow. | 2.00 |
| 0943 | 87 | Tenneco | 1/24/1988 | SSDC/MAT | Gear oil | 220.0 | Helicopter sling failure during transfer of drums to SSDC | Scooped up contaminated snow and ice | 220.0 |
| 1482 | 109 | SWEPI | 7/7/1989 | Explorer III Drillship | Hydraulic fluid | 10.0 | Hydraulic line connector | Sorbent pads | 0.84 |
| 1092 | 97 | AMOCO | 10/1/1991 | CANMAR Explorer | Hydraulic fluid | 2.00 | Hydraulic line rupture | None | None |
| 0865 | 87 | ARCO | 7/24/1993 | Beaudril Kulluk | Diesel | 0.06 | Residual fuel in bilge water | None | None |
| 0866 | 87 | ARCO | 9/8/1993 | CANMAR Kulluk | Hydraulic fluid | 1.26 | Seal on shale shaker failed | None | None |
| 0866 | 87 | ARCO | 9/24/1993 | CANMAR Kulluk | Fuel | 4.00 | Fuel transfer in rough weather | 3 gallons on deck of barge recovered, none in sea | 3.00 |
| 1597 | 124 | ARCO | 10/31/1993 | CANMAR Kulluk | Fuel | 0.50 | Released during emptying of disposal caisson | None | None |
| 1585 | 124 | BP Alaska | 1/20/1997 | Ice Road to Tern Island | Diesel, Hydraulic Fluid | 10.5 | Truck went through ice; fuel line ruptured | Scooped up contaminated snow and ice. Some product entered water | Unknown |

Source: USDOI, BOEM 2011. Note: No exploration drilling activities after 2003, rec. = recovered.

spill is likely and is a reasonably foreseeable scenario during exploratory drilling in the Chukchi Sea. The historical data shows small spills often are into containment or contained on vessels, platforms, facilities, or gravel islands, or onto ice, and may be cleaned up.

Table A-4 shows no large exploration spills occurred on the Beaufort Sea and Chukchi Sea OCS from 1981-2003. One large exploration spill occurred in the Canadian Beaufort Sea from an exploration well site, when the island eroded during a storm and a facility fuel tank was damaged, spilling approximately 2,440 bbl of diesel P-50 fuel oil (Hart Crowser, 2000). Diesel tanks used in Alternative 2-The Proposed Action and Alternative 3- One Well per Season are internal to the drillship and erosion would not be a causal factor for a large oil spill. If the internal diesel fuel tanks on the ship failed or leaked, it is unlikely a large spill would reach water.

## 4.2 Historical Crude and Condensate Oil Spills from Well-Control Incidents on the OCS and Alaska North Slope

The Gulf of Mexico, Pacific and Alaska OCS data show that a large/very large spill likely would not result from a well-control incident. BOEM considers well-control incidents that result in pollution to the environment to be very unlikely events. Well-control-incident events often are equated with very large oil spills because these spills receive media attention. However, in the last 39 years very few OCS well-control-incident events have resulted in spilled oil, and the volumes spilled often are small with the exception of the *Deepwater Horizon*. Five OCS well-control-incident events ≥1,000 bbl occurred between 1964 and 1970 and a sixth, the Macondo Well 252 (hereafter called the Deepwater Horizon event) occurred in 2010 in the Gulf of Mexico (Table A-5). Following the Santa Barbara well-control incident in 1969 and two large well control incidents in 1970 in the Gulf of Mexico

OCS, amendments to the OCS Lands Act and implementing regulations significantly strengthened safety, inspection, and pollution-prevention requirements for OCS offshore activities. Well-control training, redundant pollution-prevention equipment, subsurface safety devices and regular inspections were among the provisions adopted in the regulatory program (Visser, 2011). The year 1971 is considered reflective of the modern OCS regulatory environment. For 39 years no OCS well control incidents resulted in a large or very large oil spill. In 2010 and 2011 new regulations were again implemented to significantly strengthen safety, inspection, and pollution-prevention requirements for OCS offshore activities after the Deepwater Horizon event. These new regulations are discussed in USDOI, BOEM (2011, pages 4-90 - 4-99).

### 4.2.1 OCS Well Control Incident Rates

This section updates information in the 2009 Chukchi Sea EA Appendix A, Section A.1.c which discussed OCS well control incidents from 1971-2009 (USDOI, MMS, 2009). The year 1971 is considered reflective of the modern OCS regulatory environment. The term “loss of well control” was first defined in the 2006 update to the incident reporting regulations (30 CFR 250.188). Prior to this 2006 update, the incident reporting regulations included the requirement to report all blowouts, and the term blowout was undefined. Three relevant data sets are considered: (1) all well control incidents from 1971-2009 prior to the Deepwater Horizon event to update the 2009 Chukchi Sea EA baseline, then (2) well control incident rates from exploration and development drilling including the Deepwater Horizon event, and finally (3) oil spills associated with well control incidents from exploration drilling including the Deepwater Horizon event (USDOI, BOEMRE, AIB, 2011).

**Table A-5. Number of well control incidents with pollution per year in the Gulf of Mexico and Pacific OCS Regions and total OCS wells.**

| | | | Condensate/Crude Oil Spilled (Barrels) | | | Product-ion | Drilling | | | | Workover/ Completion | Well Type | Well Type | Wells Drilled |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Total Number of Incidents | Incidents with Condensate/ Crude Oil | Production, Workover, Completion, P&A | Drilling | Total Exploration and Development | Total | Total | Exploration | Development | Unknown | Total | Development | Exploration | Total |
| 1956 | 1 | 0 | — | — | 0 | — | 1 | — | 1 | 0 | — | 204 | 46 | 258 |
| 1957 | 1 | 0 | — | — | 0 | — | 1 | — | 1 | 0 | — | 333 | 58 | 391 |
| 1958 | 2 | 1 | 0.9 | — | 0.9 | — | 1 | 1 | — | 0 | 1 | 210 | 65 | 275 |
| 1959 | 1 | 0 | — | — | 0 | — | 1 | — | 1 | 0 | — | 229 | 96 | 325 |
| 1960 | 2 | 0 | — | — | 0 | 1 | 1 | 1 | — | 0 | — | 290 | 138 | 428 |
| 1961 | 0 | 0 | — | — | 0 | — | — | — | — | 0 | — | 351 | 133 | 484 |
| 1962 | 1 | 0 | — | — | 0 | — | 1 | — | 1 | 0 | — | 385 | 159 | 544 |
| 1963 | 1 | 0 | — | — | 0 | — | 1 | 1 | — | 0 | — | 400 | 209 | 609 |
| 1964 | 7 | 3 | 10,280 | 100 | 10,380 | 4 | 3 | 2 | 1 | 0 | — | 507 | 234 | 742 |
| 1965 | 5 | 2 | 0.9 | 1688 | 1,688.9 | 1 | 4 | 1 | 3 | 0 | — | 648 | 194 | 842 |
| 1966 | 2 | 2 | 0.9 | 0.9 | 1.8 | — | 1 | — | 1 | 0 | 1 | 628 | 299 | 973 |
| 1967 | 2 | 1 | 0.9 | — | 0.9 | 0 | — | — | — | — | 2 | 638 | 321 | 988 |
| 1968 | 8 | 0 | — | — | 0 | 1 | 6 | 2 | 4 | — | 1 | 735 | 358 | 1094 |
| 1969 | 3 | 3 | — | 82,500.9 | 82,500.9 | 0 | 3 | 1 | 2 | 0 | — | 731 | 254 | 993 |
| 1970 | 3 | 2 | 118,000.0 | — | 118,000.0 | 1 | 1 | — | 1 | 0 | 1 | 756 | 248 | 1006 |
| **1956-1970** | 39 | 14 | 128,283.60 | 84,289.80 | 212,573.40 | 8 | 25 | 9 | 16 | 0 | 6 | 7,045 | 2,812 | 9,952 |
| **Major Regulatory Changes to Outer Continental Shelf Lands Act** | | | | | | | | | | | | | | |
| 1971 | 6 | 2 | 460 | — | 460 | 2 | 2 | 1 | 1 | 0 | 2 | 620 | 285 | 909 |
| 1972 | 6 | 2 | 2 | 0.9 | 2.9 | 1 | 4 | 2 | 2 | — | 1 | 608 | 309 | 917 |
| 1973 | 3 | 1 | | 0.9 | 0.9 | 0 | 3 | 2 | 1 | — | — | 569 | 321 | 890 |
| 1974 | 6 | 2 | 275 | — | 275 | 2 | 2 | 1 | 1 | — | 2 | 512 | 355 | 869 |
| 1975 | 7 | 1 | 0.9 | — | 0.9 | — | 5 | 4 | 1 | — | 2 | 569 | 334 | 904 |
| 1976 | 6 | 0 | — | — | 0 | 1 | 5 | 1 | 4 | — | — | 851 | 317 | 1169 |

| | | | Condensate/Crude Oil Spilled (Barrels) | | | Product-ion | Drilling | | | | Workover/ Completion | Well Type | Well Type | Wells Drilled |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Total Number of Incidents | Incidents with Condensate/ Crude Oil | Production, Workover, Completion, P&A | Drilling | Total Exploration and Development | Total | Total | Exploration | Development | Unknown | Total | Development | Exploration | Total |
| 1977 | 10 | 1 | 2 | — | 2 | 1 | 4 | 3 | 1 | — | 5 | 975 | 398 | 1373 |
| 1978 | 12 | 1 | 0.9 | — | 0.9 | — | 8 | 4 | 4 | — | 4 | 935 | 361 | 1298 |
| 1979 | 5 | 2 | | 1.8 | 1.8 | — | 5 | 4 | 1 | — | — | 895 | 420 | 1316 |
| 1980 | 8 | 1 | 1 | — | 1 | 2 | 4 | 3 | 1 | — | 2 | 943 | 412 | 1356 |
| 1981 | 10 | 5 | 66.7 | 0.9 | 67.6 | 1 | 3 | 1 | 2 | — | 6 | 1012 | 400 | 1412 |
| 1982 | 9 | 2 | 1.8 | — | 1.8 | — | 5 | 1 | 4 | — | 4 | 970 | 457 | 1427 |
| 1983 | 12 | 1 | — | 2 | 2 | — | 10 | 5 | 5 | — | 2 | 872 | 458 | 1330 |
| 1984 | 5 | 0 | — | — | 0 | — | 4 | 3 | 1 | — | 1 | 862 | 663 | 1525 |
| 1985 | 6 | 1 | 50 | — | 50 | 0 | 4 | 3 | 1 | — | 2 | 783 | 574 | 1361 |
| 1986 | 2 | 0 | — | — | 0 | — | 1 | — | 1 | — | 1 | 517 | 296 | 813 |
| 1987 | 8 | 2 | 61 | — | 61 | 3 | 2 | 2 | — | — | 3 | 534 | 439 | 973 |
| 1988 | 4 | 1 | 4.5 | — | 4.5 | 1 | 2 | 1 | 1 | — | 1 | 510 | 584 | 1094 |
| 1989 | 12 | 0 | — | — | 0 | 3 | 7 | 4 | 3 | 0 | 2 | 572 | 489 | 1061 |
| 1990 | 7 | 3 | 17.5 | — | 17.5 | 0 | 3 | 1 | 1 | 1 | 4 | 638 | 521 | 1159 |
| 1991 | 8 | 1 | — | 0.8 | 0.8 | — | 6 | 3 | 3 | 0 | 2 | 483 | 350 | 833 |
| 1992 | 3 | 1 | — | 100 | 100 | — | 3 | 3 | — | — | — | 376 | 229 | 605 |
| 1993 | 4 | 0 | — | — | 0 | — | 4 | 1 | 3 | — | — | 645 | 365 | 1010 |
| 1994 | 1 | 0 | — | — | 0 | — | — | — | — | — | 1 | 686 | 438 | 1124 |
| 1995 | 1 | 0 | — | — | 0 | — | 1 | 0 | 1 | — | — | 784 | 395 | 1179 |
| 1996 | 4 | 0 | — | — | 0 | — | 2 | 1 | 1 | — | 2 | 805 | 462 | 1267 |
| 1997 | 5 | 0 | — | — | 0 | — | 4 | 1 | 3 | — | 1 | 932 | 549 | 1481 |
| 1998 | 9 | 3 | 2.6 | 1.62 | 4.22 | 3 | 3 | 2 | 1 | — | 3 | 665 | 495 | 1161 |
| 1999 | 5 | 1 | 125 | — | 125 | — | 3 | 1 | 2 | — | 2 | 676 | 371 | 1048 |
| 2000 | 9 | 3 | 0.02 | 200.5 | 200.52 | — | 8 | 6 | 2 | — | 1 | 950 | 443 | 1396 |
| 2001 | 10 | 1 | 1 | — | 1 | 2 | 5 | 2 | 3 | — | 3 | 867 | 411 | 1278 |
| 2002 | 6 | 3 | 350.505 | — | 350.505 | 2 | 3 | 1 | 2 | | 1 | 654 | 310 | 964 |
| 2003 | 5 | 1 | 10 | — | 10 | 2 | 2 | 0 | 1 | 1 | 1 | 557 | 354 | 911 |
| 2004 | 6 | 4 | 2.5 | 22.06 | 24.56 | 1 | 3 | 3 | — | — | 2 | 569 | 363 | 932 |
| 2005 | 4 | 0 | — | — | 0 | — | 4 | 1 | 3 | — | — | 482 | 355 | 841 |
| 2006 | 2 | 2 | 10 | 24.5 | 34.5 | — | 1 | 1 | — | — | 1 | 375 | 414 | 789 |
| 2007 | 8 | — | — | — | — | 2 | 2 | 2 | | | 4 | 328 | 300 | 630 |
| 2008 | 9 | 0 | — | — | 0 | 3 | 4 | 1 | 3 | | 2 | 304 | 267 | 571 |
| 2009 | 6 | 2 | 27.94 | — | 27.94 | 1 | 1 | 1 | | | 4 | 179 | 147 | 338 |
| 2010 | 4 | 1 | — | TBD | TBD | 3 | 1 | 1 | | | 0 | 181 | 80 | 267 |
| **1971-2010*** | **253** | **51** | **1,472.87** | **355.98** | **1,828.85** | **36** | **143** | **77** | **64** | **2** | **74** | **26,245** | **15,491** | **41,781** |

Notes: Wells drilled columns include hydrocarbon, sulfur and salt wells. The total column includes core tests and relief wells in addition to exploration and development wells; therefore the total column may be slightly higher than the sum of the development and exploration wells columns for some years.

TBD - the final volume for the Deepwater Horizon that occurred on 4/20/2010 has not been determined by BOEM.

The 1971-2010 spill volume totals for the columns showing Drilling and Total Exploration and Development do not include the volume for the Deepwater Horizon incident that occurred on 4/20/2010.

### Exploratory and Development/Production Operations From 1971-2009

There were 249 well control incidents during exploratory and development/production operations on the OCS (this includes incidents associated with exploratory and development drilling, completion, workover, plug and abandon, and production operations). During this period, 41,514 wells were drilled on the OCS and 15.978 billion barrels (Bbbl) of oil were produced. Of the 249 well control incidents that occurred during this period, 50 (20%) resulted in the spillage of condensate/crude oil ranging from <1 bbl to 450 bbls. The total spilled from these 50 incidents was 1,829 bbls. This volume spilled was approximately 0.000011447% of the volume produced during this period.

In 2010, four well control incidents occurred, including the Deepwater Horizon event. Although a final spillage volume from the Deepwater Horizon event has not been determined by BOEM, the current government estimate from Lubchenco et al. (2010) is 4.9 million bbls. The three other well control incidents that occurred in 2010 did not result in the spillage of condensate/crude oil.

#### Development and Exploration Well Drilling From 1971-2010

There were a total of 41,781 wells drilled in the OCS comprising of 40,565 wells in the Gulf of Mexico, 1,086 wells in the Pacific Region, 46 wells in the Atlantic Region and 84 wells in the Alaska Region. Of these, 26,245 were development wells, 15,491 were exploration wells and 43 were core tests or relief wells. The overall drilling well control incident rate is 1 well control incident per 292 wells drilled, compared to 1 well control incident per 410 development wells drilled, and 1 well control incident per 201exploration wells drilled. These well control incident rates include all well control incidents related to drilling operations whether they spilled oil or not.

#### Exploration Well Drilling From 1971-2010

Industry has drilled 223 exploration wells in the Pacific OCS, 46 in the Atlantic OCS, 15,138 in the Gulf of Mexico OCS, and 84 in the Alaska OCS, for a total of 15,491 exploration wells. During this period, there were 77 well control incidents associated with exploration drilling. Of those 77 well control incidents, 14 (18%) resulted in crude, condensate and oil in drilling mud spills ranging from 0.5 bbl to 200 bbls, for a total 354 bbls, excluding the estimated volume from the Deepwater Horizon event. From 1971-2010 one well control incident resulted in a spill volume of 1,000 bbls or more and that was the Deepwater Horizon event.

### 4.2.2 OCS and North Sea Well Control Incident Duration

This section summarizes information from well-control incidents that occurred during drilling from 1992 through 2006 on the OCS and includes all well-control incidents from drilling, even if no pollution occurred to the environment (Izon, Danenberger, and Mayes, 2007). Overall, the 1992-2006 period saw an improvement (decrease) in well-control-incident duration. Like the previous study (Danenberger, 1993), a significant number of well-control-incident events were of short duration. During the current study, 49% of the well-control incidents stopped flowing in 24 hours or less, compared with 57% during the previous study. In the current study, 41% lasted between 1 and 7 days, compared with 26% during the previous study. There were fewer well-control incidents that lasted more than 7 days. The well-control incident with the longest duration during the current study period was 11 days, compared with more than 30 days in the previous period (Izon, Danenberger, and Mayes, 2007).

The SINTEF blowout database was used to plot the duration of offshore blowouts in the U.S. and North Sea from 1980-2003. Ninety-six percent of offshore blowouts were 30 days or less in duration and 84% were 5 days or less in duration (Shell, 2011c).

### 4.2.3 Alaska North Slope Well Control Incident Information

The blowout record for the Alaska North Slope remains the same as reported previously in USDOI, MMS (2003) and summarized herein. Of the 10 blowouts, 9 were gas and 1 was oil. The oil blowout in 1950 resulted from drilling practices that are no longer used. A third study confirmed that no crude oil spills ≥100 bbl from blowouts occurred from 1985-1999 (Hart Crowser, Inc., 2000). The remaining blowouts released dry gas or gas condensate only, resulting in minimum environmental impact (NRC, 2003).

Scandpower (2001) used statistical blowout frequencies modified to reflect specific field conditions and operative systems at Northstar in the Beaufort Sea. This report concludes that the blowout frequency for drilling the oil-bearing zone is $1.5 \times 10^{-5}$ per well drilled (all wells). This compares to a statistical blowout frequency of $7.4 \times 10^{-5}$ per well (for an average development well). This same report estimates that the frequency of oil quantities per well drilled for Northstar for a spill >130,000 bbl is $9.4 \times 10^{-7}$ per well.

## 4.3 Historical Exploration Well-Control Incidents on the OCS and Canadian Beaufort

Thirty-five (35) exploration wells were drilled between 1981 and 2003 in the U.S. Chukchi and Beaufort seas. Historically, no exploration drilling blowouts occurred as a result of Chukchi Sea and Beaufort Sea OCS exploration drilling, nor have any occurred from the approximately 84 exploration and 14 deep stratigraphic test wells drilled within the Alaska OCS.

One exploration drilling blowout of gas has occurred on the Canadian Beaufort. Up to 1990, 85 exploratory wells were drilled in the Canadian Beaufort Sea, and one shallow-gas blowout occurred. A second incident was not included at the Amaluligak wellsite with the Molikpaq drill platform. This resulted in a gas flow through the diverter, with some leakage around the flange. The incident does not qualify as a blowout by the definition used in other databases and, therefore, was excluded (Devon Canada Corporation, 2004).

From 1971-2010 industry has drilled approximately 223 exploration wells in the Pacific OCS, 46 in the Atlantic OCS, 15,138 in the Gulf of Mexico OCS, and 84 in the Alaska OCS, for a total of 15,491 exploration wells. From 1971-2010, there were 77 well-control incidents associated with exploration drilling. Of those 77 well-control incidents, 14 resulted in spills of (1)drilling mud with oil or synthetic oil, (2) crude or (3) condensate. With the exception of the Deepwater Horizon event of 4.9 million barrels, spill sizes ranged from 0.5 bbl to 200 bbl (Table A-5). One OCS spill (large/very large) occurred from 1971-2010 during temporary abandonment of an exploration well. In summary, out of the more than 15,000 exploration wells drilled, one crude oil spill (large/very large) occurred during temporary abandonment and 13 small spills resulted in drilling mud oil, crude or condensate reaching the environment from well-control incidents during exploration drilling (Table A-5).

## 4.4 Fault Tree Model Exploration Well-Control Incident Frequencies

Bercha (2006, 2008) developed an oil-spill occurrence fault-tree model to estimate the oil-spill rates associated with exploration, development and production for Arctic OCS locations. The information from Bercha (2006) was used in the USDOI MMS (2007) oil-spill analyses in the Chukchi Sea which estimated approximately 1/2 of a large spill (≥1,000 bbl) over the 40 year exploration and development life of the lease sale which included drilling 3-6 exploration and 4-8 delineation wells. The majority of the fractional mean spill estimate was from the development phase.

Because limited historical spill data for the Arctic exist, Bercha incorporated Gulf of Mexico and Pacific OCS and North Sea data and modified the existing base data using fault trees to arrive at oil-spill frequencies for future exploration, development, and production scenarios. For offshore exploration drilling, Bercha (2006, 2008) used historical oil well blowout statistics derived from Holand (1997) for non-Arctic drilling operations and Scandpower's (2001) blowout frequency assessment for Northstar to estimate the expected size and frequency distribution of spills. Bercha reported the historical spill frequency for non-Arctic exploration well drilling as $3.42 \times 10^{-4}$ per well for a blowout ≥150,000 bbl (23,848 $m^3$).

Where historical statistics are limited, it is possible to add variability in the fault tree, through a Monte Carlo simulation, to reduce the uncertainty in the fault tree analysis. To model the historical data variability for Arctic exploration well blowouts, Bercha applied a numerical simulation approach to develop the probability distribution for blowouts of 150,000 bbl (23,848 $m^3$) or greater, and arrived at a frequency ranging from a low of $1.5 \times 10^{-4}$ per well to a high of $6.97 \times 10^{-4}$ per well. The expected value for a blowout of this size was computed to be $3.94 \times 10^{-4}$ per well (Bercha 2008). To address causal factors associated with blowouts, Bercha applied adjustments for improvements to logistics support and drilling contractor qualifications that resulted in lower predicted frequencies for

Arctic drilling operations. No fault-tree analysis or unique Arctic effects were applied as a modification to existing spill causes for exploration, development, or production drilling frequency distributions. For exploration wells drilled in analogous water depths to planned Chukchi Sea wells (30-60 m), Bercha (2008) estimated the adjusted expected value frequency is 6.12 per $10^{-4}$ per well for a blowout sized between 10,000 bbl (1,590 $m^3$) and 149,000 bbl (23,689 m3), and 3.54 x $10^{-4}$ per well for a blowout >150,000 bbl (23,848 $m^3$).

The adjusted frequencies discussed above were applied in a fault tree model to estimate the rate of large and very large oil spills. Both the historical non-Arctic frequency distributions and spill causal distributions were modified to reflect specific effects of the Arctic setting, and the resultant fault tree model was evaluated using Monte Carlo simulation to adequately characterize uncertainties treated as probability distribution inputs (described above) to the fault tree. Using the spill rates derived from the fault tree analysis BOEM estimated approximately 1/2 of a large spill over the 40 year exploration and development life of a lease sale.

## 4.5 Historical Worldwide Well Control Incident Spills ≥150,000 Barrels

Very large spills (≥150,000 bbl) happen very infrequently, and there are limited data for use in BOEM's statistical analysis and predictive efforts. The chance of a very large spill occurring is very low. Five of the six well control-incident events ≥1,000 bbl in the OCS database occurred between 1964 and 1970 (Table A-5). The sixth OCS well control incident resulting in a large spill was the Deepwater Horizon event. Although no official volume has been determined by BOEM or BSEE it is clear from the spill volume estimates that the Deepwater Horizon exceeds the threshold of a VLOS. The current estimate is 4.9 million bbls and is greater than the 150,000 barrel threshold for a VLOS (Lubchenco et al. 2010; McNutt et al. 2011).

Internationally, from 1965 through 2010, seven offshore oil well control incidents, resulting in an oil spill of greater than or equal to 150,000 bbl, were identified from the peer reviewed or "gray" literature (Table A-6). One of the well control incidents was the result of military action. There were roughly 1.066 trillion barrels of oil produced worldwide from 1965–2010 (British Petroleum, 2011). BOEM compares numbers of very large oil spills to overall production because the number of exploration wells worldwide is not publically and readily available. Using the 6 very large oil spills which were not a result of war, these data provide an approximate rate of about 1 very large offshore oil spill worldwide for approximately every 180 Bbbl of oil produced. Using international data increases the size of the data set and is more likely to capture rare events. However, it assumes that non-US events are relevant to US events to the extent that technology, maintenance, operational standards and other factors are equal. However, this is not likely to be the case (especially in cases of military action).

**Table A-6. Historical Very Large Oil Spills from Offshore Well Control Incidents 1965-2010.**

| Name | Company | Spill Source | Activity | Location | Oil | Begin | End | Duration (Days) | Bbls | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Deep Water Horizon/ Macondo MC 252 | BP | Expl. Well | Temporary Abandonment | U.S. OCS, Gulf of Mexico | Crude | 4/20/ 2010 | 7/15/ 2010 | 87 | 4,900,000 | McNutt et al. 2011. National Oil Spill Commission 2011. |
| Ixtoc | PEMEX | Expl. Well | Drilling | Mexico, Gulf of Mexico | Crude | 6/3/ 1979 | 3/23/ 1980 | 295 | 3,500,000 | OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992. |
| Dubai | | Dev. Well | Drilling | | | 1973 | | | 2,000,000 | Gulf Canada Resources Inc. 1982 |

| Name | Company | Spill Source | Activity | Location | Oil | Begin | End | Duration (Days) | Bbls | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| Nowruz Oil Field No. 3 Well* | Iranian Offshore Oil | Platform | Production | Iran, Persian Gulf | Crude | 2/4/ 1983 | 9/18/ 1983 | 224 | 1,904,762 | OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992. |
| Abkatun 91 | PEMEX | Prod. Well | Workover | Mexico, Gulf of Mexico, Bay of Campeche | Crude | 10/ 23/ 1986 | | 15 | 247,000 | OSIR, 1998; Etkin, 2009; Fingas, 2000; |
| Ekofisk Bravo Platform B14 | Phillips Petroleum | Prod. Well | Workover | Norway, North Sea, Ekofisk Oil Field | Crude | 4/22/ 1977 | 4/30/ 1977 | 8 | 202,381 | OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992. |
| Funiwa No. 5 Well | Nigerian National Petroleum | Prod. Well | Drilling | Nigeria, Niger Delta/ Atlantic Ocean | Crude | 1/17/ 1980 | 2/1/ 1980 | 14 | 200,000 | OSIR, 1998; Etkin, 2009; Fingas, 2000; USDOC, NOAA, 1992. |

Note: * Military attack-related events; cells with no data means the information is not readily available in the open literature.

Source: USDOI, BOEM, (2011) compiled from cited references

# A-5. Oil-Spill Analysis Framework

There are three potential size categories of oil spills in connection with exploratory operations in Alternative 2-The Proposed Action and Alternative 3-One Well per Season: (1) a large spill (≥1,000 bbl) from exploration operations; (2) a very large spill (≥150,000 bbl) from a well-control incident; and (3) a small spill (<1,000 bbl) from exploration operations. Historical and modeling oil spill data demonstrates that the frequency of a large spill occurring during exploration is low and, therefore, this EA does not analyze the impacts of large spills from exploration operations. The occurrence of a very large spill resulting from a well-control incident is similarly very low. Nonetheless, this EA tiers to BOEM's prior analyses of the impacts of a large and very large oil spill in the Sale 193 FEIS and SFEIS. See further discussion in Section 4.0 of this EA. It is likely a small spill could occur during exploration operations and the oil spill analysis scenario further includes small oil spill factors.

## 5.1 Small Oil Spills

This section provides the small oil spill analysis framework used for the determination of impacts in Section 4.0 of this EA for Alternative 2-The Proposed Action and Alternative 3- One Well per Season. Historical Beaufort Sea and Chukchi Sea OCS exploration spill data, discussed in Section 1.3.1, suggest that the most likely cause of an oil spill during exploration could be operational, such as a hose rupture, and the spill could be relatively small. For purposes of analysis, a 48-bbl diesel fuel-transfer spill was chosen as the spill volume in the small category. This was based on historical spill size in the Beaufort and Chukchi OCS and OCS oil-spill analysis which indicated 99.7% of all OCS spills are <50 bbl (Anderson and LaBelle, 2000). The spill is estimated to last less than 3 days on the surface of the water, based on the SINTEF Oil Weathering Model calculations. In terms of timing, a small spill from the exploration activities could happen at any time from July to October. Conservatively, BOEM assumes that the vessel would not retain any of the 48 bbl of diesel fuel, and depending on the time of year, a small spill could reach the vessel and then the environment. The environment could be open water or open water and ice. The analysis of a small spill examines the weathering of the estimated 48 bbl diesel fuel spill. BOEM estimates the following fate of the diesel fuel without cleanup.

BOEM summarizes below the estimates for the fate and behavior of diesel fuel in the analysis of the effects of oil on environmental, economic and social resources in Section 4.0. BOEM outlines the scenario assumptions for a small spill to provide a consistent analysis of small oil spill impacts by resource:

- One small spill occurs.
- The spill size is 48 bbl.
- The oil type is diesel fuel.
- All the oil reaches the environment; the vessel or facility absorbs no oil.
- There is no reduction in volume due to cleanup or containment. (Pollution prevention, containment and cleanup is analyzed separately as mitigation.)
- The spill could occur at any time of the exploration operations (July–October).
- The spill weathering is as shown in Table A-7, and the spill lasts less than 3 days on the water.
- The spill starts within Launch Area 11.
- The time and chance of contact from an oil spill are calculated from an oil-spill-trajectory model
- The chance of contact is analyzed from the location where it is highest when determining effects.

### 5.1.1 Modeling Simulations of Oil Weathering

To judge the effect of a small oil spill, BOEM makes estimates regarding how much oil evaporates, how much oil is dispersed, and how much oil remains after a certain time period. BOEM derives the weathering estimates of diesel fuel oil from the SINTEF Oil Weathering Model Version 3.0 (Reed et al., 2005) modeling results for up to 30 days. Table A-7 summarizes the results BOEM estimates for the fate and behavior of a 48-bbl diesel fuel spill. BOEM's estimate is slightly more conservative than the estimate in the Shell Appendix F, EIA Table 2.10-3 which used the ADIOS model and a water temperature 2 degrees higher. Both models provide a reasonable estimated range of the fate and behavior of diesel fuel under slightly different environmental conditions. Based on modeling simulations and historical response experience, a small, 48-bbl diesel fuel oil spill will be localized and short term.

**Table A-7. Fate and Behavior of a Hypothetical 48-Barrel Diesel Fuel Oil Spill.**

| Scenario Element | Summer Spill[1] | | | | | | |
|---|---|---|---|---|---|---|---|
| Time After Spill in Hours | 1 | 2 | 3 | 6 | 12 | 24 | 48 |
| Oil Remaining (%) | 96 | 91 | 84 | 65 | 31 | 4 | 0 |
| Oil Naturally Dispersed (%) | 3 | 7 | 12 | 28 | 57 | 79 | 83 |
| Oil Evaporated (%) | 1 | 2 | 4 | 7 | 12 | 17 | 17 |
| Thickness (mm) | 0.7 | 0.5 | 0.5 | 0.3 | 0.1 | 0.1 | 0 |

Notes: Calculated with the SINTEF oil-weathering model Version3.0 of Reed et al. (2005) and assuming diesel fuel no 2.
[1] Summer (July through September), 12-knot wind speed, 2 degrees Celsius water temperature, 0.4-meter wave height.

## 5.2 Large and Very Large Accidental Oil Spills

This EA tiers to previous analyses of large and very large accidental oil spills. After the Exxon Valdez oil spill in 1989, BOEM, Alaska OCS Region analyzed very large spills in several OCS locations, two of which were in the Chukchi Sea (USDOI MMS, 1990a, b, 1991, 1995a, b, 1996, 1998, 2002, 2003a, b; USDOI, BLM and MMS, 1998, 2003; USDOI, BLM, 2005, USDOI, BOEMRE, 2011). The frequency of a very large spill (≥150,000) is very low, but its potential effects were most recently analyzed in Chukchi Sea Sale 193 FSEIS. The spill scenario was based on an initial flow rate of 61,000-bbl declining to 20,479-bbls at 74 days and totaling approximately 2.2 MMbbl. In the unlikely event of a very large accidental oil spill, the potential for major impacts exist as was identified in USDOI, BOEMRE, (2011).

The chance of a large (≥1,000 bbl) spill during exploration activities is also low, but the potential consequences were analyzed in Section IV.C. the Lease Sale 193 Final EIS (USDOI, MMS, 2007), and Section 4.5 of the Arctic Multiple-Sale Draft EIS (USDOI, MMS, 2008). Based on OCS median spill sizes, the MMS (now BOEM) estimated a 1,500-bbl diesel, condensate or crude oil spill from a facility or a 4,600-bbl crude or condensate oil spill from a pipeline for purposes of analyzing a large spill volume (Anderson and LaBelle, 2000). Updated median U.S. OCS large spill sizes are discussed below. These median large spill sizes are not statistically larger than those previously analyzed. Therefore, the conclusions of large spill analysis referenced above would not change.

In preparation for the 2012-2017 Oil and Gas Leasing Program Programmatic EIS, median large OCS spill size estimates were updated (USDOI, BOEM, 2011). During the last 15 years (1996-2010), 7 oil spills ≥1,000 bbl occurred from U.S. OCS pipelines. The median spill size was 1,720 bbl (Anderson, in preparation as cited in USDOI, BOEM 2011). During the last 15 years (1996-2010), 2 oil spills ≥1,000 bbl occurred from U.S. OCS U.S. OCS platforms/rigs. Accounting for the previous trend, the median spill size was 5,066 bbl and over the entire record was 7,000 bbl (Anderson, in preparation as cited in USDOI, BOEM 2011). For purposes of oil spill analysis in the 2012-2017 Programmatic EIS, BOEM used the estimated median spill sizes rounded to the nearest hundred barrels of a 1,700 bbl pipeline spill and a 5,100 platform spill.

The conditional probabilities estimated by the Oil-Spill Risk Analysis (OSRA) model (expressed as percent chance) of a spill ≥1,000 bbl contacting environmental resource areas or land segments within a given time frame from launch areas (LA1-13) and pipeline segments (P1-11) assuming a spill occurs are discussed in USDOI, MMS (2007, 2008). In the unlikely event of a large accidental oil spill, there is potential for major impacts as identified in previous analyses (USDOI, MMS, 2007, 2008).

## 5.3 Hydrocarbon Spill Transport and Trajectory Analysis

The previously referenced large and very large oil spill analyses considered surface releases. Subsurface releases are estimated to rise to the surface in the moderate water depths (<50m) of the drill sites in a short period of time and within 1000-2000m of the release site (Daling et al., 2003). The proposed action and one well per season area water depths are relatively shallow (<46m [Shell, 2011a: Figures 1.b-3 through 1.b-8]). A subsurface release or a surface release would be represented by LA11 for Shell exploration well locations in Alternative 2-The Proposed Action and Alternative 3-One Well per Season.

### 5.3.1 Conditional Probabilities

The summer conditional probabilities (expressed as percent chance) from LA 11 (USDOI, MMS, 2007: Tables A2-25 through A2-27. A.2-30 through A.2-33 and A.2-37 through A.2-39) were previously compared to the Shell’s 2010 lease blocks (USDOI, MMS, 2009). The conditional probabilities from LA 11 are statistically representative of the lease blocks cited in the 2010 Shell EP (USDOI, MMS, 2009) and the lease blocks in the 2012 Shell Revised Chukchi Sea EP (Johnson, 2011. per comm.). The chance of a large spill contacting, assuming a large spill occurs, is summarized specifically for the LA11 and compared to the Shell 2010 lease blocks. These conditional probabilities are representative of the lease blocks in the Revised EP and are inclusive in the conditional probability discussions in USDOI, MMS (2007) cited above. The estimated conditional probabilities do not factor in pre-booming or spill response; these are considered mitigation, and is analyzed and discussed as such in the impact sections of each resource. A successful or partially successful spill response would reduce the chance of spill contact or make contact nonexistent.

Figures 4.3-1 through 4.3-3 in the Shell Chukchi Sea EIA (Shell, 2011a: Appendix F) show the locations of Environmental Resource Areas (ERA) and Land Segments (LS) in the nearshore region with a chance of contact from LA11 greater than or equal to 0.5% during summer. Tables A.5 and A.6 summarize the chances of contact below for all land segments, grouped land segments and environmental resource areas (ERAs) from Sale 193 LA11 and Shell's 2010 Burger lease blocks with a chance of contact greater than or equal to 0.5%. Figures A.1-2 through 3, in the Sale 193 FEIS Appendix A (USDOI, MMS, 2007), show the locations of ERAs, land segments, and grouped land segments.

### Launch Area 11

**Summer 3 Days.** The OSRA model estimates the chance of a spill ≥1,000 bbl contacting ERAs 47-54 (ice/sea segments) is <0.5-3%. The chance of contacting ERA10 (Ledyard Bay Spectacled Eider Critical Habitat) is 8 %. The chance of contacting ERAs 39 and 40 (Point Lay and Wainwright Subsistence Area) is 1%. The chance of contacting ERA56 (ERA 56) is <3%. The chance of contacting ERA 36 is 34%. The chance of contacting Land or individual LSs is <0.5%. The chance of contacting any grouped land segment (GLS) is <0.5%.

**Summer 10 Days.** The OSRA model estimates the chance of a spill ≥1,000 bbl contacting ERAs 46-54 (ice/sea segments) is 6%. The chance of contacting ERA10 (Ledyard Bay Spectacled Eider Critical Habitat) is 14 %. The chance of contacting ERAs 39 and 40 (Point Lay and Wainwright Subsistence Area) is 7 and 6%, respectively. The chance of contacting ERA56 is 8%. The chance of contacting Land is 5%. The chance of contacting individual LSs is <0.5% except 73, 74 or 75 which is 1% for each. The chance of contacting ERA 36 is 40%. The chance of contacting a GLS is <0.5% except NPRA which is 1% and the United States Chukchi Coast which is 5%.

**Summer 30 Days.** The OSRA model estimates the chance of a spill ≥1,000 bbl contacting ERAs 46-54 (ice/sea segments) is <0.5-13%. The chance of contacting ERA10 (Ledyard Bay Spectacled Eider Critical Habitat) is 21 %. The chance of contacting ERAs 38, 39 and 40 (Point Hope, Point Lay and Wainwright Subsistence Area) is 1, 18, and 13%, respectively. The chance of contacting ERA56 (ERA 56) is 15%. The chance of contacting Land is 19%. The chance of contacting individual LSs is <0.5% except 71-81 which ranges from 1-3%. The chance of contacting a GLS is <0.5-4% except the United States Chukchi Coast, which is 19%.

### Comparison to Shell 2012 Blocks.

In USDOI, MMS (2009) LA11 was compared to Shells Lease Blocks (OCS-Y-2280, 2267, 2321) on the Burger prospect. The existing conditional probability information for Burger (MMS, 2009) was determined to be representative for the Shell's 2012 lease blocks (OCS-Y-2280, 2267, 2321, 2294, 2278 and 2324) on the Burger prospect (Johnson, 2011, per comm.) In general, conditional probabilities from the Shell blocks are lower for nearshore areas and higher for ERAs directly adjacent to the blocks (Tables A-8 and A-9). Launch Area 11 is representative of the conditional probabilities for these blocks (OCS-Y-2280, 2267, 2321, 2294, 2278 and 2324).

**Table A-8. Summer Conditional Probabilities (Expressed as Percent Chance) that an Oil Spill Starting at LA 11 Chukchi Sea Sale 193 or Lease Blocks 2267, 2280 and 2321 Will Contact a Certain Land Segment or Group of Land Segments Within 3, 10 or 30 Days Assuming a Spill Occurs.**

| | | LA11 | | | 2267 Burger F | | | 2280 Burger A | | | 2321 Burger J | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Land Segment Name** | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days |
| **65** | Buckland, Cape Lisburne | : | : | : | : | : | 1 | : | : | 1 | : | : | 1 |
| **71** | Kukpowruk River, Sitkok Point | : | : | 1 | : | : | : | : | : | : | : | : | : |
| **72** | Point Lay, Siksrikpak Point | : | : | 1 | : | : | : | : | : | : | : | : | : |
| **73** | Tungaich Point, Tungak Creek | : | 1 | 2 | : | : | : | : | : | : | : | : | 1 |
| **74** | Kasegaluk Lagoon, Solivik Isl. | : | 1 | 3 | : | : | : | : | : | : | : | : | : |
| **75** | Akeonik, Icy Cape | : | 1 | 3 | : | : | : | : | : | : | : | : | 2 |
| **76** | Avak Inlet, Tunalik River | : | : | 1 | : | : | : | : | : | : | : | : | : |
| **77** | Nivat Point, Nokotlek Point | : | : | 1 | : | : | : | : | : | : | : | : | 2 |
| **78** | Point Collie, Sigeakruk Point | : | : | 2 | : | : | 2 | : | : | 3 | : | 1 | 3 |
| **79** | Point Belcher, Wainwright | : | : | 2 | : | : | 4 | : | : | 4 | : | : | 3 |
| **80** | Eluksingiak Point, Kugrua Bay | : | : | 1 | : | : | 3 | : | : | 3 | : | : | 2 |
| **81** | Peard Bay, Point Franklin | : | : | 1 | : | : | 2 | : | : | 2 | : | : | 1 |
| **82** | Skull Cliff | : | : | : | : | : | 1 | : | : | : | : | : | : |
| **ID** | **Grouped Land Segment Name** | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days |
| **89** | National Petroleum Reserve Alaska | : | 1 | 4 | : | : | 6 | : | : | 6 | : | : | 7 |
| **90** | Kasegaluk Lagoon Special Use Area | : | : | 2 | : | : | 1 | : | : | 1 | : | : | 3 |
| **96** | United States Chukchi Coast | : | 5 | 19 | : | 1 | 14 | : | 1 | 16 | : | 2 | 18 |

**Notes:** ** = Greater than 99.5 percent; : = less than 0.5 percent; LA = Launch Area Rows with all values less than 0.5 percent are not shown.

**Table A-9. Summer Conditional Probabilities (Expressed as Percent Chance) that an Oil Spill Starting at LA11 Chukchi Sea Sale 193 or Lease Blocks 2267, 2280 and 2321 Will Contact a Certain Environmental Resource Area Within 3, 10 or 30 Days Assuming a Spill Occurs.**

| | | LA5 | | | LA11 | | | 2267 Burger F | | | 2280 Burger A | | | 2321 Burger J | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ID** | **Environmental Resource Area Name** | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days |
| **—** | LAND | : | : | 6 | : | 5 | 19 | : | 1 | 14 | : | 1 | 16 | : | 2 | 18 |
| **1** | Kasegaluk Lagoon | : | : | 3 | 1 | 5 | 13 | : | : | 2 | : | : | 3 | : | 1 | 8 |
| **6** | ERA 6 | : | : | 3 | : | 3 | 12 | : | 2 | 19 | : | 3 | 20 | : | 4 | 19 |
| **10** | Ledyard Bay Spectacled Eider Critical Habitat | : | 1 | 6 | 8 | 14 | 21 | : | 1 | 4 | : | 1 | 5 | : | 2 | 7 |
| **11** | Wrangel Island 12 nmi Buffer | : | : | 1 | : | : | : | : | : | : | : | : | : | : | : | : |
| **14** | Cape Thompson Seabird Colony Area | : | : | 1 | : | : | 1 | : | : | : | : | : | : | : | : | : |
| **15** | Cape Lisburne Seabird Colony Area | : | : | 2 | : | 1 | 3 | : | : | 1 | : | : | 1 | : | : | 2 |
| **18** | ERA 18 | : | : | 7 | : | : | 5 | : | : | 4 | : | : | 4 | : | : | 5 |
| **20** | Chukchi Spring Lead 2 | : | : | : | : | : | 1 | na | na | na | na | na | na | na | na | na |
| **21** | Chukchi Spring Lead 3 | : | : | : | : | 2 | 3 | na | na | na | na | na | na | na | na | na |
| **22** | Chukchi Spring Lead 4 | : | : | : | 1 | 2 | 3 | na | na | na | na | na | na | na | na | na |
| **35** | ERA 35 | : | 1 | 4 | 6 | 12 | 18 | 8 | 21 | 36 | 10 | 22 | 37 | 5 | 15 | 27 |
| **36** | ERA 36 | 6 | 13 | 22 | 34 | 40 | 46 | 11 | 23 | 35 | 17 | 29 | 40 | 67 | 71 | 76 |

| ID | Environmental Resource Area Name | LA5 | | | LA11 | | | 2267 Burger F | | | 2280 Burger A | | | 2321 Burger J | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days | 3 Days | 10 Days | 30 Days |
| 38 | Pt. Hope Subsistence Area | : | : | 1 | : | : | 1 | : | : | 1 | : | : | 1 | : | : | 1 |
| 39 | Point Lay Subsistence Area | : | : | 3 | 1 | 7 | 13 | : | : | 2 | : | : | 3 | : | 1 | 5 |
| 40 | Wainwright Subsistence Area | : | : | 4 | 1 | 6 | 18 | : | 2 | 17 | : | 2 | 20 | : | 4 | 20 |
| 45 | ERA 45 | : | : | 1 | : | : | 2 | : | : | 1 | : | : | 1 | : | : | 1 |
| 46 | Herald Shoal Polynya | : | 2 | 9 | : | : | 3 | : | : | 5 | : | : | 5 | : | : | 6 |
| 47 | Ice/Sea Segment 10 | 14 | 22 | 29 | : | 3 | 9 | : | 5 | 13 | : | 5 | 12 | : | 7 | 16 |
| 48 | Ice/Sea Segment 11 | 1 | 6 | 13 | 1 | 6 | 13 | 2 | 12 | 20 | 1 | 9 | 17 | : | 5 | 14 |
| 49 | Hanna's Shoal Polynya | : | 1 | 3 | : | : | 2 | : | : | 3 | : | : | 2 | : | : | 2 |
| 50 | Ice/Sea Segment 12 | : | : | 3 | 3 | 6 | 10 | : | 6 | 14 | : | 5 | 12 | : | 2 | 7 |
| 51 | Ice/Sea Segment 13 | : | : | 1 | : | : | 3 | 1 | 1 | 8 | 1 | 1 | 8 | : | : | 4 |
| 56 | ERA 56 | : | 2 | 6 | 3 | 8 | 15 | 3 | 14 | 30 | 1 | 12 | 27 | : | 7 | 19 |
| 64 | Peard Bay | : | : | : | : | : | 2 | : | : | 4 | : | : | 4 | : | : | 3 |
| 70 | ERA 70 | : | : | 1 | : | : | : | : | : | 1 | : | : | 1 | : | : | : |

**Notes:** ** = Greater than 99.5 percent; : = less than 0.5 percent; LA = Launch Area, na =ERA spatial location changed. Rows with all values less than 0.5 percent are not shown.

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# Appendix B

## Level of Effect Definitions

# Appendix B. Table of Contents

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# Appendix B. Level of Effect Definitions

## B-1. Introduction

This appendix defines and explains the levels of effect used in the EA to evaluate potential environmental impacts. Impacts are described in terms of frequency, duration, general scope, and/or size and intensity. Each level considers such factors as the nature of the impact, the spatial extent, recovery times, and the effects of mitigation. The terms negligible, minor, moderate, and major are used to describe the relative degree or anticipated level of effect of an action on a specific resource. Following each term listed below for a specified resource are the general characteristics used to determine the anticipated level of effect. For each term, best professional judgment was used to evaluate the best available data concerning the affected resource.

For each resource, a “significance threshold” is also provided. Adverse impacts that do not meet the significance threshold are considered “not significant.” Required mitigation measures may reduce otherwise “significant” impacts to a level of “not significant.”

The absence of a significant effect does not equate to “no effect.” As shown in the four-category scale, and in the numerous analyses that BOEM has undertaken, effects from activities can be adverse and noticeable before they reach the significance threshold. Furthermore, in the cumulative effects analysis, BOEM analyzes the combined effects of projected activities with other actions, because BOEM recognizes that effects that individually do not reach this significance threshold may exceed that significance threshold when considered collectively.

## B-2. Air Quality

The levels of effect applied to the air quality analysis are based on the results of two levels of analyses, the emission inventory, and if required, the more rigorous ambient air analysis based on computer dispersion modeling. A thorough investigation of the applicable federal and state regulations upon which these levels of effect are based is provided in Appendix D, Air Quality.

### 2.1 Significance Threshold

A significant effect on air quality is determined when

(1) project-related emissions cause an increase in pollutant concentrations over the nearest onshore area of at least 20 square kilometers that

- (a) exceeds half of any of the National Ambient Air Quality Standards (NAAQS) (except for ozone); or
- (b) exceeds half of the maximum allowable increase for any pollutant for the Prevention of Significant Deterioration (PSD) for a Class II area under 40 CFR 52.21(c) or 18 AAC 50.020(b); or
- (c) is expected to exceed half the ozone NAAQS based on an analysis of the potential increase in the ozone precursor emissions of volatile organic compounds (VOC) and nitrogen oxides (NOX); or

(2) design concentrations violate the NAAQS or if applicable, the Alaska Ambient Air Quality Standards (AAQS).

### 2.2 Level of Effects

**Negligible**

- Emission rates would be less than 100 tons per year for VOCs and all pollutants regulated under the NAAQS, and, if applicable, the Alaska AAQS.

**Minor**

- Emission rates would be equal to or greater than 100 tons per year for VOCs and all pollutants regulated under the NAAQS, and, if applicable, the Alaska AAQS.

**Moderate**

- Project-related emissions cause pollutant concentrations of at least one pollutant to exceed one-half of the PSD maximum allowable increases; or
- Project-related emissions cause pollutant concentrations of at least one pollutant to exceed one-half of the NAAQS, and, if applicable, the Alaska AAQS; or
- Increases in emissions of NOx and VOC would result in the formation of ozone to a level that would be expected to exceed one-half the ozone NAAQS.

**Major**

- Design concentrations of at least one pollutant would equal or exceed one-half the NAAQS, and, if applicable, one-half the Alaska AAQS; or
- Increases in emissions of NOx and VOC would result in the formation of ozone to a level that would be expected to equal or exceed the ozone NAAQS.

## B-3. Water Quality

The levels of effect applied to water quality analysis consider the context and intensity of impacts, EPA's NPDES permitting program, and criteria under 40 CFR 125.122:

(1) The quantities, composition and potential for bioaccumulation or persistence of the pollutants to be discharged;

(2) The potential transport of such pollutants by biological, physical or chemical processes;

(3) The composition and vulnerability of the biological communities which may be exposed to such pollutants, including the presence of unique species or communities of species, the presence of species identified as endangered or threatened pursuant to the Endangered Species Act, or the presence of those species critical to the structure or function of the ecosystem, such as those important for the food chain;

(4) The importance of the receiving water area to the surrounding biological community, including the presence of spawning sites, nursery/forage areas, migratory pathways, or areas necessary for other functions or critical stages in the life cycle of an organism.

(5) The existence of special aquatic sites including, but not limited to marine sanctuaries and refuges, parks, national and historic monuments, national seashores, wilderness areas and coral reefs;

(6) The potential impacts on human health through direct and indirect pathways;

(7) Existing or potential recreational and commercial fishing, including finfishing and shellfishing;

(8) Any applicable requirements of an approved Coastal Zone Management plan;

(9) Such other factors relating to the effects of the discharge as may be appropriate;

(10) Marine water quality criteria developed pursuant to section 304(a)(1).

### 3.1 Significance Threshold

A significant effect on water quality is determined by any of the following: (1) the action is likely to violate its National Pollution Discharge Elimination System permit; (2) in the event of an accidental spill of crude oil or refined oil, total aromatic hydrocarbon or total aqueous hydrocarbon criteria for the Alaska marine or fresh-water quality standards are exceeded; or (3) the action is otherwise likely to introduce changes in the physical, chemical, or biological characteristics of a waterbody which case an unreasonable degradation of the marine environment as defined at 40 CFR 125.121 and determined in accordance with 40 CFR 125.122.

### 3.2 Level of Effects

**Negligible:** Temporary and localized impacts to water quality that do not cause an unreasonable degradation under 40 CFR 125.122.

**Minor:** Long-term and/or widespread impacts to water quality that do not cause an “unreasonable degradation” under 40 CFR 125.122.

**Moderate:** Impacts to water quality that exceed NPDES permit criteria or cause a temporary or localized “unreasonable degradation” under 40 CFR 125.122.

**Major:** Impacts to water quality that cause long-term and widespread “unreasonable degradation” under 40 CFR 125.122.

## B-4. Lower Trophic Organisms

### 4.1 Significance Threshold

An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status.

### 4.2 Level of Effects

**Negligible:**

- No measurable impacts. Population-level effects are not detectable.
- Localized, short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across multiple seasons.
- No population level impacts to reproductive success or recruitment are anticipated.
- Mitigation measures are implemented fully and effectively or are not necessary.

**Minor:**

- Population-level effects are not detectable.
- Widespread annual or chronic disturbances or habitat effects not anticipated to accumulate across 1 year, or localized effects that are anticipated to persist for more than 1 year.
- Mitigation measures may be implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable.
- Unmitigatable or unavoidable adverse effects are short term and localized.

**Moderate:**

- Disturbances could occur, but not on a scale resulting in population-level effects.
- Widespread annual or chronic disturbances or habitat effects could persist for more than one year and up to a decade.

- Widespread implementation of mitigation measures for similar activities may be effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are short term and widespread, or long term and localized.

**Major**

- Disturbances occur that result in measurable population-level effects.
- Widespread seasonal, chronic, or effects from subsequent seasons are cumulative and are likely to persist for more than 1 decade.
- Mitigation measures are implemented only for a small portion of similar impacting activities, but more widespread implementation for similar activities could be more effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are widespread and long lasting.

# B-5. Fish

## 5.1 Significance Threshold

An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status.

## 5.2 Level of Effects

**Negligible:**

- No measurable impacts. Population-level effects are not detectable.
- Localized, short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across multiple seasons.
- No mortality or impacts to reproductive success or recruitment are anticipated.
- Mitigation measures are implemented fully and effectively or are not necessary.

**Minor:**

- Population-level effects are not detectable. Temporary, nonlethal adverse effects to some individuals.
- Widespread annual or chronic disturbances or habitat effects not anticipated to accumulate across 1 year, or localized effects that are anticipated to persist for more than 1 year.
- Low mortality levels may occur, measurable in terms of individuals or <1% of the local post-breeding fish populations.
- Mitigation measures may be implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable.
- Unmitigatable or unavoidable adverse effects are short term and localized.

**Moderate:**

- Mortalities or disturbances could occur, but not on a scale resulting in population-level effects.
- Widespread annual or chronic disturbances or habitat effects could persist for more than 1 year and up to a decade.
- Some mortality could occur but remains limited to a number of individuals insufficient to produce population-level effects.
- Widespread implementation of mitigation measures for similar activities may be effective in reducing the level of avoidable adverse effects.

- Unmitigatable or unavoidable adverse effects are short term and widespread, or long term and localized.

**Major**

- Mortalities or disturbances occur that have measureable and thus significant population-level effects.
- The action may adversely affect an endangered or threatened species or its habitat in a way that has been deemed to be critical under the Endangered Species Act of 1973.
- For fishes, the anticipated mortality is estimated or measured in terms of tens of thousands of individuals or >20% of a local breeding population and/or >5% of a regional population, which may produce short-term, localized, population-level effects.
- Widespread seasonal, chronic, or effects from subsequent seasons are cumulative and are likely to persist for more than 1 decade.
- Mitigation measures are implemented only for a small portion of similar impacting activities, but more widespread implementation for similar activities could be more effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are widespread and long lasting.

# B-6. Marine and Coastal Birds

## 6.1 Significance Threshold

Threatened and Endangered Species: An adverse impact that results in a decline in abundance and/or change in distribution requiring one or more generation for the indicated population to recover to its former status.

All other Marine and Coastal Birds: An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status.

## 6.2 Level of Effects

**Negligible**

- Localized short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across one year.
- No mortality is anticipated.
- Mitigation measures implemented fully and effectively or are not necessary.

**Minor**

- Widespread annual or chronic disturbances or habitat effects not anticipated to accumulate across one year, or localized effects that are anticipated to persist for more than 1 year.
- Anticipated or potential mortality is estimated or measured in terms of individuals or <1% of the local post-breeding population.
- Mitigation measures are implemented on some, but not all, impacting activities, indicating that some adverse effects are avoidable.
- Unmitigatable or unavoidable adverse effects are short-term and localized.

**Moderate**

- Widespread annual or chronic disturbances or habitat effects anticipated to persist for more than one year, but less than a decade.

- Anticipated or potential mortality is estimated or measured in terms of tens or low hundreds of individuals or <5% of the local post-breeding population, which may produce a short-term population-level effect.
- Mitigation measures are implemented for a small proportion of similar impacting activities, but more widespread implementation for similar activities likely would be effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are short-term but more widespread.

**Major**

- Widespread annual or chronic disturbance or habitat effect experienced during one season that would be anticipated to persist for a decade or longer.
- Anticipated or potential mortality is estimated or measured in terms of hundreds or thousands of individuals or <10% of the local post-breeding population, which could produce a long-term population-level effect.
- Mitigation measures are implemented for limited activities, but more widespread implementation for similar activities would be effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are widespread and long lasting.

# B-7. Marine Mammals

## 7.1 Significance Threshold

Threatened and Endangered Species: An adverse impact that results in a decline in abundance and/or change in distribution requiring one or more generation for the indicated population to recover to its former status.

All other Marine Mammals: An adverse impact that results in a decline in abundance and/or change in distribution requiring three or more generations for the indicated population to recover to its former status.

## 7.2 Level of Effects

**Negligible:**

- Localized, short-term disturbance or habitat effect experienced during one season that is not anticipated to accumulate across multiple seasons. Temporary, nonlethal adverse effects to a few individuals are possible.
- May cause brief behavioral reactions such as temporary avoidances of or deflections around an area. No mortality or population-level effects are anticipated.
- The action is not anticipated to affect an endangered or threatened species or critical habitat under the Endangered Species Act of 1973.
- Mitigation measures are implemented fully and effectively or are not necessary.
- Unmitigatable or unavoidable adverse effects are difficult to measure or observe.

**Minor:**

- Localized, disturbance or habitat effects experienced during one season may accumulate across subsequent seasons, but not over one year.
- Temporary, nonlethal adverse effects to some individuals. May cause behavioral reactions such as avoidances of or deflections around a localized area. Mortality or population-level effects are not anticipated.
- The action may adversely affect an endangered or threatened species or critical habitat under the Endangered Species Act of 1973.

- Mitigation measures are fully implemented or are not necessary.
- Unmitigatable or unavoidable adverse effects are short term and localized.

**Moderate:**

- Widespread annual or chronic disturbances or habitat effects could persist for more than 1 year and up to a decade.
- Mortalities or disturbances could occur, but would be below the estimated Potential Biological Removal[1] (PBR). Population-level effects are not anticipated.
- The action is likely to adversely affect an endangered or threatened species or modify critical habitat under the Endangered Species Act of 1973.
- Widespread implementation of mitigation measures for similar activities may be effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are short term and widespread, or long term and localized.

**Major**

- Widespread seasonal or chronic effects from subsequent seasons are cumulative and are likely to persist for more than 1 decade.
- Mortalities or disturbances could occur at or above the estimated Potential Biological Removal (PBR), which could be a population-level effect.
- The action may adversely affect an endangered or threatened species or critical habitat under the Endangered Species Act of 1973, but would not necessarily jeopardize the continued existence of an ESA-listed species.
- Mitigation measures are implemented only for a small portion of similar impacting activities, but more widespread implementation for similar activities could be more effective in reducing the level of avoidable adverse effects.
- Unmitigatable or unavoidable adverse effects are widespread and long lasting.

# B-8. Sociocultural Systems

Sociocultural systems include social organization, cultural values, and institutional arrangements. The level of significance effect would be reached at the high level. The level of effects used for sociocultural systems is as follows:

## 8.1 Significance Threshold

A disruption of social organization, cultural values, and/or institutional arrangements with a tendency towards displacement of existing social patterns.

## 8.2 Level of Effects

**Negligible**: Periodic disruption of social organization, cultural values, and/or institutional arrangements occurs without displacement of existing social patterns.

**Minor**: Disruption of social organization, cultural values, and/or institutional arrangement occurs for a period of less than one year, without a tendency toward displacement of existing social patterns.

**Moderate**: Chronic disruption of social organization, cultural values, and/or institutional arrangements occurs for a period of more than one year, without a tendency toward displacement of existing social patterns.

**Major**: Disruption of social organization, cultural values, and/or institutional arrangements with a tendency towards displacement of existing social patterns.

# B-9. Subsistence

## 9.1 Significance Threshold

Adverse impacts which disrupt subsistence activities, or make subsistence resources unavailable, undesirable for use, or only available in greatly reduced numbers, for a substantial portion of a subsistence season for any community.

## 9.2 Level of Effects

**Negligible**

- Subsistence resources could be periodically affected with no apparent effect on subsistence harvests.

**Minor**

- Adverse impacts to subsistence activities are of an accidental and/or incidental nature and limited to a short-term.

**Moderate**

- Adverse impacts which disrupt subsistence activities, or make subsistence resources unavailable, undesirable for use, or only available in greatly reduced numbers, for a substantial portion of a subsistence season for any community.

**Major**

- Adverse impacts resulting in one or more important subsistence resources becoming unavailable, undesirable for use, or available only in greatly reduced numbers for any community.

# B-10. Economy

The effects levels used for this analysis focus on the impacts associated with the proposed activities on socioeconomic systems, including employment, personal income, and revenues accruing to the local, state, and federal government.

## 10.1 Significance Threshold

Economic effects that would cause important and sweeping changes in the economic well-being of the residents or the area or region. Local employment is increased by 20% or more for at least 5 years.

## 10.2 Level of Effects

**Negligible**

- No measurable effects beyond short term, periodic impacts.

**Minor**

- Adverse impacts to the affected activity or community are unavoidable without proper mitigation.
- Impacts would not disrupt the normal or routine functions of the affected activity or community. Economic systems would be impacted for a period of up to 1 year.
- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects from the proposed action without any mitigation.

**Moderate**

- Impacts to the affected activity or community are unavoidable. Proper mitigation would reduce impacts substantially during the life of the project.
- Effects on economic systems would be unavoidable for a period longer than 1 year.
- The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the project.
- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects from the proposed action if proper remedial action is taken.

**Major**

- Impacts to affected community are unavoidable.
- Proper mitigation would reduce impacts somewhat during the life of the project.
- The affected activity or community would experience unavoidable disruptions to a degree beyond what is normal.
- Once the effect producing agent is eliminated, the affected activity or community may retain measurable effects of the proposed action indefinitely, even if remedial action is taken.

# B-11. Public Health

## 11.1 Level of Effects

**Negligible**

- Infrequent minor acute health problems, not requiring medical attention.
- No measurable effects on normal or routine community functions.
- No long-term consequences for Public Health or well being.

**Minor**

- Public Health affected, but the effects would not disrupt normal or routine community functions for more than one week.
- Effects would not occur frequently.
- Effects would not affect large numbers of individuals.
- Effects could be avoided with proper mitigation.

**Moderate**

- Adverse effects on Public Health occurring for brief periods of time that do not result in or incrementally contribute to deaths or long-term disabilities.
- Effects can be prevented, minimized, or reversed with proper mitigation.
- Effects could occur more frequently than minor events, but would not be frequent.

**Major**

- Effects on Public Health would be unavoidable and would contribute to the development of disabilities, chronic health problems, or deaths.
- Alternatively, occurrence of minor health problems with epidemic frequency.
- Effective mitigation might minimize the adverse health outcomes but would not be expected to reverse or eliminate the problem.

# B-12. Archaeology

## 12.1 Level of Effects

**Negligible**

- This category equates to No Historic Properties Affected as defined by 36 CFR 800.4(d)(1), the Code of Federal Regulations that promulgates Section 106 of the National Historic Preservation Act of 1966 as amended.

**Minor**

- This category equates to a finding of No Historic Properties Affected when the Agency identifies a potential conflict within an Area of Potential Effect due to the presence of a geomorphological feature and revises the plan to avoid it prior to consultation with the State Historic Preservation Officer.

**Moderate**

- This category equates to a finding of No Adverse Effect as defined by 36 CFR 800.5(b) when the SHPO identifies a conflict that requires a change in plan to avoid effects on an Historic Property as defined by 36 CFR 800.16(l)(1&2).

**Major**

- This category equates to a finding of Adverse Effect as defined by 36 CFR 800.5(C) requiring mitigation and a Memorandum of Agreement.

# B-13. Environmental Justice

Executive Order 12898 requires Federal Agencies to evaluate whether proposed projects would have "disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low income populations."

## 13.1 Significance Threshold

The significance threshold for Environmental Justice is when minority or low-income populations experience disproportionate, high adverse human health or environmental effects from the proposed action. Disproportionately high adverse impacts are those impacts which exceed the significance thresholds for subsistence, sociocultural, or public health effects for minority populations or low income populations.

## 13.2 Level of Effects

The levels of effect for Environmental Justice correspond to the levels of effects for subsistence, sociocultural, or public health effects as experienced by minority populations or low income populations.

# B-14. References

USDOI, MMS. 2008. Cape Wind Energy Project Draft Environmental Impact Statement. OCS EIS/EA MMS 2007-024. Herndon, VA: USDOI, BOEM.

Notes:

[1] Marine mammal stock management is often based on a theoretical concept called Potential Biological Removal (PBR). The PBR is defined as the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustained population. An optimum sustained population is defined as the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem. For example, as the bowhead whale population continues to grow, it continues to approach its carrying capacity. Contemporary population ecology suggests that at carrying capacity, a stable population is achieved when mortality equals productivity.
The PBR is calculated as the product of the minimum population estimate, one-half the theoretical productivity rate, and a "recovery factor". For example, the current estimate for the rate of increase for the bowhead whale stock (3.3%) should not be used as an estimate of maximum productivity because the population is currently being harvested and because the population has recovered to population levels where the growth is expected to be significantly less than maximum productivity. For the Western Arctic bowhead whale stock, the population size is estimated to be 9,472 (estimated in 2001), the theoretical productivity rate is 0.2, and the recovery factor is 0.5. The PBR is generally only used by the NMFS to guide decisions regarding the allowable removal of individual animals from a stock.
The conceptual PBR is used in the level of effects to identify a threshold whereby maximum population growth is sustained or not. If an anticipated effect could result in a loss of whales that exceeded the PBR, this would be inferred to be a population-level effect. In reality, given the conservative values used to derive the PBR, the loss of marine mammals that exceeded calculated PBR could be entirely consistent with a stable population.

# Appendix C

## Cumulative Effects

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# Appendix C. Cumulative Effects

## C-1. Cumulative Effects Defined

The Council on Environmental Quality (CEQ) Regulations defines cumulative effects at 40 CFR 1508.7:

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

## C-2. Cumulative Effects Scenario

The scope of this assessment includes the incremental impact from the action alternatives plus the aggregate effects of other activities that are known to occur or that can be reasonably expected to occur at the same time as, and in the vicinity of the proposed action, and which have a potential to affect the same resources as the proposed action.

This cumulative effects scenario tiers from information provided in Chapter 5 of the Lease Sale 193 Final SEIS (USDOI, BOEMRE, 2011). That information is incorporated by reference and summarized below. Further, it is updated to consider the years 2012 through 2017 and reflect the past, present, and reasonably foreseeable activities which may occur within the special confines and within the time period of the proposed action.

## C-3. Impact Sources

The main sources of impacts which could have a cumulative impact with the proposed action on the resources in the Arctic OCS are: (1) marine vessel traffic, (2) aircraft traffic, (3) subsistence and other community activities, (4) scientific research activities, and (5) oil and gas-related.

### 3.1 Marine Vessel Traffic

Past marine vessel traffic has been associated with subsistence hunting, oil exploration, research, and military activities. Weather and ice have traditionally limited marine vessel traffic in the proposed exploration area to the open-water period of July through September.

The number of marine vessels in the Chukchi Sea has increased in recent years due to advances in the technology of ice strengthening and ice breaking capacities of marine vessels, changes in ice cover and classification of ice, and increased interest in scientific and economic pursuits in the area. Vessel traffic related to the Proposed Action would include the drillship and support vessels. Other reasonably foreseeable traffic in the U.S. Chukchi Sea includes small craft involved in the fall whaling hunt at Barrow and Wainwright; USCG vessels; cargo vessels; other supply ships, tugs, and barges; cruise ships; and vessels associated with scientific endeavors. The USCG estimates that from 2008 to 2010 the number of vessels in the Arctic increased from around 100 to more than 130, and the number of transits through the Bering Strait increased from around 245 to more than 325 (USCG, 2011). The estimated number of miles of non-seismic vessel traffic in the Chukchi Sea for July through October increased from approximately 2,000 miles in 2006 to more than 11,500 miles in 2010 (Shell, 2011: Appendix F, Table 4.2-2). Vessel tracks from 2009 indicate vessel transits in the vicinity of Barrow and Wainwright are traditionally concentrated along the coast (Marine Exchange of Alaska, 2011). This area corresponds to the subsistence use areas described in Section 3.2.10 for those communities.

Marine vessels are the greatest contributors of anthropogenic sound introduced to the Chukchi Sea. Sound levels and frequency characteristics of vessel sound generally are related to vessel size and speed. Larger vessels generally emit more sound than do smaller vessels. Same size class vessels travelling at higher rates of speed generally emit more sound than the same vessels travelling at lesser speeds. Vessels underway with a full load, or vessels pushing or towing loaded non-powered vessels, generate more sound than unladen vessels in a similar size class. The most common sources of marine vessel mechanical components that generate sound waves are propulsion engines, generators, bearings, and other mechanical components, as well as fathometers and other vessel navigation and operations equipment, all of which create and propagate sound into the marine environment through the vessel hull. The most intense level of sound pressure introduced into the water from an underway marine vessel originates from cavitation associated with the action of spinning propellers. Moored vessels generate sound from the operation of engines and pumps. Cranes or other similar operational equipment performing construction activities or other work functions at docks may transmit sound directly to the environment or indirectly through propagation of sound waves through the hull .

It is reasonably foreseeable that vessel traffic will increase over the proposed period of the exploration plan. This traffic would likely include industry activities in the form of seismic surveys, seafloor archaeological and biological surveys, seafloor geotechnical programs, biological monitoring surveys, research activites, coastwise commercial and community vessel traffic, and military actions.

## 3.2 Aircraft Traffic

Past air traffic activities in the area of the proposed exploration drilling and support activities have been limited to movement of people and supply materials between industry operations, native villages, and military outposts.

Air traffic has increased in recent years, mostly from increases in academic and commercial ventures, and increases in military operations. Aircraft traffic in the Arctic includes fixed wing and helicopter flights for research programs and marine mammal monitoring operations; cargo flights for supplies to villages and for commercial ventures including oil and gas related activities (such as crew changes and supply flights); flights for regional and inter-village transport of passengers; air-ambulance and search and rescue emergency flights; general aviation for the purpose of sport hunting and fishing or flightseeing activities; and multi-governmental military flights. Air traffic not associated with the proposed project may involve flight patterns at a lower altitude than the 1,500-ft limit required for aircraft related to the proposed action. Shell calculated that an average of 306 commercial flights per month occurred from Wainwright airport between July and October, 2000 to 2008 (Shell 2011: Appendix F, Table 4.1.11-6).

Air traffic is expected to continue at present levels for the reasonably foreseeable future.

## 3.3 Subsistence Activities and Other Community Activities

Subsistence hunting and other community activities associated with regional native villages such as Wainwright and Point Lay have persisted for millennia, and are expected to continue during the period of proposed activities. Additional information regarding these activities is provided in Chapters 3 and 4.

Overall, vessel traffic associated with native village activities within the proposed exploration drilling area is expected to be consistent with the level of traffic observed in recent years. Most vessel traffic in the region is nearshore, or is a result of exploration activity and academic or industry research efforts. Nearshore traffic is expected to consist of barges (with their associated towing / pushing vessels) transiting through the area during open water conditions within 12.5 mi (20 km) of the coast

(Shell, 2011b: 4-131). With the reduction in ice cover and increase in open water season, cumulative vessel traffic in the region due to military, tourism, and foreign shipping interests may increase (Arctic Marine Shipping Assessment, 2005)

## 3.4 Scientific Research Activities

A sizable scientific research effort by governmental, non-governmental, and academic organizations operating from marine vessels and aircraft occurs annually in the Chukchi Sea. The programs conducted by these organizations are expected to continue through the period of the proposed action. Marine environmental baseline studies involve deployment of oceanographic equipment for collecting water and sediment samples, and use of nets and trawls for fish sampling and collection of phytoplankton, zooplankton, benthic invertebrates, and pelagic invertebrates. Also continuing will be observations of marine and coastal birds and marine mammals using standardized survey transect methods and passive acoustic monitoring. Metocean buoys and acoustic wave and current meters will continue to be deployed for studies of physical oceanography and climate. Previous environmental assessments, such as the environmental assessment for Shell's Beaufort Sea marine research program, describe the techniques used and the effects of these programs in detail (USDOI, BOEMRE, 2011).

**Pacific Arctic Group (PAG).** Ongoing activities in the general Beaufort and Chukchi Sea regions include multinational efforts carried out by the Pacific Arctic Group (PAG). Organized under the International Arctic Science Committee (IASC), the PAG mission is to serve as a Pacific Arctic regional partnership to plan, coordinate, and collaborate on science activities of mutual interest to the Arctic region. Some of these activities could coincide in time and space with Shell's proposed exploration plan activities. The Diversified Biological Observatory is a multi-national cooperative effort coordinated by the PAG, with the USA, Canada, Russia, Japan, China, and Korea contributing cruise data from past, ongoing, and planned research programs. The programmatic sampling includes continuation of collections from prior and existing research stations, including BOEM-funded projects. Focus is on four geographical research areas within the Bering Sea, Bering Strait, Chukchi Sea, and Beaufort Sea. This work includes the synthesis of studies in fields including physical oceanography, marine chemistry, biological oceanography and marine biology (primary productivity, zooplankton, phytoplankton, ice algae, epontic, pelagic, and benthic collections), and marine mammal and marine bird ecology (PAG, 2011).

**Bowhead Whale Feeding Ecology Study (BOWFEST).** August–September 2012. NOAA Fisheries and National Marine Mammal Laboratory. The BOWFEST (NMML, 2011a) is a multiyear BOEMRE-funded study which was started in 2007 that focuses on late summer oceanography and prey densities relative to whale distribution over continental shelf waters within 100 miles north and east of Point Barrow, Alaska. National Marine Mammal Laboratory (NMML), will conduct aerial surveys, acoustic monitoring, and boat-based surveys to provide information on the spatial and temporal distribution of bowhead whales in the study area.

**2012 Low-level Aerial Coastal Survey.** This plan includes implementation of aerial surveys of coastal areas to approximately 23 mi (37 km) offshore between Point Hope and Point Barrow. These surveys will continue until exploration drilling operations in the Chukchi Sea are completed. Flight altitudes and speeds will comply with LOA and 4MP guidelines. These flights will occur in addition to activities described in the Aircraft Traffic section of this appendix. Saw-tooth flight transects were designed by placing transect start/end points every 34 mi (55 km) along the offshore boundary of this 23 mi (37 km) wide nearshore zone, and at midpoints between those points along the coast. The transect line start/end points will be shifted along both the coast and the offshore boundary for each survey based upon a randomized starting location, but overall survey distance will not vary substantially. The coastline transect will simply follow the coastline or barrier islands. "No-fly" zones around coastal villages or other hunting areas established during communications with village representatives will be in place until the end of the hunting season.

**Chukchi Sea Acoustic Oceanographic Zooplankton (CHAOZ).** July – September, 2012. CHAOZ goals are to conduct passive acoustic/biological/biophysical surveys of whales, their prey, and their environment in the Bering, Chukchi, and Beaufort seas for three field seasons, 2010–2012. The study includes research vessel transects from Wainwright, Icy Cape, Point Lay, Cape Lisburne, and Point Hope into the Chukchi and Bering seas for deployment of acoustic and ice buoys, CTD casts, zooplankton sampling, and for collection of marine mammal observation data. In addition, biological and population studies of large whales will be continued by deploying radio and satellite transmitters on whales, conducting photo-identification, and biopsy sampling.

**Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA).** Mid-June – October, 2012. NOAA Fisheries and National Marine Mammal Laboratory. The Northeast Chukchi Sea aerial cetacean survey COMIDA (NMML, 2011b) is a BOEM-funded project designed to understand the distribution and relative abundance of cetaceans by using aerial surveys during the open-water (ice-free) months, from mid-June to the end of October. Surveys follow standard line-transect protocols. Flights begin and end in Barrow, AK. The science team flies in either a De Havilland Twin Otter Series 300 or Aero Commander 690A fixed wing aircraft at altitudes between 1,000-1,500 feet and at 100-110 kts speed. Surveys are flown every day, weather permitting.

**2012 Shell Chukchi Sea EP Biological Monitoring Program.** In addition to monitoring of marine mammals, a comprehensive environmental monitoring program will be implemented during exploration drilling operations. A dedicated science vessel staffed by a team of physical and biological oceanographers will be responsible for assessing pre-, during, and post-drilling conditions in both biota, and water and sediment quality. All of Shell's proposed drilling locations have been sampled at multiple times during the last three years to provide a baseline understanding of pre-existing conditions and interannual variability at these sites. Physical oceanography characteristics that will be monitored continuously at each location throughout the drilling process include surface wind direction and speed, ambient air temperature, current speed and direction throughout the water column, water temperature through the water column, and salinity through the water column. Water chemistry and characteristics that will be monitored will include assessment of metals and organics through the water column at multiple fixed and random locations around the exploration drilling operation. These measurements will be made regularly before, during, and after drilling, and will capture conditions during all significant phases of the exploration drilling operations and potential discharges. Physical characteristics of the water column will also be assessed (including turbidity, temperature, and oxygen content) in an effort to document and model plumes of released discharges. Samples of biota will be collected before and after operations for tissue analysis for metals and organics. Bird and mammal observations will be made from all of Shell's support vessels throughout the exploration drilling activities in accordance with the 4MP and Bird Strike Avoidance and Lighting Plan.

**Hanna Shoal Ecosystem Study (Hanna Shoal).** July – October 2012, with similar proposed operating schedules through 2016. This research project will include benthic sampling, food web analysis, and contaminant measurements and focuses on the Hanna Shoal area, located between the boundary of the Chukchi and Arctic Ocean waters and the Burger prospect. Water column primary and secondary production and biomass also will be measured. Cruise zooplankton data will be supplemented by data from moored zooplankton-sensing acoustic Doppler current profilers (ADCP) (units that are capable of distinguishing copepod and euphausid biomass signatures). Moored and shipboard instruments of currents, sea ice drift, and hydrography (including geochemistry) will examine circulation and density fields. Instrument moorings will be used for long term profiling of temperature and salinity, including under ice measurements in winter. Additional oceanographic data may be obtained from other projects such as the proposed extension of the Chukchi oceanographic study. These data include HF radar, moored ADCPs, meteorological buoys, and gliders. Formal integration with the results of other BOEM-funded projects will be made through the planned

"Marine Mammal/Physical Oceanography Synthesis" to provide upper trophic components to the study. Coordination will occur with other international, NSF, NOAA, ADEC, and industry research in the Chukchi Sea.

It is reasonable to foresee there will be further research efforts in this region during the projected period of the exploration period, due to continuing interest in the changing ice and climate patterns. For example, the Pacific Arctic Group (PAG), organized under the International Arctic Science Committee, plans, coordinates, and collaborates on science activities of mutual interest to the Arctic region. It is not presently known exactly what research PAG will conduct, but it is reasonably foreseeable that the projects specified above are only a sample of the total research that will be conducted in the Chukchi during the duration of the proposed activities.

### 3.5 Oil and Gas Related Activities

Past oil and gas related activities in the Chukchi Sea OCS include exploration wells drilled at the Burger prospect in 1990 and at the Klondike prospect in 1989, exploration seismic surveys,shallow geologic hazards surveys, geotechnical sampling programs, baseline biological studies and surveys, and other environmental studies and sampling programs.

Current reasonably foreseeable oil and gas activities in the Arctic OCS include Shell's multiple-well exploration drilling program on leases in the Beaufort Sea, which would occur concurrently with Shell's proposed activities in the Chukchi Sea. Shell proposes using dedicated and independent drilling and support vessels for the Chukchi Sea and Beaufort Sea operations, with some shared oil spill response resources. Weather, ice, and other environmental conditions at the specific locations would ultimately dictate the sequence of Shell's operations. Shell's Beaufort Sea and Chukchi Sea exploration drilling project areas are more than 400 mi apart. Discharges and emissions associated with drilling at the two project areas would not overlap in space. Sound generated from the various project stages would not overlap in space. Because of the travel time for migrating species between the project areas, some individual animals could be exposed to sound from both drilling operations.

Other current and ongoing activities related to oil and gas, such as vessel and air traffic in state waters and onshore, are expected to remain at their current levels for the duration of the proposed action.

Additional industry activities that may occur during the time frame of the proposed action include potential exploration projects by Statoil USA E&P Inc. and Conoco Philips; however, no exploration plans for these activities have been submitted to BOEM. Should Arctic lease sales be included in the 2012-2017 Five-Year OCS oil and Gas Leasing Program, potential bidders would likely propose to conduct exploration seismic surveys under BOEM-issued G&G permits. It is reasonably foreseeable that one or more such surveys could occur during the timeframe of the proposed action. BOEM would complete environmental evaluations, including cumulative effects analysis, for any such proposed activities.

## C-4. Climate Change and Ocean Acidification

Climate change is an ongoing consideration in evaluating cumulative effects on environmental resources of the Arctic region (NOAA, 2011). It has been implicated in changing weather patterns, changes in the classification and seasonality of ice cover, ocean surface temperature regimes, and the timing and duration of phytoplankton blooms in the Chukchi Sea. These changes have been attributed to rising $CO_2$ levels in the atmosphere and corresponding increases in the $CO_2$ levels of the waters of the world's oceans. These changes have also led to the phenomena of ocean acidification (IPCC, 2007; Royal Society, 2005). This phenomenon is often called a sister problem to climate change, because they are both attributed to human activities that are leading to increased $CO_2$ levels in the atmosphere. The capacity of the Arctic Ocean to uptake $CO_2$ is expected to increase in response to climate change (Bates and Mathis, 2009). Further, ocean acidification in high latitude seas is happening at a more advanced rate than other areas of the ocean. This is due to the loss of sea ice that increases the surface area of the Arctic seas. This exposure of cooler surface water lowers the solubility calcium carbonate, which results in lower saturation levels of calcium carbonate within the water, and in turn leads to lower available levels of the minerals needed by shell-producing organisms, such as pteropods, foraminifers, sea urchins, and molluscs (Fabry et al., 2009; Mathis, 2011).

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# Appendix D

## Air Quality

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# Appendix D. Table of Contents

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## D-1. Introduction

Outside air becomes polluted and air quality conditions deteriorate when small particles, liquids, and potentially harmful gases are released into the atmosphere by a variety of sources. The emission sources may be natural or man-made, and may be stationary or mobile. Natural (biogenic) sources of air pollutants include, but are not limited to, volcanoes and forest fires that produce dust and smoke; sea salt aerosols; and vegetation, which is a source of pollen and organic compounds during evaporation (EPA, 2010a). Man-made (anthropogenic) sources are related to human activities such as transportation (motor vehicles, aircraft, and marine vessels); industrial and residential heating; construction; and specifically any activity associated with the combustion of fossil fuels (EPA, 2010a). Stationary anthropogenic sources are fixed-site producers of emissions, which are primarily power-generating-plants requiring fuel combustion, and industrial processes, such as refineries, chemical manufacturing facilities, and smelting (EPA, 2010c). A drillship temporarily anchored to the seabed floor on the Outer Continental Shelf (OCS) is also considered a stationary source (40 CFR Part 55.2). Mobile anthropogenic sources are powered by onboard engines. Mobile sources account for more than half of all the air pollution in the United States, where the primary source is the automobile (EPA, 2010b). Other mobile sources include marine vessels, aircraft, equipment used for construction, agriculture, and recreation vehicles. Regardless of the type of emissions source, or whether sources are permanent or temporary, emissions can build up in the atmosphere in concentrations larger than what can be tolerated without humans suffering some sort of harm.

The information provided in this appendix supplements the discussion of air quality conditions and impacts contained in the 2012 Shell Revised Chukchi Sea EP. In addition to the information provided in this EA, the Shell Revised Chukchi Sea EP provides an examination of air quality conditions and impacts in the environmental impact analysis. Further, supplemental information regarding the inventory of emissions, computer modeling, and results of the ambient air analysis is included in the air operating permits submitted by Shell to Environmental Protection Agency (EPA) Region 10 in Seattle. The review of air quality impacts in this EA examined and relied on the information in the Shell and EPA documents.

## D-2. Regulatory Overview

The outside air, referred to in the regulations as ambient air, becomes polluted when harmful gases and particles build up in concentrations sufficient to directly or in indirectly cause measurable damage to human health, wildlife, or property (Monks, Granier, & Stohl et al., 2009). Thus, emissions of pollutants and the buildup of pollutant concentrations are regulated under local, state, and federal regulations.

The assessment of air quality was prepared pursuant to the National Environmental Policy Act (NEPA, 1969) and is regulated primarily by the requirements of the Clean Air Act (CAA, 1990). The ambient air in Alaska is further regulated through the state’s Air Quality Management Program contained in the State Implementation Plan when federal actions are proposed within 25 miles of the three-geographical mile seaward boundary (ADEC, 2010c). When a proposed federal action is expected to cause emissions of any of the pollutants regulated under the CAA, the environmental review must contain an assessment of air quality. The assessment should include a description of existing conditions of sufficient scope and depth to discern the baseline characteristics of air quality over the project area. The assessment should also include an analytical evaluation of the projected emissions under each alternative considered in the environmental assessment. The project in the Chukchi Sea proposes the operation of a drillship and various support vessels, which are powered by fossil fuel. Operation of the ships’ engines will create emissions of regulated pollutants, thus this environmental review to include consideration of emissions from the Proposed Action.

The condition of air quality is measured and reported in the assessmentrelative to established criteria, or standards, that define the acceptable concentration of specific pollutants in the ambient air. Under the CAA, the Environmental Protection Agency (EPA) is responsible for establishing and maintaining the National Ambient Air Quality Standards (NAAQS) (National Primary and Secondary Ambient Air Quality Standards, 2010), which limit concentrations of the following potentially harmful air pollutants, known as the criteria pollutants:

- Carbon monoxide (CO)
- Lead (Pb)
- Nitrogen dioxide ($NO_2$)
- Ozone
- Particulate matter ($PM_{2.5}$ and $PM_{10}$)
- Sulfur dioxide ($SO_2$)

For each of these pollutants, the EPA establishes primary standards intended to protect public health, and secondary standards for the protection of other aspects of public welfare, such as preventing materials damage, preventing crop and vegetation damage, and assuring good visibility. Each state establishes standards similar to the NAAQS and publishes the standards in the State Implementation Plan (SIP). State standards may be more stringent than the NAAQS and could include additional pollutants. The Alaska Department of Environmental Conservation (ADEC) established ambient air quality standards for Alaska, which are published in the Alaska SIP (ADEC State Implementation Plan, 2010). A summary of the Alaska AAQS and the NAAQS is provided in 2. The table defines the standards in terms of pollutant concentrations, stated either in parts per million (ppm), micrograms per cubic meter (μg/m$^3$), or in milligrams per cubic meter (mg/m$^3$).

**Table D-2. Alaska and National Ambient Air Quality Standards.**

| Pollutant | Averaging Period | Alaska AAQS | National NAAQS (Primary and/or Secondary Standards) | |
|---|---|---|---|---|
| **Carbon Monoxide (CO)** | 8-hour | 10 mg/m$^3$ | 10 mg/m$^3$ | Primary Only |
| | 1-hour | 40 mg/m$^3$ | 40 mg/m$^3$ | Primary Only |
| **Lead** | Rolling 3-month | 0.15 μg/m$^3$ | 0.15 μg/m$^3$ (2008 Standard) | Both |
| | Calendar Quarter | Not Applicable | 1.5 μg/m$^3$ (1978 Standard) | Both |
| **Nitrogen Dioxide ($NO_2$)** | Annual | 100 μg/m$^3$ | 100 μg/m$^3$ | Both |
| | 1-hour | Not Established | 188 μg/m$^3$ (2010 Standard) | Primary Only |
| **Ozone** | 8-hour (2008 Standard) | 0.075 ppm | 0.075 ppm | Both |
| | 8-hour (1997 Standard) | Not Established | 0.08 ppm | Both |
| | 1-hour | Not Established | 0.12 ppm | Both |
| **Particulate Matter ($PM_{2.5}$)** | Annual | 15.0 μg/m$^3$ | 15.0 μg/m$^3$ | Both |
| | 24-hour | 35 μg/m$^3$ | 35 μg/m$^3$ (2006 Standard) | Both |
| **Particulate Matter ($PM_{10}$)** | 24-hour | 150 μg/m$^3$ | 150 μg/m$^3$ | Both |
| **Sulfur Dioxide ($SO_2$)** | Annual | 80 μg/m$^3$ | 80 μg/m$^3$ | Primary Only |
| | 24-hr | 365 μg/m$^3$ | 365 μg/m$^3$ | Primary Only |
| | 30-minute | 50 μg/m$^3$ | Not Established | |
| | 3-hour | 1300 μg/m$^3$ | 1300 μg/m$^3$ | Secondary Only |
| | 1-hour | Not Established | 0.075 ppm (2010 Standard) | Primary Only |
| **Ammonia ($NH_3$)** | 8-hour | 2.1 mg/m$^3$ | Not Established | |

Sources: Alaska Department of Environmental Conservation (ADEC). Ambient Air Quality Standards. 18 ACC §50.010, 2011.

EPA. National Primary and Secondary Ambient Air Quality Standards. 40 CFR Part 50.4 – 50.13.

Each air quality standard is subject to limitations, such as restrictions on how many times during a calendar year a standard may be violated and still comply with the standard. These limitations are provided in the federal regulations at 40 CFR Part 50.4-50.13, *National Ambient Air Quality Standards*; for the State of Alaska, the limitations are stated in the Alaska Administrative Code (AAC), Title 18, Chapter 50, *Air Quality Control*. Several of the NAAQS have been recently established or revised. The relevant EPA code revisions are listed in the following sections that include explanations of the revisions and implications to the Proposed Action.

## 2.1 Lead

The EPA updated the lead standard in 2008 to add a rolling three-month average of 0.15µg/$m^3$ (73 *FR* 66964, 11/12/2008). The existing 1978 standard, 1.5 µg/$m^3$ as a quarterly average, remains in effect for some areas previously designated nonattainment for the older standard, and until the appropriate SIPS to attain or maintain the 2008 standard are approved. The 1978 quarterly average is not listed in the Alaska SIP as a standard; however, ADEC submitted a request in April 2010 to amend Alaska's State Air Quality Control Plan, as part of the SIP, to adopt the NAAQS for lead (ozone, and $PM_{2.5}$ are also included); approval of the Alaska amendment by EPA is pending (ADEC, 2010c).

Lead is not a pollutant considered in the air quality impacts analysis for this EA because lead is not a pollutant resulting from burning diesel fuel or unleaded fuel. The criteria pollutants of concern for the Proposed Action are $NO_{2/x}$, $SO_{2/x}$, $PM_{10}$, $PM_{2.5}$, and VOC.

Lead is not a pollutant considered in the air quality impacts analysis for this EA because lead is not a relevant pollutant resulting from burning diesel fuel or unleaded fuel. The criteria pollutants of concern for the Proposed Action are $NO_{2/x}$, $SO_{2/x}$ $PM_{10}$, $PM_{2.5}$, and VOC.

## 2.2 Nitrogen Dioxide ($NO_2$)

The EPA final rule for the new one-hour standard was published in February 2010 (75 *FR* 6474, 2/9/2010). The annual average concentration standard for nitrogen dioxide is sometimes stated as 0.053 ppm (40 CFR Part 50.22(c)). For the purpose of the emission inventory in this analysis, emissions of nitrogen oxides ($NO_X$) are conservatively considered to be entirely composed of $NO_2$. Shell demonstrated in the ambient air analysis included the operating permits that emissions from the Proposed Action would comply with this new standard (Shell, 2011b).

## 2.3 Ozone

The EPA has made several adjustments in recent years to the standard for ozone. The EPA proposed a revision to the 2008 eight-hour standard and has delayed the final rule until July 29, 2011. The final rule is proposed to be an annual standard within the range of 0.060 to 0.070 ppm (73 *FR* 16436, 3/28/2008; 75 *FR* 2938, 1/19/2010; Kelly, 2010). The ADEC submitted a request in April 2010 to amend Alaska's State Air Quality Control Plan, as part of the SIP, to adopt the NAAQS for ozone (lead and $PM_{2.5}$ are also included). Approval by EPA is pending. Ozone is not specifically addressed in the air quality assessment because ozone is not a pollutant emitted directly from any source. Rather, ozone is formed in the atmosphere in the presence of precursor pollutants, nitrogen oxides ($NO_X$) and volatile organic compounds (VOC) and sunlight. Thus the levels of $NO_X$ and VOC are an indication of potential ozone development. The air quality analysis for the Proposed Action includes the projected emissions of $NO_X$ and VOC (Shell, 2011a; Shell, 2011d).

## 2.4 Particulate Matter ($PM_{10}$ and $PM_{2.5}$)

The newest standard for $PM_{2.5}$ is the 24-hour average concentration set at 35 $\mu g/m^3$ (71 *FR* 61144, 10/17/2006). The ADEC submitted a request in April 2010 to amend Alaska's State Air Quality Control Plan, as part of the SIP, to adopt the NAAQS for $PM_{2.5}$ (lead and ozone are also included). Approval by EPA is pending. Shell demonstrated in the ambient air analysis included the operating permits that emissions from the Proposed Action would comply with this new standard (Shell, 2011a; Shell, 2011d).

## 2.5 Sulfur Dioxide ($SO_2$)

The EPA updated the $SO_2$ standards to include a primary one-hour average of 0.75 ppm; at the same time EPA revoked both the primary annual and 24-hour standards, effective August 23, 2010 (75 *FR* 35520, 6/22/2010). However, the two revoked standards will stay in effect for an interim time until the required SIPs are approved, and also for one year after the new designations are made. This will serve the anti-backsliding goals of the CAA. The three-hour standard for $SO_2$ is sometimes stated as 0.5 ppm (40 CFR Part 50.59a). For the purpose of the emission inventory in this analysis, emissions of sulfur oxides ($SO_X$) are conservatively considered to be entirely composed of $SO_2$. Shell demonstrated in the ambient air analysis included the operating permits that emissions from the Proposed Action would comply with this new standard (Shell, 2011a; Shell, 2011d).

## 2.6 Regulatory Jurisdiction

Emission sources on land areas of the United States are controlled by each state, and the Alaska Department of Environmental Conservation (ADEC) has jurisdiction over proposed federal projects that have the potential to affect the North Slope of Alaska. The North Slope is considered a Class II area for purposes of air quality management, meaning the area has clean outside air with scenic vistas and esthetic value (42 USC 7472(b); Godish, 2004). While not protected to the same degree as a wilderness area or national park, a Class II area requires protection from new emission sources that would be large enough to degrade the air quality. As such, a proposed federal action with the potential to affect a Class II area may require an air quality operating permit or pre-construction permit (18 AAC 50).

The territorial waters extending seaward from the Alaskan coastlines are also subject to protection under the CAA. However, these areas are not regulated that way land areas are and pose unique challenges for CAA compliance. Federal projects proposed within three geographical miles (gm) of shore (the seaward boundary) are subject to State rules and jurisdiction; beyond the seaward boundary, EPA has jurisdiction. In the case of Alaska, the jurisdiction lies with EPA Region 10 in Seattle, Washington. When the proposed project is within 25-gm of the seaward boundary, the EPA has the discretion to incorporate State rules that are applicable for implementing the CAA; beyond the 25-gm boundary, however, federal rules apply (Submerged Land Act, 43 USC 1301, 1312). Federal rules for regulating emissions on the OCS are specifically provided for in the CAA under Section 328 *Air Pollution from Outer Continental Shelf Activities* (42 USC 7627) and are established as the OCS Air Regulations (40 CFR Part 55). Additional EPA regulation of emission sources on the OCS is authorized under the New Source Review program, which includes the Prevention of Significant Deterioration rule and the Title V operating rule.

## 2.7 Definitions

The following definitions are developed from 40 CFR Part 55.2, and are modified as they would apply directly to the Alaskan OCS in Chukchi seas. The definitions are helpful in describing the methods and procedures of the air quality assessment.

*Attainment area* – a geographical area where EPA defines the air quality as a clean resource, and pollutant concentrations are as good as or better than the NAAQS or the Alaska AAQS. An area may be an attainment area for one pollutant and a nonattainment area for others.

*BACT* – Best Available Control Technology; any Prevention of Significant Deterioration (PSD) permit would be required to use BACT to reduce emissions.

*Corresponding Onshore Area (COA)* – the onshore area that is geographically closest to the OCS source, and applies when the proposed location of the source would be located within 25 miles of Alaska's three-gm seaward boundary.

*Design concentration* – the translation of the emission inventory to pollutant concentrations, with the background concentrations added to the project-related concentration values to disclose total maximum concentrations.

*Exploratory OCS source* – a temporary source on the Alaskan OCS conducted for the sole purpose of gathering information. This includes an EP intended to determine the characteristics of the reservoir and may involve the extraction of oil and gas.

*Federal waters* – those waters located outside the three-geographical mile Submerged Lands Act boundary.

*Major stationary source* is defined distinctly depending on the location of the source and the attainment status of the associated COA.

1. PSD rules apply on the state and federal level, only in an attainment area for sources with the potential to emit (PTE) 250 tons per year or more, and only for emissions of $NO_2$, $PM_{10}$, and $SO_2$ (40 CFR Part 52.21(c)). A source that is major for VOC or $NO_X$ shall be considered major for ozone.
2. Title V rules for the OCS apply regardless of the attainment status, and apply on the state and federal level. Fugitive emissions are not subject to Title V for OCS sources. A major source under Title V has the PTE 100 tons per year of any regulated pollutant. Regulated pollutants include all the criteria pollutants regulated under the NAAQS; and the Alaska AAQS adds reduced sulfur compounds and ammonia. Precursor emissions of VOC are also included because VOC is regulated under the general conformity rule (40 CFR Part 93), and VOC are related to the definition for a major source of ozone in 40 CFR Part 52.21.

*Nearest Onshore Area (NOA)* – Geographically, the onshore land area closest to a proposed project

*New OCS source* – an Alaskan OCS source not already existing and does not include an action proposing modifications for an existing source. The following regulations apply to new OCS stationary sources:

1. Prevention of Significant Deterioration (PSD) rules apply under 40 CFR 52.21, when the source is located beyond 25 miles of Alaska's three-gm seaward boundary, and applies inside the boundary when PSD rules already apply on the COA. The PSD rules apply when the COA is designated as attainment; otherwise NSR rules would apply to nonattainment and maintenance areas. The North Slope Borough of Alaska is designated as attainment and is subject to the PSD rules when the source has the PTE 250 tons per year or more. Alaska adopts the rules in 40 CFR Part 52, Subpart C, Air Programs, according to Class designation; and the North Slope Borough is a Class II area. Any PSD permits must be approved and issued before construction may begin on the project; thus PSD permits are also referred to as pre-construction air permits.

2. Title V of the CAA for the OCS: The federal Title V rule applies to the OCS under 40 CFR 71 (outside the OCS Part 70 applies for Title V permits), whether or not the source is located beyond 25 miles of Alaska's three-gm seaward boundary, and applies inside the boundary where the Title V rule already applies on the COA. Title V air permits are issued by states under 40 CFR Part 70 and EPA regional offices issue Title V permits under 40 CFR Part 71 in Indian country and in other situations, such as for the OCS.

*Nonattainment area* – a geographic area identified by the EPA as not meeting either the NAAQS or the Alaska AAQS for one or more of the regulated pollutants.

*OCS source* – any equipment, activity, or facility which:

1. Emits or has the PTE any air pollutant, and;
2. Is regulated or authorized under the Outer Continental Shelf Lands Act ("OCSLA") (43 U.S.C. §1331 et seq.); and
3. Is located on the OCS or in or on waters above the OCS. This definition shall include marine vessels only when they are:
   a. Permanently or temporarily attached to the seabed, erected on the seabed, and used for the purpose of exploring, developing or producing resources from the seabed (Section 4(a)(1) of OCSLA (43 U.S.C. §1331 et seq.)); or
   b. Physically attached to an OCS facility, in which case only the stationary sources aspects of the vessels will be regulated.

*Potential emissions* – the maximum emissions of a pollutant from an OCS source operating at its design capacity. Any physical or operational limitation on the capacity of a source to emit a pollutant, including air pollution control equipment (such as BACT) and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as a limit on the design capacity of the source if the limitation is federally enforceable. Emissions from vessels servicing or associated with an OCS source shall be considered direct emissions from such a source while at the source, and while en-route to or from the source when within 25 miles of the source, and is referred to as the PTE for an OCS source.

*Maximum Allowable Increases (MAIs)* – ambient air increments caused by a stationary source, in areas designated as Class I, II, or III; increase in pollutant concentration over the baseline concentration; the MAIs are the maximum allowable increase, measured in micrograms per cubic meter.

## 2.8 Air Operating Permits

Air operating permits issued by EPA and ADEC will ensure that emission levels caused by the Shell Revised Chukchi Sea EP will remain low enough to prevent harm to human health and the environment under all operating scenarios. Shell's permit applications include an emission inventory and ambient air analysis (dispersion modeling) that include the worst-case highest hourly, enforceable emission rates from the *Discoverer* and its support vessels. The CAA regulations require certain facilities that emit criteria pollutants or hazardous substances to obtain a permit establishing limits on the types and amounts of emissions, governing operating parameters for pollution control and monitoring devices, and monitoring and record-keeping requirements. Refer to the definitions in this appendix for a major stationary source, new OCS sources, and potential emissions. In this case, EPA Region 10 will issue the air permits for the *Discoverer*.

Air Quality Permit under the Clean Air Act (CAA), issued by the U.S. Environmental Protection Agency (EPA) Region 10. The EPA regional offices have jurisdiction to approve and issue air quality operating permits under the New Source Review (NSR) program. As such, for proposed federal actions on the Alaska OCS, EPA Region 10 in Seattle, Washington, requires and has jurisdiction to approve and issue air permits under the NSR program. Under the NSR program, Shell has applied for a Prevention of Significant Deterioration (PSD) air quality operating permit, which is a pre-construction permit to operate the drillship *Discoverer* (40 CFR part 52.21). The permit is intended to limit and regulate air emissions in a Class II area of otherwise clean air on the North Slope of Alaska, adjacent to the Chukchi Sea. The first PSD permit application associated with the Chukchi Sea EP was submitted by Shell on December 19, 2008, and the EPA issued PSD Permit AK-09-01 on March 31, 2010. The permit was overturned on December 30, 2010, by the Environmental Appeals Board (EAB) and the permit was remanded back to EPA for further consideration (EAB, 2010). Shell provided EPA with additional analyses in response to the remand order and EPA published notice of the issuance of the revised draft PSD permit on July 1, 2011 (EPA, 2011). The EPA issued the revised PSD Permit R10OCS/PSD-AK-09-01 on September 19, 2011 (EPA, September 19, 2011) On October 24, 2011, the permit was challenged by Petitioners requesting review by the EAB, after which the EAB directed the EPA to respond by November 16, 2011, to address the Petitioners' arguments and determine whether the Petitioners have satisfied the requirements to grant an EAB review (EPA, October 26, 2011). The EPA responded to the Petitioner's arguments on November 16, 2011, and requested the EAB deny the petitions for review (EPA, November 16, 2011). While the status of the permit may not be fully resolved at the time of the preparation of this environmental review, approval of the Shell Revised Chukchi Sea EP by BOEM is conditional upon issuance of the final PSD permit.

## D-3. NEPA Air Quality Analysis

In the course of preparing the air operating permits, Shell conducted an analysis of emissions for the *Discoverer*, which includes all the marine support vessels associated with the drillship. The analysis included computer modeling, which was conducted according to the protocols submitted to EPA by Shell for the *Discoverer* (Shell, 2011b). The analysis and air quality modeling conducted by Shell was required for the application of a PSD permit for the *Discoverer*. The air quality assessment required for this NEPA environmental review by the BOEM is distinct from the requirements for an air permit application and relies, in part, on the emission inventory and the ambient air analysis (dispersion analysis) conducted by Shell for the permit applications. However, the finding by BOEM for air quality impacts in this EA is a finding based on the BOEM independent review of air quality impacts and not a finding on the permits. The emission inventory includes the following pollutants for compliance with the NEPA guidelines and Alaska regulations:

- Nitrogen oxides ($NO_X$)
- Fine particulate matter ($PM_{2.5}$)
- Coarse particulate matter ($PM_{10}$)
- Carbon monoxide (CO)
- Sulfur oxides ($SO_X$)
- Volatile organic compounds (VOC)
- Lead (Pb)
- Ammonia ($NH_3$)
- Carbon dioxide equivalent emissions ($CO_2e$)

The emission inventory for the drillship *Discoverer* is provided in EA Section 4.1.2, Table 20. The emission inventory was translated into an ambient air analysis through computer dispersion modeling using the EPA AERMOD model. The dispersion analysis was conducted for the NAAQS, and includes:

- Nitrogen dioxide ($NO_2$)
- Fine particulate matter ($PM_{2.5}$)
- Coarse particulate matter ($PM_{10}$)
- Carbon monoxide (CO)
- Sulfur dioxide ($SO_2$)

The results of the dispersion analysis are provided in the application documents for the air operating permits for the *Discoverer*, and are provided in this EA in Section 4.1.2, Table 21. BOEM thoroughly reviewed and evaluated the methods and results of the analyses prepared by Shell to ensure the accuracy and credibility of the results. The results of the air impact analysis show concentrations of pollutants associated solely with the Proposed Action would comply with the BOEM level of effect for air quality.

# D-4. Air Quality Levels of Effect

The levels of effect applied to the air quality analysis are based on the results of two levels of analyses, the emission inventory, and if required, the more rigorous ambient air analysis based on computer dispersion modeling. Further, the levels of effect consider whether the Proposed Action is:

- Temporary or permanent
- Located within or beyond 25 miles from the Alaska seaward boundary (25-mile threshold)
- Associated with a COA that is designated as a Class I, Class II, or Class III area
- Adjacent to a COA that is designated attainment or nonattainment
- Location of the NOA

The levels of effect are first defined by applying threshold values to the emission inventory. The emission inventory is the first step in assessing the potential for adverse impacts to air quality due to a proposed federal action. While the inventory is not intended to define the severity of the impact, the character of the emission inventory can provide insight to the potential for future impacts. An inventory that demonstrates emissions that equal or exceed established thresholds can initiate further more rigorous analyses that will provide the ‘hard look’ required under NEPA (Robertson v. Methow Valley Citizens Council, 1989). Inherent in the hard look provision is the necessity to consider and investigate the relevant issues using the most appropriate expertise and methodology available. Thus, Accordingly, BOEM applied thresholds provided in the long-established EPA guidelines for air operating permits, the PSD permit and the Title V permit rules. The OCS Air Regulations require air operating permits under 40 CFR Part 55.6, Permit Requirements, and include Clean Air Act (CAA) Title V permits and PSD permits.

## 4.1 CAA Title V Threshold

The requirement for a Title V permit for an OCS source is found at 40 CFR Part 55.6(c)(3), which invokes the rules under 40 Part 71. The Part 71 Title V permit program is intended to document a state’s major sources of stationary emissions regardless of the attainment status of the geographical area. A Part 71 permit is required for projects with stationary sources proposed on the OCS regardless of whether the project is located within or beyond the 25-mile threshold. The Part 71 permit is an enforceable permit issued by the EPA after the source has begun to operate. Under Part 71, a permit is required when a stationary source has the PTE 100 tons or more of any regulated pollutant, including VOCs (42 USC 7602(j); 42 USC 7661a(b)(3)(B)(ii)(I, II, & III)). For the purpose of the BOEMRE air quality levels of effect, a proposed action that has the PTE less than 100 tons per year of any regulated pollutant would be considered a negligible source. In summary, a Title V Part 71 air operating permit on the Alaska OCS applies under the following conditions:

- Attainment or nonattainment area
- Obtain after construction
- Within or beyond the 25-mile boundary on the OCS adjacent to the coastline
- Federal EPA authority (EPA has authority on the OCS, whereas the Part 70 Title V is authorized by the state agency; Part 70 is nearly identical to Part 71)
- Major stationary source has emissions equal to or greater than 100 tons per year
- Applies to all regulated criteria and precursor pollutants

## 4.2 PSD Threshold

The EPA requires operating permits for new and modified stationary sources, referred to as pre-construction permits. A pre-construction permit is enforceable and must be obtained before construction on the federal action commences. This permit program is promulgated under the New Source Review rules (NSR), where NSR applies to areas of nonattainment and PSD rules apply to the attainment areas. The PSD permit program is intended to limit the amount of pollution emitted from a major stationary source to the best extent possible and reasonable in an area with otherwise clean air. On the OCS, a PSD permit may be required when the location of the proposed action is either within or beyond the 25-mile threshold (40 CFR Part 55.13(d)).

A project sponsor will apply for a PSD permit when a stationary source on the OCS has the PTE 250 tons or more of any regulated pollutant, including VOCs, even after BACT and ORR are applied (40 CFR 52.21(b)(1)(i)(b)). An action proposed on the OCS that creates a new stationary source with the PTE 250 tons per year or more of any criteria or precursor pollutant, controlled or uncontrolled, is defined as a major source. Under the rules for a PSD major source, an ambient air analysis is necessary to compare results to MAIs defined in the PSD rule.

The EPA establishes MAIs for pollutant concentrations under the PSD rule. The MAIs apply in much the same way as the emission thresholds apply to the emission inventory, except MAIs are expressed in pollutant concentrations, such as parts per million (ppm) or micrograms per cubic meters ($\mu g/m^3$), and are the result of computer dispersion modeling. Referred to as ambient air incremental increases, the MAIs are applied according to the classification of the Proposed Action's COA, such as Class I, Class II, or Class III. Alaska's North Slope Borough is a Class II area (i.e. not a wildlife refuge) (40 CFR Part 52.21(c) Class II). The MAIs applicable to the Alaskan OCS adjacent to the Chukchi Sea are provided in this EA in Section 4.1.2, Table 21. In summary, PSD air pre-construction permit for stationary sources on the Alaska OCS applies under the following conditions:

- Attainment or unclassified area
- Obtain before construction begins (pre-construction)
- Within or beyond the 25-mile threshold on the OCS adjacent to the coast line
- Federal EPA authority, and when applicable, Alaska DEC has jurisdiction for the COA
- Major stationary source has emissions equal to or greater than 250 tons per year
- Requires BACT and/or other owner-requested restrictions
- Applies to all New Source Review (NSR) regulated pollutants, which are $NO_2$, $PM_{2.5}$, PM10, and $SO_2$
- Public comment procedures are required

## 4.3 Defining the Four Levels of Effect

To ensure protection of outside air and to control the impact to human health, the BOEM set criteria to define the levels of effect from a proposed project. Air Quality levels of effect assigned by BOEM to federal projects proposed for the OCS are limited to four categories, negligible, minor, moderate, and major. The purpose of the air quality levels of effect is to determine whether or not the proposed project would have the potential to create a significant impact to air quality and human health by violating the BOEM criteria defining a moderate or major effect. To categorize a moderate or major effect, the BOEM relied on references to the maximum allowable increase thresholds permitted under the PSD rules, and the maximum allowable pollutant concentrations established under the NAAQS and the Alaska AAQS.

To categorize the smallest projects, the BOEM relied on emission rates described in the well-established federal and Alaska permitting programs. Under both the Title V and PSD permit criteria, emission rates less than 100 tons per year are not considered major. A sensitivity analysis of $NO_x$ emissions was conducted to discern the effect of limiting project emissions to just 100 tons for a proposed season of exploratory drilling operations on the Alaska OCS, which is approximately 120 days per year. The sensitivity analysis showed that if typical vessels proposed for exploratory drilling were to operate until the emissions of $NO_X$ reached 100 tons, the operation could continue for only 35 days, when the time needed to complete only one well to total depth requires 34 to 44 days. The BOEM believes projects with emission rates less than 100 tons per year defines a small project with respect to air quality, and the effects could be reasonably defined as negligible. Although no ambient air analysis would likely be conducted for such a small project, the emissions would be presumed to conform to the BOEM pollutant concentration limitations for maximum allowable increases, the NAAQS, and the Alaska AAQS. Consequently, when considering proposed projects with projected emission rates greater than 100 tons per year, the expected level of effect would increase with the size of the project to minor, moderate, or major effects.

Based on this methodology, the following levels of effect are defined for air quality impacts and are summarized in Appendix B, Level of Effect Definitions.

### 4.3.1 Negligible Level of Effect

A negligible level of effect reflects a small proposed project with low emission rates. No further analysis would be required. The proposed project would meet the BOEM criteria for protecting Alaska’s outside air and ensure little or no impact to human health. The following statements describe a proposed project that would have a negligible level of effect:

- New sources of air emissions are unavoidable over an area of at least 20 square kilometers on the nearest onshore area; and
- Project-related sources would have maximum uncontrolled PTE emissions that are less than 100 tons per year for VOCs and all pollutants regulated under the NAAQS, and, if applicable, the Alaska AAQS; and
- Project-related emissions would not have the potential to cause pollutant concentrations of any pollutant to exceed one-half of the PSD maximum allowable increases; and
- Project-related emissions would not have the potential to cause pollutant concentrations of any pollutant to exceed one-half of the NAAQS (excluding ozone), and, if applicable, the Alaska AAQS (excluding ozone); and
- Increases in emissions of $NO_x$ and VOC would not have the potential to result in the formation of ozone to a level that would be expected to exceed one-half the ozone NAAQS; and

- Design concentrations are presumed to not have the potential to cause or contribute to a violation of any NAAQS (excluding ozone), and, if applicable, the Alaska AAQS (excluding ozone).

### 4.3.2 Minor Level of Effect

A minor level of effect reflects a proposed action with emission rates that could define a major source of emissions under the PSD rule. If the emissions constitute a major source, an ambient air analysis would be available for comparison to the relevant BOEM thresholds. The following statements describe a proposed project that would have a minor level of effect:

- New sources of air emissions are unavoidable over an area of at least 20 square kilometers on the nearest onshore area; and
- Project-related sources would have maximum uncontrolled PTE emissions that are equal to or greater than 100 tons per year for VOCs and all pollutants regulated under the NAAQS, and, if applicable, the Alaska AAQS; and
- Project-related emissions would not cause pollutant concentrations of any pollutant to exceed one-half of the PSD maximum allowable increases; and
- Project-related emissions would not cause pollutant concentrations of any pollutant to exceed one-half of the NAAQS (excluding ozone), and, if applicable, the Alaska AAQS (excluding ozone); and
- Increases in emissions of $NO_x$ and VOC would not result in the formation of ozone to a level that would be expected to exceed one-half the ozone NAAQS; and
- Design concentrations would not cause or contribute to a violation of any NAAQS (excluding ozone), and, if applicable, the Alaska AAQS (excluding ozone).

### 4.3.3 Moderate Level of Effect

A moderate level of effect reflects a proposed action with emissions that could define a major source of emissions under the PSD rule. If the emissions constitute a major source, an ambient air analysis would be available for comparison to the relevant BOEM thresholds. The following statements describe a proposed project that would have a moderate level of effect:

- New sources of air emissions are unavoidable over an area of at least 20 square kilometers on the nearest onshore area; and
- Project-related sources would have maximum uncontrolled PTE emissions that are equal to or greater than 100 tons per year for VOCs and all pollutants regulated under the NAAQS, and, if applicable, the Alaska AAQS; and
- Project-related emissions would cause pollutant concentrations of at least one pollutant to exceed one-half of the PSD maximum allowable increases; or
- Project-related emissions would cause pollutant concentrations of at least one pollutant to exceed one-half of the NAAQS (excluding ozone), and, if applicable, the Alaska AAQS (excluding ozone); or
- Increases in emissions of NOx and VOC would result in the formation of ozone to a level that would be expected to exceed one-half the ozone NAAQS; and
- Design concentrations would not cause or contribute to a violation of any NAAQS, and, if applicable, the Alaska AAQS (excluding ozone).

### 4.3.4 Major Level of Effect

A major level of effect reflects a proposed action with emissions that could define a major source of emissions under the PSD rule. If the emissions constitute a major source, an ambient air analysis would be available for comparison to the relevant BOEM thresholds. The following statements describe a proposed project that would have a major level of effect:

- New sources of air emissions are unavoidable over an area of at least 20 square kilometers on the nearest onshore area; and
- Project-related sources would have maximum uncontrolled PTE emissions that are equal to or greater than 100 tons per year for VOCs and all pollutants regulated under the NAAQS, and, if applicable, the Alaska AAQS; and
- Project-related emissions would cause pollutant concentrations of at least one pollutant to exceed one-half of the PSD maximum allowable increases; or
- Project-related emissions would cause pollutant concentrations of at least one pollutant to exceed one-half of the NAAQS (excluding ozone), and, if applicable, the Alaska AAQS (excluding ozone); or
- Increases in emissions of $NO_x$ and VOC would result in the formation of ozone to a level that would be expected to equal or exceed the ozone NAAQS; or
- Design concentrations of at least one pollutant would equal or exceed one-half the NAAQS (excluding ozone), and, if applicable, one-half the Alaska AAQS (excluding ozone).

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# Appendix E

## Climate Change

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# Appendix E. Climate Change

## E-1. Introduction

Climate change in the Arctic is projected to be more pronounced than in other areas of the globe (ACIA, 2005). However, Arctic climate has a larger natural variability and is highly complex and, therefore, climate projections may have greater uncertainty. The changes have not been uniform over the area. Large changes have taken place abruptly, spanning just a few decades. The changes include melting glaciers, melting sea ice and permafrost, shifting precipitation and snowfall patterns, and unusual forest and tundra growth. These changes have results in changes in wildlife habitat and migration, changes in fish populations, changes in agricultural zones, and an increase in forest fires (NOAA, 2011).The driving factors are complex but involve changes in solar radiation, atmospheric circulations, ocean circulations, and the cryosphere. The assessments of climate change and effects in the Arctic given here are based on the 2007 publication by the Intergovernmental Panel on Climate Change (IPCC, 2007) and the Arctic Research Center's Arctic Climate Impact Assessment (2005). These two reports are considered to include the most thorough scientific evaluation of climate change (Karcher, 2010).

## E-2. Temperatures

The Arctic climate is undergoing changes as a result of global climate change as well as natural cyclical variations. The Arctic Climate Impact Assessment (ACIA, 2005) summarized spatial and temporal temperature trends in the Arctic based on observations from the Global Historical Climatology Network database (Peterson and Vose, 1997) and the Climate Research Unit database (Jones and Moberg, 2003). The greater amount of warming in the Arctic compared to that for the globe as a whole is consistent with climate model projections (IPCC, 2007). In general, temperatures increased from 1900 to the mid-1940s, decreased until about the mid-1960s, and then increased again up to the present. From 1966-2003, the average rate of temperature change for the Arctic was 0.40 °C (0.7 °F) per decade (ACIA, 2005). When temperature trends are broken down by season, the largest changes occurred in winter and spring.

An analysis by Rigor, Colony, and Martin (2000) for the entire Arctic Ocean for the period 1979-1997, indicates an increase in surface air temperature of about 1.0 °C (1.8 °F) per decade in the eastern Arctic, whereas the western Arctic shows no trend. During fall, the trends show cooling of about 1.0 °C (1.8 °F) per decade over the Beaufort Sea and Alaska. During spring, a warming trend of 2 °C (3.6 °F) per decade can be seen over most of the Arctic. Summer shows no significant trend.

A trend analysis for first-order observing stations in Alaska for the period of 1949-2007 shows an average temperature change of 1.9 °C (3.4 °F). The largest increase was seen in winter and spring, with the smallest change in autumn. The trend has been far from linear. There was a decrease in temperature in the period from 1949-1976 followed by an abrupt increase in temperature in the period from 1973-1979. Since 1979, little additional warming has occurred in Alaska with the exception of Barrow and a few other locations (Rigor, Colony, & Martin, 2000).

## E-3. The Arctic Oscillation

The Arctic Oscillation (AO) refers to opposing atmospheric surface pressure patterns in the northern middle and high latitudes (NSIDC, 2011). The AO can be described as the relative difference in the intensity of the semipermanent low-pressure center over the North Pole (north of 20 North latitude). The AO describes the degree to which cold Arctic air is able to penetrate into the middle latitudes. The character of the AO is believed to be related to weather patterns many thousands of miles away.

When surface pressure is low in the Arctic, this is the positive stage. Under these circumstances the middle latitude jet stream moves strongly and consistently from west to east. This keeps cold air from leaving the polar regions. When the AO index is negative, there is high pressure in the Arctic, the zonal winds are weaker, and the cold air moves more freely into the middle latitudes. In the negative phase, the polar jet stream slows and begins to deform allowing low pressure centers to form farther south. When the pressure centers remain stationary for a number of days, the normal circulation of the atmosphere is disrupted. This systematic back and forth fluctuation of the weather systems defines the AO. Since the 1970s, the AO tended to stay in the positive phase. However, there is evidence that the AO is tending to be more negative and this may be contributing to unusually warmer temperatures over the Northern Hemisphere (Applied Information Systems, 2011).

## E-4. Ocean Acidification and Sea Ice

Concurrent with climate change is a change in ocean chemistry known as ocean acidification. This phenomenon is described in the IPCC Fourth Assessment Report (Climate Change 2007), a 2005 synthesis report by members of the Royal Society of London (Raven, Caldeira, Elderfield et al., 2005), and an ongoing BOEM-funded study (Mathis, 2011). The greatest degree of ocean acidification worldwide is predicted to occur in the Arctic Ocean. This amplified scenario in the Arctic is due to the effects of increased freshwater input from melting snow and ice, and from increased $CO_2$ uptake by the sea as a result of ice retreat.

## E-5. Precipitation and Storms

Precipitation in the Arctic exhibits an upward trend, consistent with what is observed in mid-latitudes. Mean annual precipitation in the Arctic has increased at the rate of 1.4% per decade in the period from 1900-2003 and at a rate of 2.2% per decade in the period from 1966-2003. A few studies also indicate that an increasingly larger portion of precipitation falls in the form of rain (ACIA, 2005). Storms in the Bering, Chukchi, and Beaufort Seas affect coastal areas of Alaska during much of the year. There has been an increase in fall-season storms in the last several years. With the storms, high wind events are more frequent on the western and northern coast. In addition, there is an increase in the loss of seasonal sea ice. The projected increase in surface temperatures is expected to cause a shift in the Pacific storm track. The Bering Sea may experience a large decrease in atmospheric pressure, which suggests a possible increase in the number of storms. The incidence of longer periods without sea ice would provide heat and moisture to the Arctic Ocean perhaps increasing the frequency or intensity of the storms (NOAA, 2011).

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# Appendix F

## Statutory Framework

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# Appendix F. Statutory Framework

## F-1. OCSLA and Operating Regulations

The Outer Continental Shelf Lands Act (OCSLA) establishes a four-stage process OCS activities: (1) a five-year leasing program; (2) individual lease sales; (3) exploration; and (4) development and production. BOEM, along with BSEE, is responsible for regulating and monitoring oil and gas operations on the OCS. BOEM regulates operations to

- promote orderly exploration, development, and production of mineral resources; and
- prevent harm or damage to, or waste of, any natural resource, and life or property, or the marine, coastal, or human environment.

Proposed EPs are reviewed under the process established by 30 CFR 550. Exploration activities on the OCS must be conducted pursuant to an approved EP and an approved Application for Permit to Drill (APD). The EP must contain all information required by the regulations, to include a detailed description of the exploration program, a thorough environmental impact assessment, an oil spill response plan, and other documentation. BOEM, along with BSEE, conducts a thorough technical and environmental review of the activities proposed in the EP and their compliance with applicable lease stipulations and applicable law. BOEM conducts NEPA analyses for proposed OCS activities and includes measures, if necessary, in permits, plan approvals, and other authorizations to minimize potential adverse effects to the human, marine, and coastal environment (30 CFR Parts 550 and Part 551). In the event that its EP is approved, the operator may submit an APD. The APD must contain detailed information about the drilling program to allow evaluation of operational safety and pollution-prevention measures. BSEE is responsible for technical review and approval of Applications for Permits to Drill (APDs), for ensuring safe OCS operations, and for monitoring OCS activities to ensure compliance with Federal laws, regulations, lease stipulations, permit or plan conditions, and required mitigation. BSEE is also responsible oversight of pollution prevention and oil spill contingency and response planning for OCS operations. BSEE's regulations are at 30 CFR Part 250 and Part 254. Approval of an APD is based on any conditions that must be met from the EP.

## F-2. Endangered Species Act

The Endangered Species Act (ESA) requires the protection and conservation of threatened and endangered species and the habitat in which they live. The ESA is administered by Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS). Section 10 of the ESA prohibits the unauthorized take of listed species. The FWS and NMFS may authorize the incidental take of listed species through an Incidental Take Statement (ITS), a Letter of Authorization (LOA) or an Incidental Harassment Authorization (IHA). Where activities under a proposed EP may incidentally take a listed species, BOEM may grant an approval of the EP with conditions. However, an incidental take authorization from FWS and/or NMFS would be required prior to BSEE approval of the APD, and prior to commencement of any EP activities.

In addition, Section 7 of the ESA requires interagency cooperation and consultation for Federal activities that may affect listed species. During the consultation process, the FWS and NMFS may set terms and conditions and make conservation recommendations for proposed activities (including OCS activities such as exploration drilling) in order to minimize potential adverse impacts to listed species and any designated critical habitat. It is BOEM's responsibility to ensure that measures to protect endangered and threatened species are implemented. BSEE has the responsibility to ensure that the operations are conducted in compliance with the ESA conditions stated in the approval of the EP or subsequent requirements from FWS and NMFS.

## F-3. Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) establishes Federal responsibility to conserve marine mammals. The MMPA is administered by NMFS and FWS. The NMFS has jurisdiction over all Arctic marine mammals except for the polar bear and Pacific walrus, which fall under FWS jurisdiction.

The MMPA prohibits the unauthorized take of marine mammals. The term "take" in this context is defined broadly and includes acts of harassment. The MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or a marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment]. The FWS and NMFS can authorize the incidental take of marine mammals, but only where the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses.

An incidental take authorization (which can take the form of a Letter of Authorization (LOA) or an Incidental Harassment Authorization (IHA)) sets forth the permissible methods of taking and requirements pertaining to the mitigation, monitoring, and reporting of such takings. If an activity may affect the availability of a marine mammal species or stock for taking for subsistence uses, the proposed monitoring plan must be independently peer-reviewed prior to the issuance of the MMA authorization.

## F-4. Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) mandates that a State with an approved Coastal Zone Management (CZM) plan reviews certain OCS activities to ensure that they are conducted in a manner consistent with the State's approved plan. State participation is on a voluntary basis. The State of Alaska's CZM plan ended on June 30, 2011, after the state legislature did not reauthorize statutory support for the program. No CZMA consistency review is required for the proposed action.

## F-5. Clean Air Act

The Clean Air Act (CAA) (Clean Air Act, as amended, 42 USC §7401 et seq.) was enacted in 1963 to control outside air emissions resulting from stationary sources, such as power plants, and mobile transportation sources (EPA, 2011). Major amendments in 1970, 1977, and 1990 expanded the act, which is now a comprehensive mandate that protects human health, the environment, and the economy. The CAA regulates air pollution on both federal and state levels, and guides local air agencies. On these three levels, regulators work in partnership to prepare emission inventories, develop emission control measures, and set up air monitoring networks (Martineau & Novello, 2004).

Emission sources on land areas of the United States are controlled by each State, and the Alaska Department of Environmental Conservation (ADEC) has jurisdiction over proposed federal projects that have the potential to affect the North Slope of Alaska. The North Slope is considered a Class II area for purposes of air quality management, meaning the area has clean outside air with scenic vistas and esthetic value (42 USC §7472(b)). While not protected to the same degree as a wilderness area or national park, a Class II area requires protection from new emission sources that would be large enough to degrade the air quality. As such, a proposed federal action with the potential to affect a Class II area may require an air quality operating permit or pre-construction permit (18 AAC 50).

Proposed operation of the drillship *Discoverer* on the Chukchi Sea is included in the Shell application for a PSD permit, which provides an analysis comparing project emissions to the NAAQS, and includes an accounting of $CO_{2e}$ emissions. The status of the permit, PSD AK-09-01, at the time of the preparation of this environmental review is provided in Appendix D-Section 2.8. Any approval of the 2012 Shell EP by the BOEM will be conditional until the required final PSD permit is issued.

## F-6. Clean Water Act

The Clean Water Act (CWA) governs the control of water pollution. A major component of the CWA is the National Pollution Discharge Elimination System (NPDES) program, which prohibits the unpermitted discharge of pollutants from point sources.

The EPA has authority to permit discharges on the OCS. Until recently, the EPA maintained a general permit for wastewater discharges from oil and gas exploration in the Arctic. This permit expired on June 26, 2011. EPA states that it will reissue the exploration general permits for the Beaufort and Chukchi Sea prior to the 2012 drilling season. A decision to approve of Shell's EP would constitute a conditional approval. Under the conditional approval, BOEM/BSEE will not approve an APD or authorize activities until Shell receives all necessary permits and authorizations – including coverage under a NPDES permit.

## F-7. Oil Pollution Act of 1990

The Oil Pollution Act of 1990 (OPA) establishes a program governing the removal of spilled oil, and requires planning for and respond to oil spills. Under OPA and BOEM and BSEE regulations at 30 CFR 554, exploration plans must include an Oil Discharge Prevention and Contingency Plan (ODPCP) for BOEM and BSEE review. The ODPCP must demonstrate the applicant's ability to prevent, or rapidly and effectively manage, oil spills that may result from exploratory drilling discharges. Approval of the ODPCP is a prerequisite to approval of the EP.

## F-8. National Historic Preservation Act

The National Historic Preservation Act (NHPA) establishes policies and procedures related to the preservation of historic and cultural resources. Section 106 of the NHPA requires federal agencies to consult with the State Historic Preservation Office (SHPO) regarding any undertaking with the potential to affect historic properties. Consultation regarding Chukchi Sea Oil and Gas Lease Sale 193 concluded in March 2007. BOEM approval of this proposed EP would require additional consultation.

In consulting under Section 106, BOEM utilizes archaeological resource surveys and reports required by agency regulations at 30 CFR 550.194. In preparing their EP, Shell conducted surveys to determine whether any of the lease blocks proposed for exploratory drilling contained shallow hazards or archaeological or historic resources. Shell has submitted that these lease blocks do not contain such conditions, and BOEM has agreed with that determination.

## F-9. National Invasive Species Act

The National Invasive Species Act of 1996 (NISA) amends the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) (16 U.S.C. 4710-4751) to regulate activities with the potential for introducing invasive species into the marine environment. Under the authority of NISA and NANPCA, the USCG maintains implementing regulations (33 CFR 151) that apply to vessels brought onto the Alaska OCS and which are intended to reduce the transfer of invasive species.

## F-10. Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1882) (MFCMA), as amended, establishes mechanisms for conserving and managing commercial fisheries. The Act creates eight Regional Fishery Management Councils (FMC), which prepare Fishery Management Plans (FMP) for each commercial species (or related group of species) of fish in need of conservation and management within each respective region. The MFCMA also requires each FMC to designate essential fish habitat, or EFH, for every FMP that they develop. EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity. The MFCMA and its implementing regulation require Federal agencies to consult with NMFS regarding any action they authorize, fund, or undertake that may adversely affect designated EFH. NMFS then provides conservation recommendations to the action agency.

## F-11. New Requirements for OCS Oil and Gas Operations

Following the Deepwater Horizon explosion and resulting oil spill in the Gulf of Mexico, comprehensive reforms to offshore oil and gas regulation and oversight were developed and implemented. The Secretary's Safety Measures Report, dated May 27, 2010, presents recommendations for immediate and long-term requirements to improve the safety of oil and gas operations in shallow and deep waters. In light of the Safety Measures Report, the MMS issued Notice to Lessees and Operators (NTL) 2010-N05, Increased Safety Measures for Energy Development on the OCS.

Pursuant to 30 CFR 550.213(g) and 30 CFR 550.219, an Exploration Plan (EP) must be accompanied by a blowout scenario description and information regarding oil spills, including calculations of the worst case discharge scenario. Under the new requirements for enhanced drilling safety (NTL 2010-N06, Information Requirements for Exploration Plans, Development and Production Plans, and Development Operations Coordination Documents on the OCS), operators must demonstrate that they are prepared to deal with the potential for a blowout and worst-case discharge.

NTL 2010-N10-*Statement of Compliance with Applicable Regulations and Evaluation of Information Demonstrating Adequate Spill Response and Well Containment Resources* requires to be included with every APD a statement signed by an authorized company official stating that the operator will conduct all authorized activities in compliance with all applicable regulations, including the Increased Safety Measures for Energy Development on the Outer Continental Shelf rulemaking (75 FR 62246). In compliance with the NTL and pursuant to 30 CFR Part 254, each operator using subsea blowout preventers (BOPs) or BOPs on floating facilities must submit information demonstrating that it has access to and can deploy surface and subsea containment resources that would be adequate to promptly respond to a blowout or other loss of well control.

The new Drilling Safety Rule imposes requirements that will enhance the safety of OCS oil and gas drilling operations. It addresses both well bore integrity and well control equipment and procedures. Well bore integrity provides the first line of defense against a blowout by preventing a loss of well control through the appropriate use of drilling fluids and the well bore casing and cementing program. Applications for Permits to drill must meet new standards for well-design, casing, and cementing, and be independently certified by a professional engineer.

The new Workplace Safety Rule covers all offshore oil and gas operations in federal waters, including equipment, safety practices, environmental safeguards, and management oversight of operations and contractors. The Workplace Safety Rule makes mandatory the previously voluntary practices in the American Petroleum Institute's (API) Recommended Practice 75 (RP 75). Companies are required to develop and maintain a Safety and Environmental Management System

(SEMS). A SEMS program is a comprehensive management program for identifying, addressing, and managing operational safety hazards and impacts, with the goal of promoting both human safety and environmental protection.

# Appendix G

## OCS Lease Sale 193
## Lease Stipulations

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# Appendix G. OCS Lease Sale 193 Lease Stipulations

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**Stipulation 5.** Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Marine Mammal Subsistence-Harvesting Activities

**Stipulation 6.** Pre-Booming Requirements for Fuel Transfers

**Stipulation 7.** Measures to Minimize Effects to Spectacled and Steller's Eiders During Exploration Activities

Shell's leases in the Chukchi Sea were obtained under Lease Sale 193 held in February 2008. The full text of the lease stipulations is provided below. Following each lease stipulation is a description of Shell's planned actions to comply with the stipulation.

## Stipulation No. 1. Protection of Biological Resources

If previously unidentified biological populations or habitats that may require additional protection are identified in the lease area by the Regional Supervisor, Field Operations (RS/FO), the RS/FO may require the lessee to conduct biological surveys to determine the extent and composition of such biological populations or habitats. The RS/FO shall give written notification to the lessee of the RS/FO's decision to require such surveys.

Based on any surveys that the RS/FO may require of the lessee or on other information available to the RS/FO on special biological resources, the RS/FO may require the lessee to:

(1) Relocate the site of operations;
(2) Establish to the satisfaction of the RS/FO, on the basis of a site-specific survey, either that such operations will not have a significant adverse effect upon the resource identified or that a special biological resource does not exist;
(3) Operate during those periods of time, as established by the RS/FO, that do not adversely affect the biological resources; and/or
(4) Modify operations to ensure that significant biological populations or habitats deserving protection are not adversely affected.

If any area of biological significance should be discovered during the conduct of any operations on the lease, the lessee shall immediately report such finding to the RS/FO and make every reasonable effort to preserve and protect the biological resource from damage until the RS/FO has given the lessee direction with respect to its protection.

The lessee shall submit all data obtained in the course of biological surveys to the RS/FO with the locational information for drilling or other activity. The lessee may take no action that might affect the biological populations or habitats surveyed until the RS/FO provides written directions to the lessee with regard to permissible actions.

### Shell's Actions – Stipulation No. 1

In their 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), Shell describes proposed actions to comply with Stipulation No. 1 as follows:

> No areas of special biological significance have been identified within or near the blocks identified in the revised Chukchi Sea EP.
>
> In addition to the shallow hazards surveys, which provide detailed information on the seafloor sediments and relief, Shell conducted or participated in the funding or in the facilitation of several types of environmental studies in and near the prospects in 2008, 2009, and 2010 to gather baseline data regarding resources in the project area. These studies included coastline surveys to assess the relative environmental sensitivity of Chukchi Sea coastline segments, walrus tagging and monitoring studies, seal tagging and monitoring studies, bird and marine mammal surveys, assessments of the benthic invertebrate communities, oceanographic studies, and sediment quality assessments at the planned drill sites. The results of the marine mammal and bird surveys are summarized in Shell's EIA (Shell, 2011: Appendix F).
>
> These studies also indicated that there are no areas of special biological significance in the vicinity of the drill sites. Video reconnaissance surveys were conducted at historical drill sites at Burger in 1989, and the results were submitted to BOEMRE at that time. These surveys also found a relatively flat and featureless seafloor with a silty substrate and a benthic fauna typical of the Lease Sale 193 Area (Finney 1989, Boudreau 1989).

## Stipulation No. 2. Orientation Program

The lessee shall include in any exploration plan (EP) or development and production plan (DPP) submitted under 30 CFR 250.211 and 250.241 a proposed orientation program for all personnel involved in exploration or development and production activities (including personnel of the lessee's agents, contractors, and subcontractors) for review and approval by the RS/FO. The program shall be designed in sufficient detail to inform individuals working on the project of specific types of environmental, social, and cultural concerns that relate to the sale and adjacent areas. The program shall address the importance of not disturbing archaeological and biological resources and habitats, including endangered species, fisheries, bird colonies, and marine mammals and provide guidance on how to avoid disturbance. This guidance will include the production and distribution of information cards on endangered and/or threatened species in the sale area. The program shall be designed to increase the sensitivity and understanding of personnel to community values, customs, and lifestyles in areas in which such personnel will be operating. The orientation program shall also include information concerning avoidance of conflicts with subsistence activities and pertinent mitigation.

The program shall be attended at least once a year by all personnel involved in onsite exploration or development and production activities (including personnel of the lessee's agents, contractors, and subcontractors) and all supervisory and managerial personnel involved in lease activities of the lessee and its agents, contractors, and subcontractors.

The lessee shall maintain a record of all personnel who attend the program onsite for so long as the site is active, not to exceed 5 years. This record shall include the name and date(s) of attendance of each attendee.

### Shell's Actions – Stipulation No. 2

In their 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), Shell describes proposed actions to comply with Stipulation No. 2 as follows:

> Shell has developed and is currently implementing an approved orientation program for Shell and contractor personnel involved in Shell's Alaska Venture exploration drilling program that was first approved by the Alaska OCS Region of the BOEMRE RS/FO on 15 February 2007. An outline of the

program was again submitted to BOEMRE with the initial Chukchi Sea EP, and found by the BOEMRE RS/FO on 7 December 2009 to satisfy the requirements of Stipulation No. 2. Shell revised the orientation program based on BOEMRE comments regarding the 2009 orientation program, and submitted the complete orientation program to BOEMRE for approval on 9 June 2011.

All Shell and contractor personnel involved in field exploration drilling activities will attend the orientation training annually. All other Shell and contractor personnel will attend the program at least once at the time they join the team. Shell will retain and maintain a record, for at least 5 years, of all personnel who attend the program, including relevant attendee and program information.

Shell has designed a specific program that addresses environmental, social, and cultural concerns related to the project area. The program is designed to increase sensitivity and understanding by Shell and its contractors of community values, customs, and lifestyles in the area they will be working, and how to avoid conflicts with subsistence activities. The program stresses the importance of not disturbing archaeological and biological resources and habitats, including endangered species, fisheries, bird colonies, and marine mammals and provides guidance on how to avoid disturbance.

Shell's Cultural Awareness Program addresses the following:

- Alaska Native Ethnic Breakdown
- Brief history of land claims
- Formation of regional corporations, and region within which Shell is working
- History of the North Slope
- Cultural diversity
- Comparison of cultural values of Alaska Natives v. non-Natives
- Patterns of language
- Communication skills and body language
- Guidelines on cultural artifacts
- Local community values and customs
- Whaling

Shell has further developed a Health, Safety, Security and Environment (HSSE) Awareness Program, which addresses the following:

- Shell's HSSE Commitment
- Intervention policy
- Journey Management requirements
- Personal Protective Equipment requirements
- General Alaska Venture Hazards, such as earthquakes and volcanoes
- Medical emergencies
- Security
- North Slope Safety requirements
- Shell Alaska Venture Standards and Procedures
  - Cold Climate Work Standard
  - Firearms Use in Wildlife Confrontations
  - Procedure for Vessel-to-Vessel Personnel Transfers
- Incident Reporting
- Environmental Awareness
  - ESA – Major Provisions
  - Endangered and threatened species
  - MMPA of 1972
  - Marine mammal interactions
  - Sensitive Habitats on the North Slope
  - Wildlife interactions
  - Prohibited activities of hunting, trapping and fishing
  - Environmental requirements, for air, spills and waste
  - Environmental training

## Stipulation No. 3. Transportation of Hydrocarbons

Pipelines will be required: (a) if pipeline rights-of-way can be determined and obtained; (b) if laying such pipelines is technologically feasible and environmentally preferable; and (c) if, in the opinion of the lessor, pipelines can be laid without net social loss, taking into account any incremental costs of pipelines over alternative methods of transportation and any incremental benefits in the form of increased environmental protection or reduced multiple-use conflicts. The lessor specifically reserves the right to require that any pipeline used for transporting production to shore be placed in certain designated management areas. In selecting the means of transportation, consideration will be given to recommendations of any Federal, State, and local governments and industry.

Following the development of sufficient pipeline capacity, no crude oil production will be transported by surface vessel from offshore production sites, except in the case of an emergency. Determinations as to emergency conditions and appropriate responses to these conditions will be made by the RS/FO.

### Shell's Actions – Stipulation No. 3

Lease Stipulation No. 3 is not applicable to the activities described by the 2012 Shell Revised Chukchi Sea EP (Shell, 2011a).

## Stipulation No. 4. Industry Site-Specific Monitoring Program for Marine Mammal Subsistence Resources

A lessee proposing to conduct exploration operations, including ancillary seismic surveys, on a lease within the blocks identified below during periods of subsistence use related to bowhead whales, beluga whales, ice seals, walruses, and polar bears will be required to conduct a site-specific monitoring program approved by the RS/FO, unless, based on the size, timing, duration, and scope of the proposed operations, the RS/FO, in consultation with appropriate agencies and co-management organizations, determines that a monitoring program is not necessary. Organizations currently recognized by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) for the co-management of the marine mammals resources are the Alaska Eskimo Whaling Commission, the Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Nanuk Commission. The RS/FO will provide the appropriate agencies and co-management organizations a minimum of 30 calendar days, but no longer than 60 calendar days, to review and comment on a proposed monitoring program prior to Minerals Management Service (MMS) approval. The monitoring program must be approved each year before exploratory drilling operations can be commenced.

The monitoring program will be designed to assess when bowhead and beluga whales, ice seals, walruses, and polar bears are present in the vicinity of lease operations and the extent of behavioral effects on these marine mammals due to these operations. In designing the program, the lessee must consider the potential scope and extent of effects that the type of operation could have on these marine mammals. Experiences relayed by subsistence hunters indicate that, depending on the type of operations, some whales demonstrate avoidance behavior at distances of up to 35 miles. The program must also provide for the following:

1) Recording and reporting information on sighting of the marine mammals of concern and the extent of behavioral effects due to operations;
2) Coordinating the monitoring logistics beforehand with the MMS Bowhead Whale Aerial Survey Project and other mandated aerial monitoring programs;
3) Inviting a local representative, to be determined by consensus of the appropriate co-management organizations, to participate as an observer in the monitoring program;
4) Submitting daily monitoring results to the RS/FO;

5) Submitting a draft report on the results of the monitoring program to the RS/FO within 90 days following the completion of the operation. The RS/FO will distribute this draft report to the appropriate agencies and co-management organizations;
6) Allowing 30 days for independent peer review of the draft monitoring report; and
7) Submitting a final report on the results of the monitoring program to the RS/FO within 30 days after the completion of the independent peer review. The final report will include a discussion of the results of the peer review of the draft report. The RS/FO will distribute this report to the appropriate agencies and co-management organizations.

The RS/FO may extend the report review and submittal timelines if the RS/FO determines such an extension is warranted to accommodate extenuating circumstances.

The lessee will be required to fund an independent peer review of a proposed monitoring plan and the draft report on the results of the monitoring program for bowhead whales. The lessee may be required to fund an independent peer review of a proposed monitoring plan and the draft report on the results of the monitoring program for other co-managed marine mammal resources. This peer review will consist of independent reviewers who have knowledge and experience in statistics, monitoring marine mammal behavior, the type and extent of the proposed operations, and an awareness of traditional knowledge. The peer reviewers will be selected by the RS/FO from experts recommended by the appropriate agencies and co-management resource organizations. The results of these peer reviews will be provided to the RS/FO for consideration in final MMS approval of the monitoring program and the final report, with copies to the appropriate agencies and co-management organizations.

In the event the lessee is seeking a Letter of Authorization (LOA) or Incidental Harassment Authorization (IHA) for incidental take from NMFS and/or FWS, the monitoring program and review process required under the LOA or IHA may satisfy the requirements of this stipulation. The lessee must advise the RS/FO when it is seeking an LOA or IHA in lieu of meeting the requirements of this stipulation and must provide the RS/FO with copies of all pertinent submittals and resulting correspondence. The RS/FO will coordinate with the NMFS and/or FWS and will advise the lessee if the LOA or IHA will meet these requirements.

The MMS, NMFS, and FWS will establish procedures to coordinate results from site-specific surveys required by this stipulation and the LOA's or IHA's to determine if further modification to lease operations are necessary.

This stipulation applies to the following blocks:

**NR02-06, Chukchi Sea:**
6624, 6625, 6674, 6675, 6723-6725, 6773-6775, 6822, 6823, 6872

**NR03-02, Posey:**
6872, 6873, 6918-6923, 6967-6973, 7016-7023, 7063-7073, 7112-7123

**NR03-03, Colbert**
6674, 6723, 6724, 6771-6774, 6820-6824, 6869-6874, 6918-6924, 6966-6974, 7015-7024, 7064-7074, 7113-7124

**NR03-04, Solivik Island**
6011-6023, 6060-6073, 6109-6122, 6157-6171, 6206-6219, 6255-6268, 6305-6317, 6354-6365, 6403-6414, 6453-6462, 6502-6511, 6552-6560, 6601-6609, 6651-6658, 6701-6707, 6751-6756, 6801-6805, 6851-6854, 6901-6903, 6951, 6952, 7001

**NR03-05, Point Lay West**

6014-6024, 6062-6073, 6111-6122, 6160-6171, 6209-6221, 6258-6269, 6307-6317, 6356-6365, 6406-6414, 6455-6462, 6503-6510, 6552-6558, 6602-6606, 6652-6655, 6702, 6703

**NR04-01, Hanna Shoal**
6223, 6267-6273, 6315-6323, 6363-6373, 6411-6423, 6459-6473, 6507-6523, 6556-6573, 6605-6623, 6654-6671, 6703-6721, 6752-6771, 6801-6819, 6851-6868, 6901-6916, 6951-6964, 7001-7010, 7051-7059, 7101-7107

**NR04-02, Barrow**
6003-6022, 6052-6068, 6102-6118, 6151-6164, 6201-6214, 6251-6262, 6301-6312, 6351-6359, 6401-6409, 6451-6456, 6501-6506, 6551, 6552, 6601, 6602

**NR04-03, Wainwright**
6002-6006, 6052, 6053

**NS04-08, (Unnamed)**
6816-6822, 6861-6872, 6910-6922, 6958-6972, 7007-7022, 7055-7072, 7104-7122

This stipulation applies during the time periods for subsistence-harvesting described below for each community.

**Subsistence Whaling and Marine Mammal Hunting Activities by Community**

**Barrow**: Spring bowhead whaling occurs from April to June; Barrow hunters hunt from ice leads from Point Barrow southwestward along the Chukchi Sea coast to the Skull Cliff area. Fall whaling occurs from August to October in an area extending from approximately 10 miles west of Barrow to the east side of Dease Inlet. Beluga whaling occurs from April to June in the spring leads between Point Barrow and Skull Cliff; later in the season, belugas are hunted in open water around the barrier islands off Elson Lagoon. Walrus are harvested from June to September from west of Barrow southwestward to Peard Bay. Polar bear are hunted from October to June generally in the same vicinity used to hunt walrus. Seal hunting occurs mostly in winter, but some open-water sealing is done from the Chukchi coastline east as far as Dease Inlet and Admiralty Bay in the Beaufort Sea.

**Wainwright**: Bowhead whaling occurs from April to June in the spring leads offshore of Wainwright, with whaling camps sometimes as far as 10 to 15 miles from shore. Wainwright hunters hunt beluga whales in the spring lead system from April to June but only if no bowheads are in the area. Later in the summer, from July to August, belugas can be hunted along the coastal lagoon systems. Walrus hunting occurs from July to August at the southern edge of the retreating pack ice. From August to September, walrus can be hunted at local haulouts with the focal area from Milliktagvik north to Point Franklin. Polar bear hunting occurs primarily in the fall and winter around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island.

**Point Lay**: Because Point Lay's location renders it unsuitable for bowhead whaling, beluga whaling is the primary whaling pursuit. Beluga whales are harvested from the middle of June to the middle of July. The hunt is concentrated in Naokak and Kukpowruk Passes south of Point Lay where hunters use boats to herd the whales into the shallow waters of Kasegaluk Lagoon where they are hunted. If the July hunt is unsuccessful, hunters can travel as far north as Utukok Pass and as far south as Cape Beaufort in search of whales. When ice conditions are favorable, Point Lay residents hunt walrus from June to August along the entire length of Kasegaluk Lagoon, south of Icy Cape, and as far as 20 miles offshore. Polar bear are hunted from September to April along the coast, rarely more than 2 miles offshore.

**Point Hope**: Bowhead whales are hunted from March to June from whaling camps along the ice edge south and southeast of the point. The pack-ice lead is rarely more than 6 to 7 miles offshore. Beluga whales are harvested from March to June in the same area used for the bowhead whale hunt. Beluga whales can also be hunted in the open water later in the summer from July to August near the southern shore of Point Hope close to the beaches, as well as areas north of the point as far as Cape Dyer. Walruses are harvested from May to July along the southern shore of the point from Point Hope to Akoviknak Lagoon. Point Hope residents hunt polar bears primarily from January to April and occasionally from October to January in the area south of the point and as far out as 10 miles from shore.

This stipulation will remain in effect until termination or modification by the Department of the Interior after consultation with appropriate agencies.

## Shell's Actions – Stipulation No. 4

In their 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), Shell describes proposed actions to comply with Stipulation No. 4 as follows:

> Although none of the blocks listed in Stipulation No. 4 are included in those planned for exploration drilling in Shell's revised Chukchi Sea EP, Shell will voluntarily submit to the BOEMRE a site-specific 4MP in support of its application for an IHA (Appendix C). Shell plans to be an active participant in future NMFS Open Water meetings and an active participant in the independent peer review of the monitoring plan and reports generated for future activities. The 4MP is located in Appendix D. Since issuance of Stipulation No. 4, Wainwright whaling crews have conducted fall whaling, with the first harvest of a fall bowhead in more than 90 years occurring in October 2010. Wainwright residents have expressed their intent to conduct fall whaling in the future when it is possible to do so. Shell's POC, 4MP, and other mitigation measures are designed to address this change in area subsistence activities.
>
> Shell intends to use contractors based in the North Slope Borough (NSB) and Northwest Arctic Borough (NWAB) that will in turn provide job opportunities to local residents, including recruitment and training of SAs and MMOs. Summaries of key components of the program are presented below.
>
> <u>Marine Mammal Observers</u>
>
> Vessel-based monitoring for marine mammals will be done throughout the period of exploration drilling operations to comply with expected provisions in the IHA and LOA that Shell receives. Those provisions will be implemented during the exploration drilling program by a team of trained MMOs. The presence of MMOs onboard drilling and support vessels will be a core component of compliance with the 4MP. The MMOs will be responsible for collecting basic data on observations of marine mammals and for implementing mitigation measures including vessel avoidance measures and factored into decisions concerning operational shutdown. The observations made by MMOs serve as the primary basis for estimation of impacts to marine mammals. Because their ranks include representatives of the Alaska Native community, the MMOs also serve as an important means of providing local hire and local oversight of the monitoring program. MMOs will be stationed on the drillship, ice management vessel, anchor handler and other drilling support vessels engaged in transit to and between drill sites, exploration drilling, and other operational and intermittent activities to monitor for marine mammals.
>
> <u>Aerial Survey Program</u>
>
> With agreement from hunters in the coastal villages, aerial surveys of coastal areas to approximately 23 mi (37 km) offshore between Point Hope and Point Barrow will begin in early- to mid- July and will continue until exploration drilling operations in the Chukchi Sea are concluded. The objectives of the aerial survey are to collect data on the distribution and abundance of marine mammals in coastal

areas of the eastern Chukchi Sea; and to collect and report data on the distribution, numbers, orientation and behavior of marine mammals, particularly beluga whales, near traditional hunting areas in the eastern Chukchi Sea.

Acoustic Recorders

A combination of acoustic recorder technologies will be employed to document the distribution of marine mammals; the distribution of marine mammals in relation to activities; to add clarity to the characterization of exploration drilling sound levels, character, and propagation; and to document presence of marine mammals in subsistence hunting areas. This will be accomplished by deploying several acoustic recorder buoys in a wide area surrounding the planned locations. Acoustic monitoring instruments have been deployed in the Chukchi Sea in past years in late July. With drilling scheduled to commence in early July, the deployment date would be pushed forward to occur after ice out and before exploration drilling. This is expected to be in late June / early July. Over-wintering sonobuoys have also been located in the proposed exploration drilling area since 2007. In that early drilling related activities would be initiated upon arrival and while the arrays are being deployed, these over-wintered recorders would capture the sound associated with early activities.

Sound Modeling

Sound modeling will be conducted during the exploration drilling program in the Chukchi Sea.

Sound Source Verification

Field measurement sound propagation profiles of vessels and the drillship will be conducted during different operational modes, so as to determine those activities that produce the greatest opportunities for mitigation. Initial sound source verification of the drillship and support vessels will be conducted within five days of arrival at the prospect. Shell will maintain acoustic recorders in the area of exploration drilling activities for the duration of the exploration drilling program.

Additional Studies

Shell plans to participate in additional studies of marine resources in the Chukchi Sea in an effort to gain an understanding of baseline conditions and the distribution of critical resources, to gain an understanding of interactions between industry activities and marine resources, and to contribute to the understanding of resource status and conservation/management needs. The list of potential studies and monitoring projects includes:

- Baseline studies of the air quality, oceanography, sediment chemistry, benthic an planktonic communities, fish, marine birds, and marine mammals in the Burger Prospect area
- Marine mammal distribution and response to industry activities in the northeastern Chukchi Sea
- Participation in, and funding of, walrus and ringed seal tagging studies
- Collection of subsistence use of coastal and offshore waters though a system of Subsistence Advisors
- Drilling waste discharge and benthic community monitoring

With the exception of the discharge monitoring, Shell has been participating in these studies since 2006. Reports summarizing the methods and findings of the studies are listed in Sections 5.0(a), (b), and (c). Discharge monitoring studies Shell expects to conduct are described in Section 10.0.

## Stipulation No. 5. Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other Marine Mammal Subsistence-Harvesting Activities

Exploration and development and production operations shall be conducted in a manner that prevents unreasonable conflicts between the oil and gas industry and subsistence activities. This stipulation applies to exploration, development, and production operations on a lease within the blocks identified below during periods of subsistence use related to bowhead whales, beluga whales, ice seals, walruses, and polar bears. The stipulation also applies to support activities, such as vessel and aircraft traffic, that traverse the blocks listed below or Federal waters landward of the sale during periods of subsistence use regardless of lease location. Transit for human safety emergency situations shall not require adherence to this stipulation.

This stipulation applies to the following blocks:

- **NR02-06, Chukchi Sea**
  6624, 6625, 6674, 6675, 6723-6725, 6773-6775, 6822, 6823, 6872
- **NR03-02, Posey**
  6872, 6873, 6918-6923, 6967-6973, 7016-7023, 7063-7073, 7112-7123
- **NR03-03, Colbert**
  6674, 6723, 6724, 6771-6774, 6820-6824, 6869-6874, 6918-6924, 6966-6974, 7015-7024, 7064-7074, 7113-7124
- **NR03-04, Solivik Island**
  6011-6023, 6060-6073, 6109-6122, 6157-6171, 6206-6219, 6255-6268, 6305-6317, 6354-6365, 6403-6414, 6453-6462, 6502-6511, 6552-6560, 6601-6609, 6651-6658, 6701-6707, 6751-6756, 6801-6805, 6851-6854, 6901-6903, 6951, 6952, 7001
- **NR03-05, Point Lay West**
  6014-6024, 6062-6073, 6111-6122, 6160-6171, 6209-6221, 6258-6269, 6307-6317, 6356-6365, 6406-6414, 6455-6462, 6503-6510, 6552-6558, 6602-6606, 6652-6655, 6702, 6703
- **NR04-01, Hanna Shoal**
  6223, 6267-6273, 6315-6323, 6363-6373, 6411-6423, 6459-6473, 6507-6523, 6556-6573, 6605-6623, 6654-6671, 6703-6721, 6752-6771, 6801-6819, 6851-6868, 6901-6916, 6951-6964, 7001-7010, 7051-7059, 7101-7107
- **NR04-02, Barrow**
  6003-6022, 6052-6068, 6102-6118, 6151-6164, 6201-6214, 6251-6262, 6301-6312, 6351-6359, 6401-6409, 6451-6456, 6501-6506, 6551, 6552, 6601, 6602
- **NR04-03, Wainwright**
  6002-6006, 6052, 6053
- **NS04-08, (Unnamed)**
  6816-6822, 6861-6872, 6910-6922, 6958-6972, 7007-7022, 7055-7072, 7104-7122

Prior to submitting an exploration plan or development and production plan (including associated oil-spill response plans) to the MMS for activities proposed during subsistence-use critical times and locations described below for bowhead whale and other marine mammals, the lessee shall consult with the North Slope Borough, and with directly affected subsistence communities (Barrow, Point Lay, Point Hope, or Wainwright) and co-management organizations to discuss potential conflicts with the siting, timing, and methods of proposed operations and safeguards or mitigating measures that could be implemented by the operator to prevent unreasonable conflicts. Organizations currently recognized by the NMFS and the FWS for the co-management of the marine mammals resources are the Alaska Eskimo Whaling Commission, the Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Nanuk Commission. Through this consultation, the lessee shall make every reasonable effort, including such mechanisms as a conflict avoidance agreement, to assure that exploration, development, and production activities are compatible with whaling and other marine mammal subsistence hunting activities and will not result in unreasonable interference with subsistence harvests.

A discussion of resolutions reached during this consultation process and plans for continued consultation shall be included in the exploration plan or the development and production plan. In particular, the lessee shall show in the plan how its activities, in combination with other activities in the area, will be scheduled and located to prevent unreasonable conflicts with subsistence activities. The lessee shall also include a discussion of multiple or simultaneous operations, such as ice management and seismic activities, that can be expected to occur during operations in order to more accurately assess the potential for any cumulative affects. Communities, individuals, and other entities who were involved in the consultation shall be identified in the plan. The RS/FO shall send a copy of the exploration plan or development and production plan (including associated oil-spill response plans) to the directly affected communities and the appropriate co-management organizations at the time the plans are submitted to the MMS to allow concurrent review and comment as part of the plan approval process.

In the event no agreement is reached between the parties, the lessee, NMFS, FWS, the appropriate co-management organizations, and any communities that could be directly affected by the proposed activity may request that the RS/FO assemble a group consisting of representatives from the parties to specifically address the conflict and attempt to resolve the issues. The RS/FO will invite appropriate parties to a meeting if the RS/FO determines such a meeting is warranted and relevant before making a final determination on the adequacy of the measures taken to prevent unreasonable conflicts with subsistence harvests.

The lessee shall notify the RS/FO of all concerns expressed by subsistence hunters during operations and of steps taken to address such concerns. Activities on a lease may be restricted if the RS/FO determines it is necessary to prevent unreasonable conflicts with local subsistence hunting activities.

In enforcing this stipulation, the RS/FO will work with other agencies and the public to assure that potential conflicts are identified and efforts are taken to avoid these conflicts.

Subsistence-harvesting activities occur generally in the areas and time periods listed below.

**Subsistence Whaling and Marine Mammal Hunting Activities by Community**

**Barrow:** Spring bowhead whaling occurs from April to June; Barrow hunters hunt from ice leads from Point Barrow southwestward along the Chukchi Sea coast to the Skull Cliff area; fall whaling occurs from August to October in an area extending from approximately 10 miles west of Barrow to the east side of Dease Inlet. Beluga whaling occurs from April to June in the spring leads between Point Barrow and Skull Cliff; later in the season, belugas are hunted in open water around the barrier islands off Elson Lagoon. Walrus are harvested from June to September from west of Barrow southwestward to Peard Bay. Polar bear are hunted from October to June generally in the same vicinity used to hunt walruses. Seal hunting occurs mostly in winter, but some open-water sealing is done from the Chukchi coastline east as far as Dease Inlet and Admiralty Bay in the Beaufort Sea.

**Wainwright:** Bowhead whaling occurs from April to June in the spring leads offshore of Wainwright, with whaling camps sometimes as far as 10 to 15 miles from shore. Wainwright hunters hunt beluga whales in the spring lead system from April to June but only if no bowheads are in the area. Later in the summer, from July to August, belugas can be hunted along the coastal lagoon systems. Walrus hunting occurs from July to August at the southern edge of the retreating pack ice.

From August to September, walruses can be hunted at local haulouts with the focal area from Milliktagvik north to Point Franklin. Polar bear hunting occurs primarily in the fall and winter around Icy Cape, at the headland from Point Belcher to Point Franklin, and at Seahorse Island.

**Point Lay:** Because Point Lay's location renders it unsuitable for bowhead whaling, beluga whaling is the primary whaling pursuit. Beluga whales are harvested from the middle of June to the middle of July. The hunt is concentrated in Naokak and Kukpowruk Passes south of Point Lay where hunters use boats to herd the whales into the shallow waters of Kasegaluk Lagoon where they are hunted. If the July hunt is unsuccessful, hunters can travel as far north as Utukok Pass and as far south as Cape Beaufort in search of whales. When ice conditions are favorable, Point Lay residents hunt walruses from June to August along the entire length of Kasegaluk Lagoon, south of Icy Cape, and as far as 20 miles offshore. Polar bears are hunted from September to April along the coast, rarely more than 2 miles offshore.

**Point Hope:** Bowhead whales are hunted from March to June from whaling camps along the ice edge south and southeast of the point. The pack-ice lead is rarely more than 6 to 7 miles offshore. Beluga whales are harvested from March to June in the same area used for the bowhead whale hunt. Beluga whales can also be hunted in the open water later in the summer from July to August near the southern shore of Point Hope close to the beaches, as well as areas north of the point as far as Cape Dyer. Walruses are harvested from May to July along the southern shore of the point from Point Hope to Akoviknak Lagoon. Point Hope residents hunt polar bears primarily from January to April and occasionally from October to January in the area south of the point and as far out as 10 miles from shore.

## Shell's Actions – Stipulation No. 5

In their 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), Shell describes proposed actions to comply with Stipulation No. 5 as follows:

> Shell has actively engaged the NSB, NWAB, and the subsistence communities of Kaktovik, Nuiqsut, Barrow, Wainwright, Point Lay, Point Hope, Kivalina, Kotzebue, Shishmaref, Kiana, Savoonga, and Gambell, and co-management organizations, including the Alaska Eskimo Whaling Commission (AWEC), Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Alaska Nanuuq Commission, to discuss potential conflicts between planned oil and gas activities and subsistence use activities. Shell's EP lease blocks do not lie within the stipulation area, but support activities associated with the exploration drilling program will transit the stipulation area.
>
> <u>Plan of Cooperation</u>
>
> Shell began consulting with potentially affected subsistence communities, stakeholders and federal, state, and local agencies in 2006 and prepared a POC for its Chukchi Sea open water activities (3D seismic activities and vessel transit) in November 2007. Shell continued with these consultations through 2011. Shell will continue to engage with subsistence stakeholders to build on its past efforts to inform and engage the communities that could be potentially affected by exploration drilling activities in the Chukchi Sea. It is also noted that a POC is required for an IHA from the NMFS and USFWS. Since issuance of Stipulation No. 4, Wainwright whaling crews have conducted fall whaling, with the first harvest of a fall bowhead in more than 90 years occurring in October 2010. Wainwright residents have expressed their intent to conduct fall whaling in the future when it is possible to do so. Shell's POC, 4MP, and other mitigation measures are designed to address this change in area subsistence activities.
>
> Shell met with public and community leaders beginning in January-April 2009 specifically to discuss the planned 2010 exploration drilling program in the Chukchi Sea as detailed in the initial Chukchi Sea EP, and to hear their concerns. Shell prepared a written POC based on that effort, which described when and where the meetings were held, what was presented by Shell, the comments received, and Shell's responses to these comments. The POC also identified mitigation measures that Shell prepared

in response to these concerns. A copy of the POC was attached as an appendix to the initial Chukchi Sea EP, and was forwarded to NMFS as part of the IHA requirements. Shell's consultation efforts have continued since that time, and in February-April of 2011, Shell held a series of meetings specifically to discuss the exploration drilling activities outline in the revised Chukchi Sea EP. The dates and locations of the meetings held in 2009, 2010, and 2011 as part of consultation effort associated with exploration drilling in the Chukchi, along with the persons Shell met with, are listed below in Table 11.0-1. Shell has prepared an addendum to the POC submitted with the 2010 Chukchi Sea EP, which provides information on the meetings held specifically to address the revised Chukchi Sea EP. The POC addendum is attached in Appendix H of this document.

Marine Mammal Co-Management Groups

Shell facilitated quarterly meetings with the co-management groups including the AEWC, Alaska Beluga Whale Committee, the Alaska Eskimo Walrus Commission, the Ice Seal Commission, and the Alaska Nanuuq Commission beginning in June 2006, and continues to meet with these groups. Shell met with representatives of these co-management groups again in 2011 to discuss the revised exploration drilling program as indicated above in Table 11.0-1 to inform them of our planned activities and discuss potential conflicts that could arise with regards to the siting, timing, and method of the planned operations as well as mitigation measures designed to avoid or minimize any such effects. Shell also attends the Open Water Meetings held annually, which include the co-management groups AEWC, NMFS, BOEMRE, USFWS, and other industry participants. Shell attended the Open Water Meeting for 2011 in Anchorage on 7-8 March 2011, at which time details regarding the exploration drilling program described in the revised Chukchi Sea EP were discussed.

## Stipulation No. 6. Pre-Booming Requirements for Fuel Transfers

Fuel transfers (excluding gasoline transfers) of 100 barrels or more will require pre-booming of the fuel barge(s). The fuel barge must be surrounded by an oil-spill-containment boom during the entire transfer operation to help reduce any adverse effects from a fuel spill. The lessee's oil spill response plans must include procedures for the pre-transfer booming of the fuel barge(s)**.**

### Shell's Actions – Stipulation No. 6

In their 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), Shell describes proposed actions to comply with Stipulation No. 6 as follows:

A copy of Shell's Fuel Transfer Plan (Alaska Fuel Operating Condition and Standard) is provided in Appendix M. On 7 December 2009, BOEMRE approved the booming configuration presented in the Fuel Transfer Plan submitted with the approved initial Chukchi Sea EP, which is the same as is presented in the attached Fuel Transfer Plan in Appendix M of this revised Chukchi Sea EP. Additional details for fuel transfers are provided in Appendix D of the Chukchi Sea Regional ODPCP. Under Shell's procedures all vessel-to-vessel, and dock-to-vessel transfers of fuel will be pre-boomed during the planned exploration drilling program covered by this revised Chukchi Sea EP.

## Stipulation No. 7. Measures to Minimize Effects to Spectacled and Steller's Eiders During Exploration Activities

This stipulation will minimize the likelihood that spectacled and Steller's eiders will strike drilling structures or vessels. The stipulation also provides additional protection to eiders within the blocks listed below and Federal waters landward of the sale area, including the Ledyard Bay Critical Habitat Area, during times when eiders are present.

**(A) General conditions:** The following conditions apply to all exploration activities.

(1) An EP must include a plan for recording and reporting bird strikes. All bird collisions (with vessels, aircraft, or drilling structures) shall be documented and reported within 3 days to MMS. Minimum information will include species, date/time, location, weather,

identification of the vessel, and aircraft or drilling structure involved and its operational status when the strike occurred. Bird photographs are not required, but would be helpful in verifying species. Lessees are advised that the FWS does not recommend recovery or transport of dead or injured birds due to avian influenza concerns.

(2) The following conditions apply to operations conducted in support of exploratory and delineation drilling.

(a) Surface vessels (e.g., boats, barges) associated with exploration and delineation drilling operations should avoid operating within or traversing the listed blocks or Federal waters between the listed blocks and the coastline between April 15 and June 10, to the maximum extent practicable. If surface vessels must traverse this area during this period, the surface vessel operator will have ready access to wildlife hazing equipment (including at least three *Breco* buoys or similar devices) and personnel trained in its use; hazing equipment may located onboard the vessel or on a nearby oil spill response vessel, or in Point Lay or Wainwright. Lessees are required to provide information regarding their operations within the area upon request of MMS. The MMS may request information regarding number of vessels and their dates of operation within the area.

(b) Except for emergencies or human/navigation safety, surface vessels associated with exploration and delineation drilling operations will avoid travel within the Ledyard Bay Critical Habitat Area between July 1 and November 15. Vessel travel within the Ledyard Bay Critical Habitat Area for emergencies or human/navigation safety shall be reported within 24 hours to MMS.

(c) Aircraft supporting drilling operations will avoid operating below 1,500 feet above sea level over the listed blocks or Federal waters between the listed blocks and the coastline between April 15 and June 10, or the Ledyard Bay Critical Habitat Area between July 1 and November 15, to the maximum extent practicable. If weather prevents attaining this altitude, aircraft will use pre-designated flight routes. Pre-designated flight routes will be established by the lessee and MMS, in collaboration with the FWS, during review of the EP. Route or altitude deviations for emergencies or human safety shall be reported within 24 hours to MMS.

**(B) Lighting Protocols.** The following lighting requirements apply to activities conducted between April 15 and November 15 of each year.

**(1) Drilling Structures:** Lessees must adhere to lighting requirements for all exploration or delineation drilling structures so as to minimize the likelihood that migrating marine and coastal birds will strike these structures. Lessees are required to implement lighting requirements aimed at minimizing the radiation of light outward from exploration or delineation drilling structures to minimize the likelihood that birds will strike those structures. These requirements establish a coordinated process for a performance-based objective rather than pre-determined prescriptive requirements. The performance-based objective is to minimize the radiation of light outward from exploration/delineation structures while operating on a lease or if staged within nearshore Federal waters pending lease deployment.

Measures to be considered include but need not be limited to the following:

- Shading and/or light fixture placement to direct light inward and downward to living and work structures while minimizing light radiating upward and outward;
- Types of lights;

- Adjustment of the number and intensity of lights as needed during specific activities;
- Dark paint colors for selected surfaces;
- Low-reflecting finishes or coverings for selected surfaces; and
- Facility or equipment configuration.

Lessees are encouraged to consider other technical, operational, and management approaches that could be applied to their specific facilities and operations to reduce outward light radiation. Lessees must provide MMS with a written statement of measures that will be or have been taken to meet the lighting objective, and must submit this information with an EP when it is submitted for regulatory review and approval pursuant to 30 CFR 250.203.

**(2) Support Vessels:** Surface support vessels will minimize the use of high-intensity work lights, especially when traversing the listed blocks and federal waters between the listed blocks and the coastline. Exterior 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 will be turned off. Interior lights and lights used during navigation could remain on for safety.

For the purpose of this stipulation, the listed blocks are as follows:

**NR02-06, Chukchi Sea:**
6624, 6625, 6674, 6675, 6723-6725, 6773-6775, 6822, 6823, 6872

**NR03-02, Posey:**
6872, 6873, 6918-6923, 6967-6973, 7016-7023, 7063-7073, 7112-7123

**NR03-03, Colbert**
6674, 6723, 6724, 6771-6774, 6820-6824, 6869-6874, 6918-6924, 6966-6974, 7015-7024, 7064-7074, 7113-7124

**NR03-04, Solivik Island**
6011-6023, 6060-6073, 6109-6122, 6157-6171, 6206-6219, 6255-6268, 6305-6317, 6354-6365, 6403-6414, 6453-6462, 6502-6511, 6552-6560, 6601-6609, 6651-6658, 6701-6707, 6751-6756, 6801-6805, 6851-6854, 6901-6903, 6951, 6952, 7001

**NR03-05, Point Lay West**
6014-6024, 6062-6073, 6111-6122, 6160-6171, 6209-6221, 6258-6269, 6307-6317, 6356-6365, 6406-6414, 6455-6462, 6503-6510, 6552-6558, 6602-6606, 6652-6655, 6702, 6703

**NR04-01, Hanna Shoal**
6223, 6267-6273, 6315-6323, 6363-6373, 6411-6423, 6459-6473, 6507-6523, 6556-6573, 6605-6623, 6654-6671, 6703-6721, 6752-6771, 6801-6819, 6851-6868, 6901-6916, 6951-6964, 7001-7010, 7051-7059, 7101-7107

**NR04-02, Barrow**
6003-6022, 6052-6068, 6102-6118, 6151-6164, 6201-6214, 6251-6262, 6301-6312, 6351-6359, 6401-6409, 6451-6456, 6501-6506, 6551, 6552, 6601, 6602

**NR04-03, Wainwright**
6002-6006, 6052, 6053

**NS04-08, (Unnamed)**
6816-6822, 6861-6872, 6910-6922, 6958-6972, 7007-7022, 7055-7072, 7104-7122

Nothing in this stipulation 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.

## Shell's Actions – Stipulation No. 7

In their 2012 Shell Revised Chukchi Sea EP (Shell, 2011a), Shell describes proposed actions to comply with Stipulation No. 7 as follows:

> Stipulation No.7 has 4 parts. Part A(1) mandates that EP's for exploration drilling anywhere in the Chukchi include a plan for recording and reporting bird strikes, and therefore applies to Shell. Parts A(2) and B(2) place restrictions and lighting requirements on vessel and aircraft operations in certain listed blocks, in federal waters shoreward of those blocks, and in the Ledyard Bay Critical Habitat Unit (LBCHU), during specific dates, and these restrictions would apply to any activities associated with Shell's EP that would take place in these areas during these dates. Part B(1) places lighting requirements on drilling structures and applies to the use of drilling structures anywhere in the Chukchi Sea, and therefore applies to Shell's EP. Part B(2) also places restrictions on the use of lights on support vessels in the listed blocks and federal waters shoreward of these blocks, and these restrictions would apply to any vessel traffic associated with Shell's EP that would occur in these specific areas.
>
> Shell has developed a Bird Strike Avoidance and Lighting Plan (Appendix I) that covers the planned exploration drilling program in the revised Chukchi Sea EP. In development of the plan, Shell considered all the measures identified for consideration in the stipulation, and selected the most proven and practical measures to minimize the likelihood that marine birds will strike the drillship or support vessels. Shell's plan includes:
>
> - Bird strike monitoring will include recording and reporting bird strikes for the collection of information on bird strikes and lighting configuration. This information can be used to better understand methods to reduce bird strikes.
> - Avian monitoring including visual observations and radar assessments to determine bird use of the prospect areas during the drilling season.
> - Installing shading and directing some drillship lights inward and downward to living and work structures to minimize the amount of light radiating from the drillship.
> - Lighting modifications including replacing some lights on the drillship with ClearSky light technology where applicable to reduce the amount of red light output.
> - Minimizing the use of high-intensity work lights on support vessels.
> - Restricting aircraft and vessel traffic such as restrictions on travel routes and flight altitudes, including: the avoidance of travel within the LBCHU between 1 July and 15 November by the drillship and all support vessels.
>
> In addition, Shell plans to conduct both visual and radar assessments of the numbers and species of birds around the drill sites during the operations, and investigate the reactions of the birds to the vessels. This data should aid in the assessment of risk for future programs and provide some indication of the efficacy of the mitigation measures. The risk of Shell's exploration drilling program having an effect on marine birds, especially Steller's eiders and spectacled eiders, due to collisions, is minimal because exploration drilling would occur after the spring migration of most of these species, and more than 64 statute mi (103 km) offshore where the bird presence is relatively low.

## References

Shell. 2011a. 2012 Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea Alaska. Anchorage, AK: Shell Gulf of Mexico Inc. http://alaska.boemre.gov/ref/ProjectHistory/2012_Shell_CK/revisedEP/EP.pdf

# Appendix H

## Worst Case Discharge Verification

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United States Department of the Interior
BUREAU OF OCEAN ENERGY MANAGEMENT
Alaska OCS Region
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

NOV 16 2011

Memorandum

To: Regional Director, Bureau of Safety and Environmental Enforcement (BSEE), Alaska OCS Region
Regional Supervisor, Leasing and Plans, Bureau of Ocean Energy Management (BOEM), Alaska OCS Region
Regional Supervisor, Environment, BOEM, Alaska OCS Region
Christy Bohl, Oil Spill Program Administrator, BSEE, Alaska OCS Region
David M. Moore, Chief, Oil Spill Response Division, BSEE, Herndon

From: Rance R. Wall
Regional Supervisor, Resource Evaluation, BOEM, Alaska OCS Region

Subject: Verification of Worst Case Discharge (WCD) Model for *Shell Gulf of Mexico Inc.* 2011 Chukchi Sea Exploration Plan

**Summary of Worst-Case-Discharge (WCD) Verification Results**

Resource Evaluation (*BOEM*, Alaska OCSR) has conducted a verification of the worst-case-discharge (WCD) model submitted by *Shell Gulf of Mexico Inc* (hereafter *Shell GOMI*) as part of their May, 2011 Chukchi Sea Exploration Plan. The proposed exploration plan includes 6 wells at the Burger structure—the Burger "J", Burger "S", Burger "A", Burger "V", Burger "F", and Burger "R" wells. Of these 6 wells, the Burger J well is presented as offering the highest potential oil discharge rate. Table 1 replicates table 2.g-1 in the public part of the *Shell GOMI* 2011 EP proposal and lists the maximum or "WCD" oil discharge rates for each of the 6 wells.

A gas accumulation, possibly capping an oil accumulation, was discovered at the Burger structure by the Burger 1 well, a two-(open-water) season well that was completed in 1990 (Craig and Sherwood, 2004) on a lease acquired in a 1988 lease offering. The 1988 leases were all relinquished by 1996, but many Burger leases were re-acquired in lease sale 193 in 2008. The Burger 1 well and the six proposed exploration wells are located in figure 1.

*BOEM* concurs with the *Shell GOMI* assertion that the Burger J well offers the highest potential discharge volume in both daily rate and cumulative flow. To validate the *Shell GOMI* WCD model for the Burger J well, *BOEM* used the *AVALON/MERLIN* software to evaluate an independent *BOEM* geological model for the WCD well based upon proprietary seismic data and geological forecasts.

The key finding is that the independent *BOEM* WCD model forecasts an oil WCD rate of 13,091 bbls/day that is considerably less than the *Shell GOMI* oil WCD rate of 23,100 bbls/day. Similarly, the *BOEM* model forecasts cumulative oil discharges over 30-, 34-, and 38-day time periods that are all considerably less than the cumulative discharges forecast by the *Shell GOMI*

WCD model. The *BOEM* and *Shell GOMI* results are compared in table 2. **The *Shell GOMI* worst-case-discharge model for the Burger J well in the 2011 Chukchi Sea exploration plan is therefore verified as a "worst case" by the independent *BOEM* WCD model.**

**Geological Setting of Burger J Well**

The Burger J well proposes to test the south flank of the Burger structure and a possible extension of a hydrocarbon accumulation discovered in 1990 by the Burger 1 (OCS Y-1413-1) well. The Burger structure is approximately 25 miles in diameter and covers nearly 200,000 acres within closure (i.e., potential hydrocarbon capture area within prospect) (Craig and Sherwood, 2004, p. 1 and pl. 2). Although the 1990 well encountered a gas accumulation and recovered some gas samples with liquids, it left many questions unanswered about the contents of the greater structure at distance from the well.

The Burger 1 well encountered two gas-bearing sandstones. The uppermost gas sandstone was encountered at about 2,000 ft (measured) within the Cretaceous (Albian or 100-112 millions of years old [Ma.])-age Nanushuk Group (numerical age brackets from Walker and Geissman, 2009). The deeper gas sandstone at 5,560 ft (measured) forms the key discovery at Burger and is informally termed the "Burger" sandstone. The Burger sandstone appears to be Valanginian (or 136-140 Ma.) in age (Mickey et al., 2006), somewhat older than the closely analogous Hauterivian-age (130-136 Ma.) Kuparuk sandstone that forms the principal oil reservoir in the 2.76-billion-barrel Kuparuk oil field (AKDOG, 2009) west of Prudhoe Bay.

The Burger sandstone is 107 ft in thickness and Craig and Sherwood (2004) estimated that 86 ft or 80% of the sandstone contains gas in sufficient saturations to support flow into a wellbore. Alternate assumptions and threshold criteria in subsequent *BOEM* reservoir models indicate that the aggregate thickness of hydrocarbon flow units could exceed 90 ft. No flow tests were conducted on the Burger sandstone although wireline "RFT" devices (termed "repeat formation testers" that extend probes into the wall of the wellbore and capture small quantities of pore fluids) recovered natural gas and petroleum liquids.

The recovered Burger sandstone petroleum liquids range from 32-57°API and appear to reside primarily in solution in the gas. Gas wetness (ratios of large-carbon-number gas molecules to methane [C1]) are elevated in the rock column beneath the Burger sandstone in the Burger 1 well, as shown in figure 2. Core samples indicate a high level of residual oil trapped within the Burger sandstone (fig. 3) and some ratios among gases (methane, ethane, butane, etc.) suggest that the gas may be in contact with free oil (Craig and Sherwood, 2004, fig. 17). Certain wireline log responses suggest free liquid saturations in the lower part of the Burger sandstone although alternate interpretations related to rock composition may explain log responses that mimic liquid saturations (Craig and Sherwood, 2004, fig. 6). These observations have spurred speculations that an oil pool exists beneath the gas encountered in the upper part of the Burger sandstone at the Burger 1 well. The *BOEM* worst-case-discharge model is constructed around an (unproven) assumption of the existence of an oil-saturated Burger sandstone at the Burger J well.

The porosity and permeability of the Burger sandstone were documented by a series of 16 rotary sidewall cores obtained in the Burger 1 well. The core porosity and permeability data are charted in figure 4. Two data groups are observed, corresponding to an upper sand member with excellent reservoir quality and a lower "muddy" sand member with diminished reservoir quality owing to the presence of detrital clays. Sherwood (2011) used the core data to calibrate a log-based model for the porosity and permeability of the Burger sandstone, shown in figure 5. The arithmetic averages (porosity, 0.271; permeability, 249 mD) of the "pay"[1] zones in the log-based models were extended to the WCD reservoir modeled for the proposed Burger J exploration well and are among the WCD input data listed in table 3.

Samples of gas and petroleum liquids were captured from the Burger sandstone at 3 depth points by RFT devices and petroleum liquids were extracted by solvents from several rotary sidewall core samples. These petroleum liquids are believed to be mostly "condensate" that resides in solution in the gas and separates from the gas when lifted to surface pressure and temperature. As shown in table 4, the API gravities of the recovered liquids range from 57.2° down to a minimum of 32°. Many of the analyses of sidewall cores reported high residual oil saturations, as shown in figure 3, but the recovered quantities were too small for gravity determinations. The RFT recoveries of liquids with API gravity <40° API could include some of the residual oil widely noted in the sidewall cores. Analyses for carbon-13 isotopes of RFT liquids and the liquids extracted from sidewall core samples are listed in table 4 and charted in figure 6. The carbon-13 isotope data for the Burger petroleum liquids plot near the 36°-37.2° API gravity oils of Umiat field and imply a correlative source or thermal history; the association further suggests a high gravity for the residual oil in the Burger sandstone and the hypothetical oil column beneath the gas. A 35.3° API gravity oil was recovered at the Klondike 1 well, but figure 6 shows that the Klondike oil is quite different from the Burger liquid petroleum in terms of carbon-13 isotopes. In the end, the gravity of the residual oil in the Burger sandstone is not explicitly known and the gravity of a hypothetical oil column beneath the gas remains a matter for speculation. Because the lowest gravity oil recovered in the Burger 1 well was a 32° API oil recovered with gas in the upper, gas-charged sand member, it seems likely that the gravity of the residual oil and perhaps the hypothetical oil column beneath the gas is somewhat less than 32° API. For purposes of WCD modeling of the Burger J well, an oil of 30° API gravity was assumed.

## The Gemini Solutions *AVALON/MERLIN* Computer Model for Worst-Case Discharge

The computer model used to forecast the flow of fluids out of the Burger J well is a state-of-the-art proprietary commercial program by *Gemini Solutions, Inc.*, of Richmond, Texas (http://www.geminisi.com/). The program is constructed as a desktop finite-difference simulator that divides the active flow system into many small cells and then iterates through time-increments of flow with mathematical re-assessments that successively modify the state of each cell in the flow system. Cells may be defined in radial or Cartesian coordinates and both types of models are typically tested and compared. Finite-difference models use approximations to relevant differential equations to calculate changes (e.g., pressures, fluid saturations, etc. in the case of fluid flow) within each cell. The incremental approach minimizes approximation errors by confining individual calculations to small, individual cells and makes it possible to quantify behavior across complex systems with internal discontinuities (e.g., flow from reservoir to open well to casing to production manifold to pipeline, etc.). The model is robust, offering the

---

[1] *"pay" zones have hydrocarbon saturations (ratio of hydrocarbon to brine) sufficiently high to permit the flow of hydrocarbons out of rock pores and to the wellbore. In this model the adopted threshold for "pay" is a 40% hydrocarbon (oil or gas) pore saturation (Sherwood, 2011, p.14).*

capability to model fluid behavior through fundamental compositional data or through measured physical properties that can be used to forecast (through correlations) other properties.

The *Gemini Solutions Inc* model consists of two components, "*AVALON*" and "*MERLIN*", that respectively simulate: 1) flow up a system of tubular passages (or "tubulars"); and 2) inflow (into the bottom of a well) from a pressurized porous reservoir. The correlative capacities of these two components of the flow system determine the discharge rate that can be achieved through the exit point at the top of the well.

In theory, the maximum possible discharge rate can be limited by either the aggregate outflow capacity of the tubulars or by the reservoir inflow capacity at the base of the well. In the design of development wells and take-away pipelines, these two components of the flow system, the tubulars and the reservoir, are balanced to achieve the most efficient long-term recovery of formation hydrocarbons from the field. For a high-yield reservoir the outflow discharge rate is usually limited by the choke effect of wellbore tubulars that are insufficient to accommodate the maximum potential inflow from the reservoir.

The capacity for flow up the open (uncased) wellbore and the casing is governed by the tubular sizes (diameter and length), roughness, frictional resistance, the driving formation pressure, and the density characteristics and thermal effects of the multiphase oil-gas-water mix (ranging from gassy liquid(s) to wet gas) moving upward through the wellbore. Flowing bottom-hole pressures at the base of the tubulars are likewise a function of the aggregate density of the multiphase wellbore fluids, frictional and gravitational resistance to flow, ambient pressure (wellhead exterior), and reservoir pressure.

The inflow from the reservoir formation is chiefly governed by flowing bottom-hole pressure, pore system size and connectivity, formation pressure, drive mechanism, fluid compositions, fluid properties at reservoir conditions of pressure and temperature, and the length of the wellbore segment passing through the reservoir formation. The geological model for inflow is discussed further below in order to illustrate how key geological variables control discharge rate.

**Darcy Radial Flow Equation and Sources of Basic Data for Burger J WCD Model**

The most important variables for the reservoir inflow component of the discharge model include the aggregate thickness of flow units (h), initial (pore) pressure ($p_i$), flowing bottom-hole pressure ($p_{wf}$), and permeability-to-oil ($k_o$) of the reservoir formation. Inflow rates are particularly sensitive to permeability, which at extremes can vary across 7 orders of magnitude (0.01-10,000 mD) or greater. Other important variables include oil viscosity ($\mu_o$) and oil formation volume factor ($B_{oi}$), which can vary by several factors. Possible quantitative ranges for variables are listed in the key below the following equation to convey a sense of variance among the key variables and relative sensitivities to outcome.

At any particular instance, the flow of fluids out of a reservoir and into a well, or "inflow", is grossly governed by the Darcy radial flow equation, as summarized in its simplest form for an oil reservoir below. The purpose of including the equation here is to illustrate the roles of the key variables in determining oil flow rate, denoted in the convention of petroleum engineers as "$q_o$". Note that in the basic Darcy equation the discharge-limiting constraint imposed by the wellbore tubular system is represented only by the assumed bottom-hole flowing pressure ($p_{wf}$). In practice, the latter is supplied by the *AVALON* analysis of the system of tubulars from the reservoir to the surface. As can be seen in the Darcy radial flow equation, $p_{wf}$ acts to oppose inflow; when $p_{wf} = p_i$, the inflow rate ($q_o$) is zero.

Darcy radial flow *(steady-state) equation from Ahmed (2010, p. 435, equation 6-144)*

$$q_o = \frac{0.00708 * k_o * h * (p_i - p_{wf})}{\mu_o * B_{oi} * ((\ln r_e/r_w) + S)}$$

where

$q_o$= oil flow rate, barrels/day;
$k_o$=permeability to oil, mD, typically 0.01- >10,000 mD;
h= thickness, ft, typically 10-200 ft;
$p_i$ = initial reservoir pore pressure, psi, typically 1,500-20,000 psi;
$p_{wf}$ = bottom-hole flowing pressure, psi, typically 300-8,000 psi;
$\mu_o$ = oil viscosity, cp, typically 0.1 to 30.0 cp;
$B_{oi}$ = oil formation volume factor, reservoir bbls per stock-tank bbl, typically 1.0-3.0;
$r_e$ = drainage radius, ft, typically 1,000-60,000 ft;
$r_w$ = radius of well, ft, typically 0.35 to 0.73 ft;
S = skin factor, dimensionless, typically 0-500.

Many other variables of lesser importance that do not appear in the Darcy radial flow equation are required for the *AVALON/MERLIN* reservoir inflow simulator. Table 3 summarizes some of the key reservoir and fluid properties and model parameters that formed the input data to the reservoir inflow model. Variables that appear in the Darcy radial flow equation above are highlighted.

In the Burger J well discharge model, no factors related to the near-wellbore alteration of the reservoir formation that might limit flow rate or arrest the discharge were incorporated into the model. The "skin factor (S)" shown in the Darcy radial flow equation above usually quantifies the plugging of reservoir pores (by drilling fluid solids) that often accompanies the drilling of a well; for the Burger J model "S" is set to zero (no effect on discharge rate). Furthermore, the *BOEM* WCD model assumes that no "bridging" or collapse of the open segment of the wellbore is present to restrict or terminate flow. And, no near-wellbore reservoir boundaries (such as faults) are invoked to limit the potential drainage area.

Reservoir pressure and temperature are forecast from data collected in the Burger 1 well located 8.5 statute miles northeast of the Burger J location (fig. 1). The tracing of the Burger sandstone reservoir formation to the Burger J location is accomplished by extending associated seismic reflection(s) away from the Burger 1 well through a grid of proprietary seismic data. Estimates for reservoir porosity and permeability are based on core and log data from the Burger 1 well.

The gross thickness of the Burger sandstone at the Burger J location is extrapolated from the Burger 1 well. The fraction (here, 85%) of the gross sandstone interval that offers sufficient porosity and permeability to flow hydrocarbons to a wellbore is estimated to be 91 ft, which forms the "h" value or the aggregate thickness of flow units for the Burger J WCD model.

The WCD oil saturation model is based on the maximum hydrocarbon saturation obtained by log calculations for the Burger sandstone at the Burger 1 well. The WCD well is modeled as in possible pressure communication with an area within a radius of 43,000 ft of the well, although the actual area of pressure support during the 90-day event is apparently within a radius of less than 1,500 ft.[2]

The oil discharged from the Burger J well is assumed to be 30° API crude oil on the basis of observations discussed above. The oil in the Burger J reservoir is assumed to be saturated (contains the maximum amount of dissolved gas possible at the inferred reservoir temperature and pressure). Therefore, the bubble-point pressure (pressure at which dissolved gas breaks out of solution and forms bubbles in the oil) is assumed to equal the initial reservoir pressure ($p_i$). The pressure-temperature model, the assumed oil gravity, and the assumption of saturation then lead through various correlations and calculations to estimates for $B_{oi}$ (oil volume factor, in reservoir barrels [rb] per surface or "stock tank" barrel [stb]), Rsi (dissolved gas content, in surface or standard cubic ft [scf] per stock tank barrel [stb]), $\mu_o$ (oil viscosity, in centipoise [cp]), reservoir oil density (g/cm$^3$), and static pressure gradient for reservoir oil (in psi/ft). Most of the fluid and rock parameters were obtained through the use of industry-accepted correlations as published by many sources including Craft and Hawkins (1959), Craft et al. (1991), Standing (1977, and other references therein), McCain (1973, and references therein), and Ahmed (2010, and many references therein).

The drive mechanism for the oil discharge is assumed to be pressure depletion and expansion of a gas cap and exsolved solution gas. The estimate for specific gas gravity is based on analyses of gas samples obtained by RFT sampling of pore fluids at the Burger 1 well. Estimates for fluid and rock compressibility are based upon assumptions about rock consolidation, porosity, pressure, temperature, dissolved gas content, relative fluid saturations, and brine composition. The brine salinity is based on formation waters recovered in an RFT sample at the Burger 1 well. The estimate for brine viscosity is based upon the salinity assumption and reservoir temperature.

The Burger J WCD model adopted a system of radial cells with an initial (innermost) cell radius of 12 ft. Outward from the well, cell radii progressively enlarge approximately 15% for each cell increment (15% wider than the adjacent inner cell).

**Comparison of Worst-Case-Discharge Modeling Results**

The *BOEM* WCD model for discharges at the Burger J well incorporates flow from an oil-bearing Burger sandstone that is speculated to be penetrated by the open-hole part of the well. Gas in proportion to oil is also discharged. Water discharge is negligible. The results of the *Shell GOMI* and *BOEM* WCD models, including cumulative oil and gas discharges at 15, 30, 34, 38, and 90 days are summarized in table 2. The *Shell GOMI* forecasts for maximum (WCD) discharge rate and cumulative oil discharge are considerably greater at all points of comparison through the flow period.

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[2] *Based upon model runs of various drainage areas that produced negligible differences in flow.*

***BOEM* WCD Model for the Burger J Well**

A comprehensive discharge schedule for the Burger J *BOEM* WCD model over a 90-day period is reported in tables 5a and 5b. Figure 7 provides a chart that illustrates the flow patterns among selected elements of tables 5a and 5b.

Following the blowout, the oil discharge in the *BOEM* model climbs rapidly to a maximum daily rate of 13,091 bbls/day over the course of day 1. After peaking in day 1, figure 7 shows that the oil discharge rate in the *BOEM* model declines abruptly (overall, 14.5% per day[3]) through the first 3 days of flow, moderately (overall, 1.1% per day) from day 3 to day 18, and thereafter declining more slowly (overall, 0.15% per day) out to 90 days. The overall annualized oil discharge decline rate over 90 days is approximately 95%/year.

Some key timelines and cumulative oil discharge estimates follow (also listed in tbls. 2, 5a and 5b):

- At the end of day 15, the cumulative oil discharge reported in the *BOEM* WCD model is 121,779 bbls. *Shell GOMI* does not publicly provide a discharge quantity at day 15.

- At the end of day 30, the cumulative oil discharge reported in the *BOEM* WCD model is 226,145 bbls. *Shell GOMI* does not publicly provide a WCD discharge quantity at day 30. *Shell GOMI* instead adopts a quantity of 750,000 bbls at day 30 (Shell, 2011, tbl. 8.d-1, p. 8-2) as the basis for their Oil Discharge Prevention and Contingency Plan (ODPCP). This quantity is considerably larger than the actual modeled discharges at 34 and 38 days, reported below and in table 2.

- At the end of day 34, the cumulative oil discharge reported in the *BOEM* WCD model is 253,234 bbls whereas the *Shell GOMI* WCD model reports a cumulative discharge of 603,564 bbls (Shell, 2011, tbl. 8.d-2, p. 8-3).

- At the end of day 38, the cumulative oil discharge reported in the *BOEM* WCD model is 279,954 bbls whereas the *Shell GOMI* WCD model reports a cumulative discharge of 669,479 bbls (Shell, 2011, tbl. 8.d-2, p. 8-3).

- Finally, at the end of day 90, the cumulative oil discharge reported in the *BOEMRE* WCD model is 613,076 bbls. *Shell GOMI* does not report a 90-day cumulative oil discharge.

Also shown in tables 2, 5a, and 5b are the substantial cumulative gas discharges from the Burger J WCD event. At the end of day 15, the cumulative gas discharge reported in the *BOEM* WCD model is $60{,}161*10^3$ cubic feet (by convention reported as 60,161 Mcf). At the end of day 30, the cumulative gas discharge reported in the *BOEM* WCD model is 113,426 Mcf. At the end of day 34, the cumulative gas discharge reported in the *BOEM* WCD model is 127,185 Mcf. At the end of day 38, the cumulative gas discharge reported in the *BOEM* WCD model is 140,821 Mcf. And, at the end of day 90, the cumulative gas discharge reported in the *BOEM* WCD model is 311,739 Mcf.

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[3] *Calculated as: decline (fraction per day) = [(final rate/initial rate)^(1/number of days)] - 1*

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If you have any questions, please contact myself (907-334-5321), Robert Peterson (907-334-5340), Kirk Sherwood (907-334-5337), or Michael Lu (907-334-5335).

Attachments

cc: Chief, REAS
Chief, RAS
K. Sherwood
M. Lu

**Table 1: Shell Offshore Inc Calculated WCD Oil Discharge Rates, 2011 Chukchi Sea EP**

| Potential Well | Calculated Worst Case Discharge (bbls/day) |
|---|---|
| Burger J | 23,100 |
| Burger S | 19,127 |
| Burger A | 19,031 |
| Burger V | 13,812 |
| Burger F | 11,763 |
| Burger R | 8,689 |

*data from table 2.g-1 (public version) of revised Shell GOMI Chukchi Sea Exploration Plan as received 11 oct'11 by BOEM-Anchorage. Highlighted well is worst-case-discharge well for the exploration plan.*

**Table 2. Comparison of Worst-Case-Discharge Modeling Results for Burger J Well**

| WCD Model-Oil | Maximum Daily Oil Rate (bbls/day) | Cumulative Oil Discharge at Day 15 (bbls) | Cumulative Oil Discharge at Day 30 (bbls) | Cumulative Oil Discharge at Day 34 (bbls) | Cumulative Oil Discharge at Day 38 (bbls) | Cumulative Oil Discharge at Day 90 (bbls) |
|---|---|---|---|---|---|---|
| *Shell GOMI* | 23,100* | Proprietary | 750,000** | 603,564*** | 669,479*** | Not Reported |
| *BOEM* | 13,091 | 121,779 | 226,145 | 253,234 | 279,954 | 613,076 |
| **WCD Model-Water** | **Maximum Daily Water Rate (bbls/d)** | **Cumulative Water Discharge at Day 15 (bbls)** | **Cumulative Water Discharge at Day 30 (bbls)** | **Cumulative Water Discharge at Day 34 (bbls)** | **Cumulative Water Discharge at Day 38 (bbls)** | **Cumulative Water Discharge at Day 90 (bbls)** |
| *Shell GOMI* | Proprietary | Proprietary | Proprietary | Proprietary | Proprietary | Not Reported |
| *BOEM* | 0 | 0 | 0 | 0 | 0 | 0 |
| **WCD Model-Gas** | **Maximum Daily Gas Rate (Mcf/day)** | **Cumulative Gas Discharge at Day 15 (Mcf)** | **Cumulative Gas Discharge at Day 30 (Mcf)** | **Cumulative Gas Discharge at Day 34 (Mcf)** | **Cumulative Gas Discharge at Day 38 (Mcf)** | **Cumulative Gas Discharge at Day 90 (Mcf)** |
| *Shell GOMI* | Proprietary | Proprietary | Proprietary | Proprietary | Proprietary | Not Reported |
| *BOEM* | 5,634 | 60,161 | 113,426 | 127,185 | 140,821 | 311,739 |

*bbls= barrels; Mcf=1,000 standard cubic feet (measured at standard conditions of 1 atmosphere and 60°F).*

* the *Shell GOMI* oil WCD rate declines over the discharge period as reported in proprietary section 3.0 of the exploration plan.

** the 30-day cumulative volume of 750,000 bbls is proposed by *Shell GOMI* for purposes of developing an Oil Discharge Prevention and Contingency Plan (ODPCP). The 30-day volume is calculated for the ODPCP by assuming a worst-case daily volume of 25,000 bbls/d held constant over 30 days (25,000*30=750,000) as noted in table 8.d-1 on page 8-2 of the *Shell GOMI* Chukchi Sea exploration plan.

*** these values are WCD model cumulative volumes excerpted (by *Shell GOMI*) from proprietary section 3.0 and made public in table 8.d-2 on page 8-3 of the Chukchi Sea exploration plan. Note that these values are exceeded by the 750,000 bbls developed by *Shell GOMI* as the basis for their Oil Discharge Prevention and Contingency Plan (ODPCP) in the Chukchi Sea exploration plan.

**Table 3. Summary of Selected Model Input Data for *BOEM* WCD Model for Burger J Well**

| | | | |
|---|---|---|---|
| Initial Reservoir Pressure (**$p_i$**, psi) | 3,186 | Oil Gravity (°API) | 30 |
| Flowing Bottom-Hole Pressure (**$p_{wf}$**, psi) - Modeled by *AVALON/MERLIN* | ~1,000 | Initial **Boi** or FVF (reservoir volume/standard volume) | 1.27 |
| Reservoir Temperature, °F (°R) | 138 (598) | Initial Rsi or GOR (standard cubic feet/surface or standard bbl) | 579 |
| Reservoir Porosity (fraction of rock) | 0.27 | Bubble Point Pressure (psi) | 3,186 |
| Reservoir Horizontal Permeability (**k**, mD) | 249 | Dead (Gas-Free) Oil Viscosity at Standard (Surface) Conditions (**$\mu_{OD}$**, cp) | 5.86 |
| Reservoir Vertical Permeability (**k**, mD) | 25 | Oil Viscosity (**$\mu_O$**, cp) | 1.28 |
| Aggregate Thickness Flow Units (**h**, ft) | 91 | Skin Factor (**S**) | 0 |
| Drainage Radius (**$r_e$**, ft) | 43,000 | Reservoir Oil Density (g/cm$^3$) | 0.778 |
| Well Radius at Reservoir (**$r_W$**, ft) | 0.35-0.52 | Static Pressure Gradient of Reservoir Oil (psi/ft) | 0.337 |
| Initial Oil Saturation (fraction of porosity) | 0.81 | Specific Gas Gravity (Air=1.0) | 0.6 |
| Residual Oil to Gas (fraction) | 0.30 | Formation Compressibility, Cf (microsips or v/v/psi*10$^{-6}$) | 2.9 |
| Residual Oil to Water (fraction) | 0.30 | Oil Compressibility, Co (microsips or v/v/psi*10$^{-6}$) | 9.7 |
| Critical Gas Saturation | 0.10 | Brine Compressibility, Cw (microsips or v/v/psi*10$^{-6}$) | 3 |
| Endpoint for Oil Relative Permeability Curve (kro, fraction of "k") | 0.90 | Total Compressibility, Ct (microsips or v/v/psi*10$^{-6}$) | 11.2 |
| Endpoint for Water Relative Permeability Curve (krw, fraction of "k") | 0.15 | Brine Salinity (ppm NaCl) | 37,700 |
| Endpoint for Gas Relative Permeability Curve (krg, fraction of "k") | 1.00 | Brine Viscosity (cp) | 0.53 |
| Exponent for Oil-Water Relative Permeability Curve ($n_{OW}$, a curve shape factor) | 3.5 | Water Volume Factor ($B_W$, reservoir volume/standard volume) | 1.012 |
| Exponent for Oil-Gas Relative Permeability Curve ($n_{OG}$, a curve shape factor) | 3.5 | Assumed Casing Roughness (inches) | 0.0018 |
| Exponent for Water Relative Permeability Curve ($n_W$, a curve shape factor) | 3.5 | Assumed Open-Hole Roughness (inches) | 0.1 |
| Exponent for Gas Relative Permeability Curve ($n_G$, a curve shape factor) | 3.5 | Ambient Wellhead Temperature (°F) | 30 |

*psi, pounds per square inch; °R, °Rankine (=°F+460); Boi, oil volume factor (aka FVF or formation volume factor); rb/stb, reservoir barrels per stock-tank barrel of oil (at 1 atmosphere and 60°F); Rsi, gas saturation (aka GOR or gas-oil ratio); scf/stb, standard cubic feet of gas per stock-tank barrel of oil (at 1 atmosphere and 60°F); cp, centipoise. Highlighted (yellow) variables appear in the Darcy radial flow equation.*

## Table 4: Burger 1 Oil & Condensate Geochemistry and $\Delta^{13}C$ Isotopes

| Formation | Sample Source | Sample Depth | Sample Fraction | Shell Sample No. | API Gravity | Sulfur % | Saturates-Carbon Isotope ($\Delta^{13}C$) | Aromatics-Carbon Isotopes ($\Delta^{13}C$) | Whole Oil/Extract-Carbon Isotopes ($\Delta^{13}C$) |
|---|---|---|---|---|---|---|---|---|---|
| Burger SS | RFT 4 | 5586 ft md | PSRD 995 | AKO-0-178A | 44.1 | nr | -27.34 | -26.73 | -28.20 |
| Burger SS | RFT 4 | 5586 ft md | PSRD 1730 | AKO-0-177A | 39.4 | 0.06 | -27.27 | -26.94 | -27.95 |
| Burger SS | RFT 4 | 5586 ft md | | AKO-0-175C | 32 | nr | nr | nr | nr |
| Burger SS | RFT 6 | 5606 ft md | nr | AKO-0-176A | 54.7 | 0.04 | -28.53 | -27.45 | -28.48 |
| Burger SS | RFT 8 | 5648 ft md | RFS-BC 1141 | AKO-0-186 | 51.3 | nr | -28.38 | -27.15 | -28.63 |
| Burger SS | RFT 8 | 5648 ft md | Cylinder 1080 | AKO-0-185 | 57.2 | nr | nr | nr | -28.66 |
| Burger SS | RFT 6 | 5606 ft md | Sond Oil/Lab | AKO-O-179A | nr | nr | -28.57 | -28.64 | -27.77 |
| Burger SS | na | na | Extract Mud Additives | AKO-S-6462 | nr | nr | -27.89 | -27.48 | -27.59 |
| Burger SS | SWC Extract | 5581-5594 ft md | Combined from rotary swc's 7 (5581 ft), 6 (5586 ft), and 5 (5594 ft) | AKO-S-6494 | nr | nr | -28.55 | -27.81 | -28.41 |
| Burger SS | SWC Extract | 5605-5610 ft md | Combined from rotary swc's 9 (5606 ft) and 10 (5610 ft) | AKO-S-6495 | nr | nr | -28.76 | -27.29 | -28.06 |
| Burger SS | SWC Extract | 5644-5647 ft md | Combined from rotary swc's 14 (5644 ft), 2 (5646 ft), and 23 (5647 ft) | AKO-S-6755 | nr | nr | -28.64 | -27.55 | -28.19 |
| Burger SS | SWC Extract | 5,624 ft md | Extract/RSWC | AKO-S-6821 | nr | 0.26 | nr | nr | nr |
| Burger SS | SWC Extract | 5,644 ft md | Extract/RSWC | AKO-S-6825 | nr | 0.2 | nr | nr | nr |
| Burger SS | SWC Extract | 5,644 ft md | Extract/RSWC | AKO-S-6825 | nr | 0.23 | nr | nr | nr |
| Valanginian SS | SWC Extract | 6157-6178 ft md | Combined from rotary swc's 20 (6157 ft), 16 (6167 ft), and 17 (6178 ft) | AKO-S-6756 | nr | nr | -29.11 | -27.91 | -28.72 |

**Table 5a.** ***BOEM*** **Worst-Case Discharge Model Results for Burger J Well, Chukchi Sea, Alaska**
***Flow Period Day 1 to Day 40; Radial Coordinate Cell System; Innermost Radius = 12 ft***

| Discharge Period (days) | Oil Discharge Rate (bbls/day) | Gas Discharge Rate (Mcf/day) | Water Discharge Rate (bbls/day) | Producing Gas-Oil Ratio (scf/bbl) | Cumulative Oil Discharge (bbls) | Cumulative Gas Discharge (Mcf) | Cumulative Water Discharge (bbls) | Flowing Bottom-Hole Pressure (psia) at Center of Reservoir | Reservoir Pressure in Cell Containing Well (psia) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3,186 |
| 1 | 13,091 | 5,634 | 0 | 430 | 13,091 | 5,634 | 0 | 1,062 | 2,216 |
| 2 | 8,900 | 4,235 | 0 | 476 | 21,991 | 9,869 | 0 | 992 | 2,110 |
| 3 | 8,196 | 4,197 | 0 | 512 | 30,187 | 14,066 | 0 | 985 | 2,097 |
| 4 | 8,088 | 4,130 | 0 | 511 | 38,275 | 18,196 | 0 | 987 | 2,088 |
| 5 | 7,995 | 4,064 | 0 | 508 | 46,270 | 22,260 | 0 | 990 | 2,080 |
| 6 | 7,913 | 4,003 | 0 | 506 | 54,183 | 26,263 | 0 | 992 | 2,073 |
| 7 | 7,835 | 3,948 | 0 | 504 | 62,018 | 30,211 | 0 | 995 | 2,065 |
| 8 | 7,757 | 3,897 | 0 | 502 | 69,775 | 34,108 | 0 | 995 | 2,057 |
| 9 | 7,676 | 3,843 | 0 | 501 | 77,451 | 37,951 | 0 | 999 | 2,052 |
| 10 | 7,597 | 3,793 | 0 | 499 | 85,048 | 41,744 | 0 | 1,002 | 2,045 |
| 11 | 7,528 | 3,751 | 0 | 498 | 92,576 | 45,495 | 0 | 999 | 2,036 |
| 12 | 7,455 | 3,711 | 0 | 498 | 100,031 | 49,206 | 0 | 996 | 2,026 |
| 13 | 7,330 | 3,666 | 0 | 500 | 107,361 | 52,872 | 0 | 996 | 2,020 |
| 14 | 7,244 | 3,649 | 0 | 504 | 114,605 | 56,521 | 0 | 994 | 2,013 |
| 15 | 7,174 | 3,640 | 0 | 507 | 121,779 | 60,161 | 0 | 991 | 2,008 |
| 16 | 7,100 | 3,639 | 0 | 513 | 128,879 | 63,800 | 0 | 984 | 2,005 |
| 17 | 7,128 | 3,599 | 0 | 505 | 136,007 | 67,399 | 0 | 990 | 2,004 |
| 18 | 6,969 | 3,624 | 0 | 520 | 142,976 | 71,023 | 0 | 994 | 2,002 |
| 19 | 7,031 | 3,599 | 0 | 512 | 150,007 | 74,622 | 0 | 984 | 1,995 |
| 20 | 7,012 | 3,589 | 0 | 512 | 157,019 | 78,211 | 0 | 985 | 1,993 |
| 21 | 6,991 | 3,578 | 0 | 512 | 164,010 | 81,789 | 0 | 984 | 1,992 |
| 22 | 6,964 | 3,561 | 0 | 511 | 170,974 | 85,350 | 0 | 988 | 1,992 |
| 23 | 6,980 | 3,553 | 0 | 509 | 177,954 | 88,903 | 0 | 985 | 1,989 |
| 24 | 6,887 | 3,556 | 0 | 516 | 184,841 | 92,459 | 0 | 988 | 1,987 |
| 25 | 6,947 | 3,511 | 0 | 505 | 191,788 | 95,970 | 0 | 987 | 1,984 |
| 26 | 6,901 | 3,515 | 0 | 509 | 198,689 | 99,485 | 0 | 987 | 1,983 |
| 27 | 6,886 | 3,503 | 0 | 509 | 205,575 | 102,988 | 0 | 988 | 1,981 |
| 28 | 6,868 | 3,492 | 0 | 509 | 212,443 | 106,480 | 0 | 988 | 1,980 |
| 29 | 6,844 | 3,480 | 0 | 509 | 219,287 | 109,960 | 0 | 990 | 1,979 |
| 30 | 6,858 | 3,466 | 0 | 505 | 226,145 | 113,426 | 0 | 988 | 1,977 |
| 31 | 6,735 | 3,483 | 0 | 517 | 232,880 | 116,909 | 0 | 992 | 1,975 |
| 32 | 6,829 | 3,417 | 0 | 500 | 239,709 | 120,326 | 0 | 989 | 1,972 |
| 33 | 6,771 | 3,435 | 0 | 507 | 246,480 | 123,761 | 0 | 989 | 1,970 |
| 34 | 6,754 | 3,424 | 0 | 507 | 253,234 | 127,185 | 0 | 990 | 1,969 |
| 35 | 6,734 | 3,415 | 0 | 507 | 259,968 | 130,600 | 0 | 989 | 1,967 |
| 36 | 6,707 | 3,404 | 0 | 508 | 266,675 | 134,004 | 0 | 991 | 1,966 |
| 37 | 6,723 | 3,391 | 0 | 504 | 273,398 | 137,395 | 0 | 989 | 1,964 |
| 38 | 6,556 | 3,426 | 0 | 523 | 279,954 | 140,821 | 0 | 993 | 1,962 |
| 39 | 6,695 | 3,343 | 0 | 499 | 286,649 | 144,164 | 0 | 986 | 1,957 |
| 40 | 6,616 | 3,381 | 0 | 511 | 293,265 | 147,545 | 0 | 986 | 1,956 |

*bbls, barrels; bbls/day, barrels per day; Mcf, thousands of standard cubic feet (at standard conditions of 1 atmosphere and 60°F); Mcf/day, thousands of standard cubic feet per day; scf, standard cubic feet*

**Table 5b. *BOEM* Worst-Case Discharge Model Results for Burger J Well, Chukchi Sea, Alaska**

*Flow Period Day 41 to Day 90; Radial Coordinate Cell System; Innermost Radius = 12 ft*

| Discharge Period (days) | Oil Discharge Rate (bbls/day) | Gas Discharge Rate (Mcf/day) | Water Discharge Rate (bbls/day) | Producing Gas-Oil Ratio (scf/bbl) | Cumulative Oil Discharge (bbls) | Cumulative Gas Discharge (Mcf) | Cumulative Water Discharge (bbls) | Flowing Bottom-Hole Pressure (psia) at Center of Reservoir | Reservoir Pressure in Cell Containing Well (psia) |
|---|---|---|---|---|---|---|---|---|---|
| 41 | 6,596 | 3,377 | 0 | 512 | 299,861 | 150,922 | 0 | 985 | 1,954 |
| 42 | 6,583 | 3,374 | 0 | 512 | 306,444 | 154,296 | 0 | 985 | 1,952 |
| 43 | 6,574 | 3,381 | 0 | 514 | 313,018 | 157,677 | 0 | 979 | 1,949 |
| 44 | 6,553 | 3,362 | 0 | 513 | 319,571 | 161,039 | 0 | 983 | 1,950 |
| 45 | 6,490 | 3,384 | 0 | 521 | 326,061 | 164,423 | 0 | 983 | 1,949 |
| 46 | 6,553 | 3,343 | 0 | 510 | 332,614 | 167,766 | 0 | 981 | 1,947 |
| 47 | 6,515 | 3,359 | 0 | 516 | 339,129 | 171,125 | 0 | 981 | 1,946 |
| 48 | 6,508 | 3,355 | 0 | 516 | 345,637 | 174,480 | 0 | 981 | 1,945 |
| 49 | 6,502 | 3,350 | 0 | 515 | 352,139 | 177,830 | 0 | 981 | 1,945 |
| 50 | 6,497 | 3,349 | 0 | 516 | 358,636 | 181,179 | 0 | 980 | 1,943 |
| 51 | 6,488 | 3,341 | 0 | 515 | 365,124 | 184,520 | 0 | 981 | 1,943 |
| 52 | 6,465 | 3,344 | 0 | 517 | 371,589 | 187,864 | 0 | 982 | 1,943 |
| 53 | 6,564 | 3,304 | 0 | 503 | 378,153 | 191,168 | 0 | 979 | 1,941 |
| 54 | 6,415 | 3,371 | 0 | 525 | 384,568 | 194,539 | 0 | 981 | 1,941 |
| 55 | 6,457 | 3,325 | 0 | 515 | 391,025 | 197,864 | 0 | 981 | 1,940 |
| 56 | 6,453 | 3,321 | 0 | 515 | 397,478 | 201,185 | 0 | 982 | 1,940 |
| 57 | 6,445 | 3,317 | 0 | 515 | 403,923 | 204,502 | 0 | 981 | 1,939 |
| 58 | 6,433 | 3,309 | 0 | 514 | 410,356 | 207,811 | 0 | 984 | 1,940 |
| 59 | 6,450 | 3,308 | 0 | 513 | 416,806 | 211,119 | 0 | 982 | 1,938 |
| 60 | 6,381 | 3,319 | 0 | 520 | 423,187 | 214,438 | 0 | 984 | 1,938 |
| 61 | 6,454 | 3,285 | 0 | 509 | 429,641 | 217,723 | 0 | 983 | 1,937 |
| 62 | 6,416 | 3,295 | 0 | 514 | 436,057 | 221,018 | 0 | 983 | 1,936 |
| 63 | 6,411 | 3,291 | 0 | 513 | 442,468 | 224,309 | 0 | 983 | 1,936 |
| 64 | 6,405 | 3,287 | 0 | 513 | 448,873 | 227,596 | 0 | 983 | 1,935 |
| 65 | 6,398 | 3,283 | 0 | 513 | 455,271 | 230,879 | 0 | 983 | 1,935 |
| 66 | 6,400 | 3,278 | 0 | 512 | 461,671 | 234,157 | 0 | 983 | 1,934 |
| 67 | 6,359 | 3,285 | 0 | 517 | 468,030 | 237,442 | 0 | 984 | 1,934 |
| 68 | 6,529 | 3,226 | 0 | 494 | 474,559 | 240,668 | 0 | 980 | 1,932 |
| 69 | 6,299 | 3,333 | 0 | 529 | 480,858 | 244,001 | 0 | 983 | 1,931 |
| 70 | 6,363 | 3,261 | 0 | 513 | 487,221 | 247,262 | 0 | 984 | 1,931 |
| 71 | 6,359 | 3,258 | 0 | 512 | 493,580 | 250,520 | 0 | 984 | 1,930 |
| 72 | 6,352 | 3,255 | 0 | 512 | 499,932 | 253,775 | 0 | 984 | 1,930 |
| 73 | 6,342 | 3,249 | 0 | 512 | 506,274 | 257,024 | 0 | 985 | 1,930 |
| 74 | 6,352 | 3,246 | 0 | 511 | 512,626 | 260,270 | 0 | 984 | 1,929 |
| 75 | 6,295 | 3,256 | 0 | 517 | 518,921 | 263,526 | 0 | 986 | 1,929 |
| 76 | 6,361 | 3,232 | 0 | 508 | 525,282 | 266,758 | 0 | 984 | 1,927 |
| 77 | 6,317 | 3,235 | 0 | 512 | 531,599 | 269,993 | 0 | 984 | 1,926 |
| 78 | 6,313 | 3,231 | 0 | 512 | 537,912 | 273,224 | 0 | 984 | 1,926 |
| 79 | 6,306 | 3,228 | 0 | 512 | 544,218 | 276,452 | 0 | 984 | 1,925 |
| 80 | 6,295 | 3,222 | 0 | 512 | 550,513 | 279,674 | 0 | 986 | 1,925 |
| 81 | 6,306 | 3,219 | 0 | 511 | 556,819 | 282,893 | 0 | 984 | 1,924 |
| 82 | 6,242 | 3,231 | 0 | 518 | 563,061 | 286,124 | 0 | 986 | 1,924 |
| 83 | 6,305 | 3,200 | 0 | 508 | 569,366 | 289,324 | 0 | 984 | 1,922 |
| 84 | 6,268 | 3,210 | 0 | 512 | 575,634 | 292,534 | 0 | 984 | 1,921 |
| 85 | 6,261 | 3,207 | 0 | 512 | 581,895 | 295,741 | 0 | 984 | 1,921 |
| 86 | 6,254 | 3,205 | 0 | 512 | 588,149 | 298,946 | 0 | 984 | 1,920 |
| 87 | 6,245 | 3,203 | 0 | 513 | 594,394 | 302,149 | 0 | 984 | 1,919 |
| 88 | 6,247 | 3,197 | 0 | 512 | 600,641 | 305,346 | 0 | 984 | 1,918 |
| 89 | 6,188 | 3,211 | 0 | 519 | 606,829 | 308,557 | 0 | 985 | 1,918 |
| 90 | 6,247 | 3,182 | 0 | 509 | 613,076 | 311,739 | 0 | 982 | 1,916 |

*bbls, barrels; bbls/day, barrels per day; Mcf, thousands of standard cubic feet (at standard conditions of 1 atmosphere and 60°F); Mcf/day, thousands of standard cubic feet per day; scf, standard cubic feet*

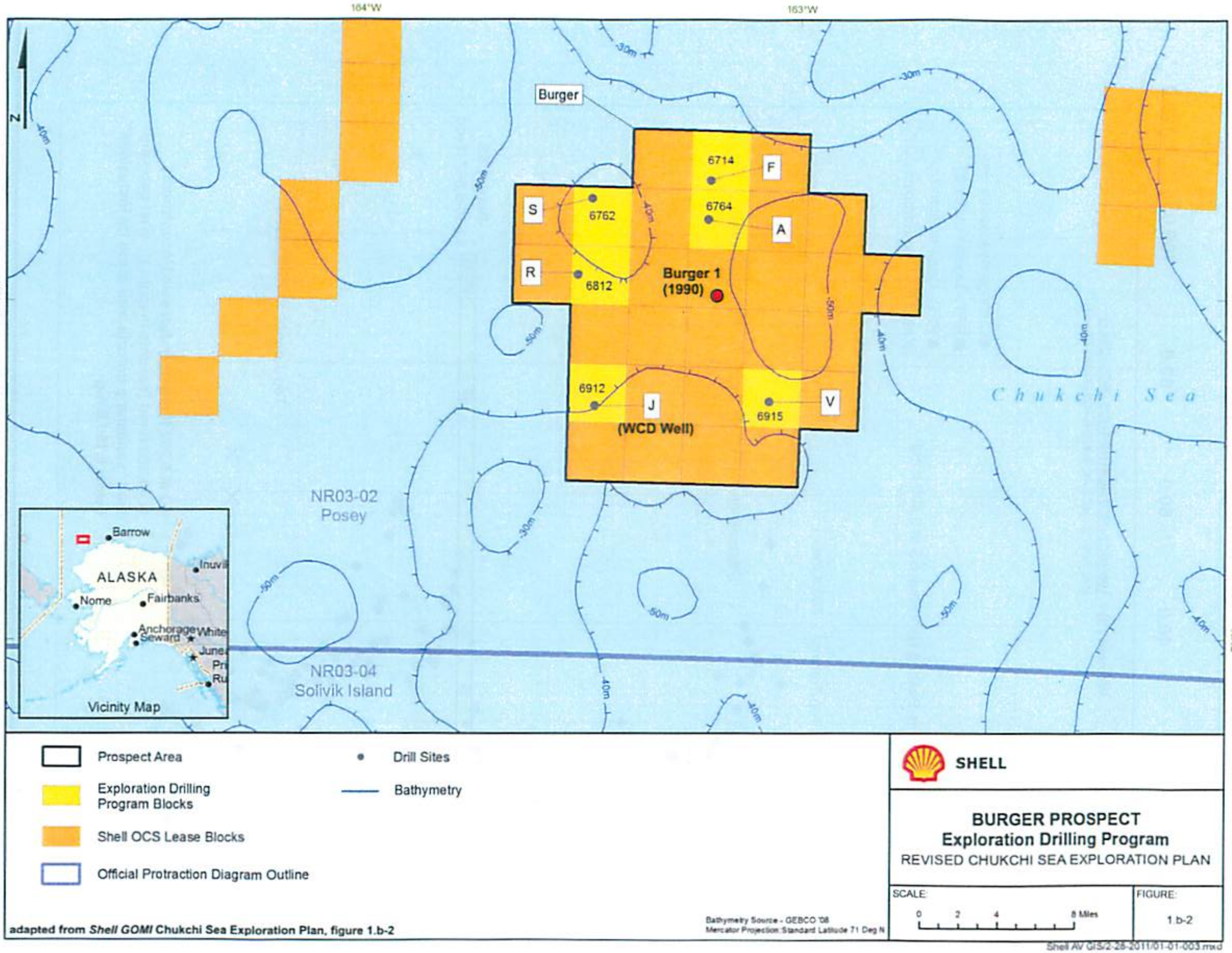


**Figure 1. Location of Burger 1 discovery well and six exploration wells proposed in the *Shell GOMI* Chukchi Sea exploration plan of May 2011. The Burger "J" well is the exploration plan WCD well.**

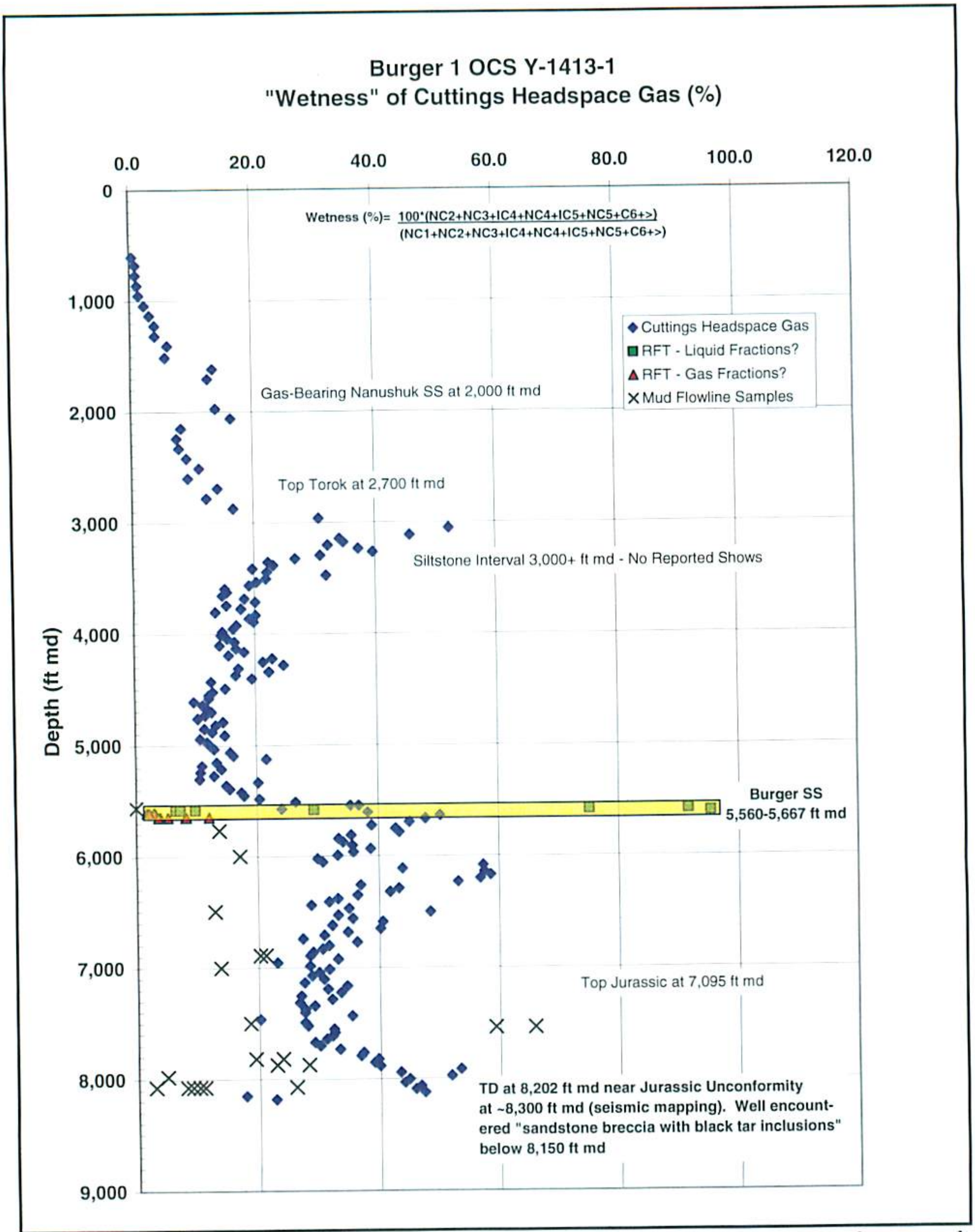


Figure 2. Gas wetness values are elevated below the Burger sandstone (highlighted in yellow) and at a second sandstone at about 6,200 ft, suggesting the possibility of a column of petroleum liquids beneath the gas column in the Burger sandstone at the Burger 1 well.

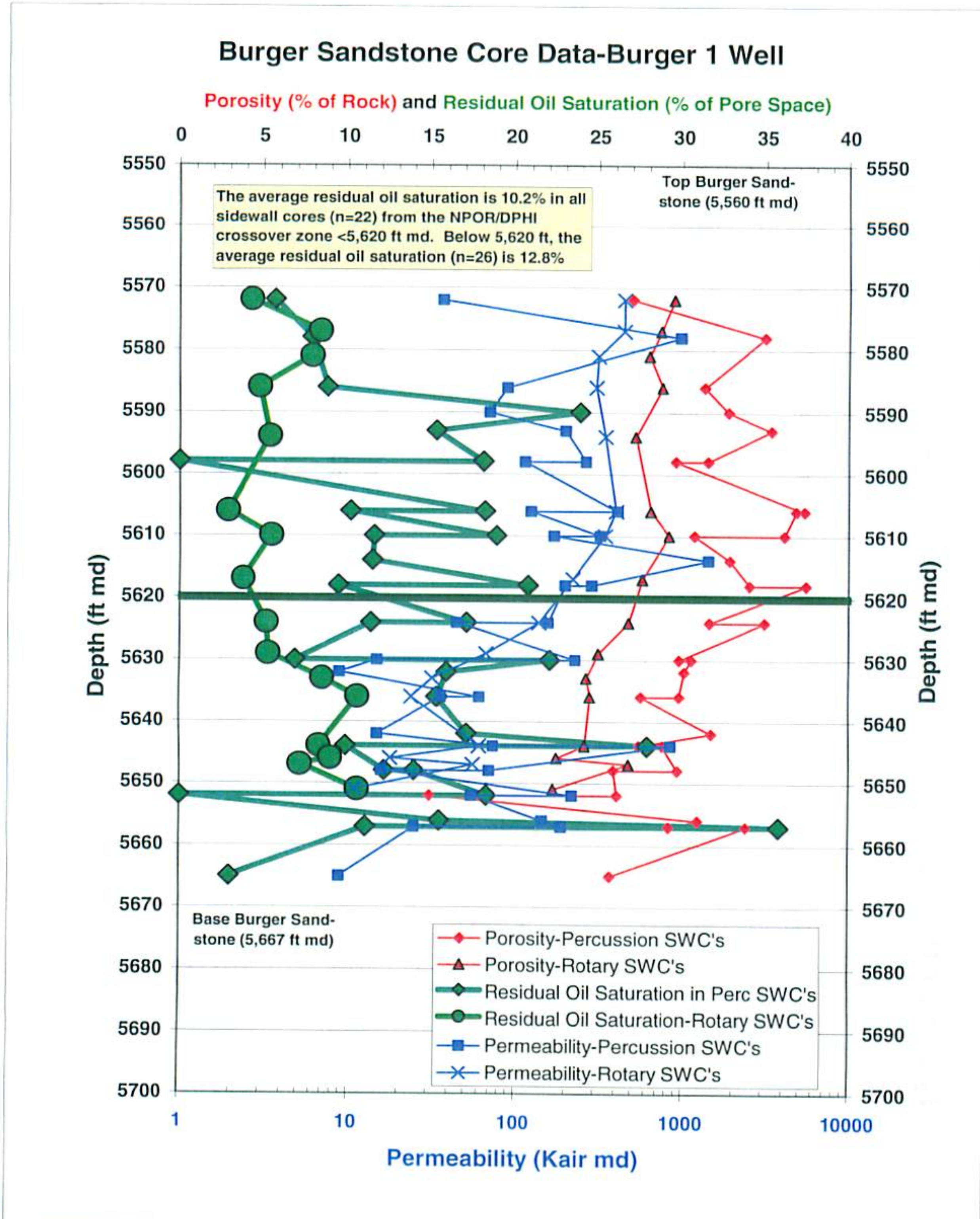


**Figure 3.** Residual oil saturations, porosity, and permeability in rotary and percussion sidewall cores taken in the Burger sandstone in the Burger 1 well. In general, higher residual oil saturations are observed in the relatively low-permeability sandstones of the lower clay-rich member (below 5,620 ft md bkb). The residual oil saturations in the upper gas-saturated sand member suggest that an oil charge of the entire sandstone may have preceded the later (and present) gas charge.

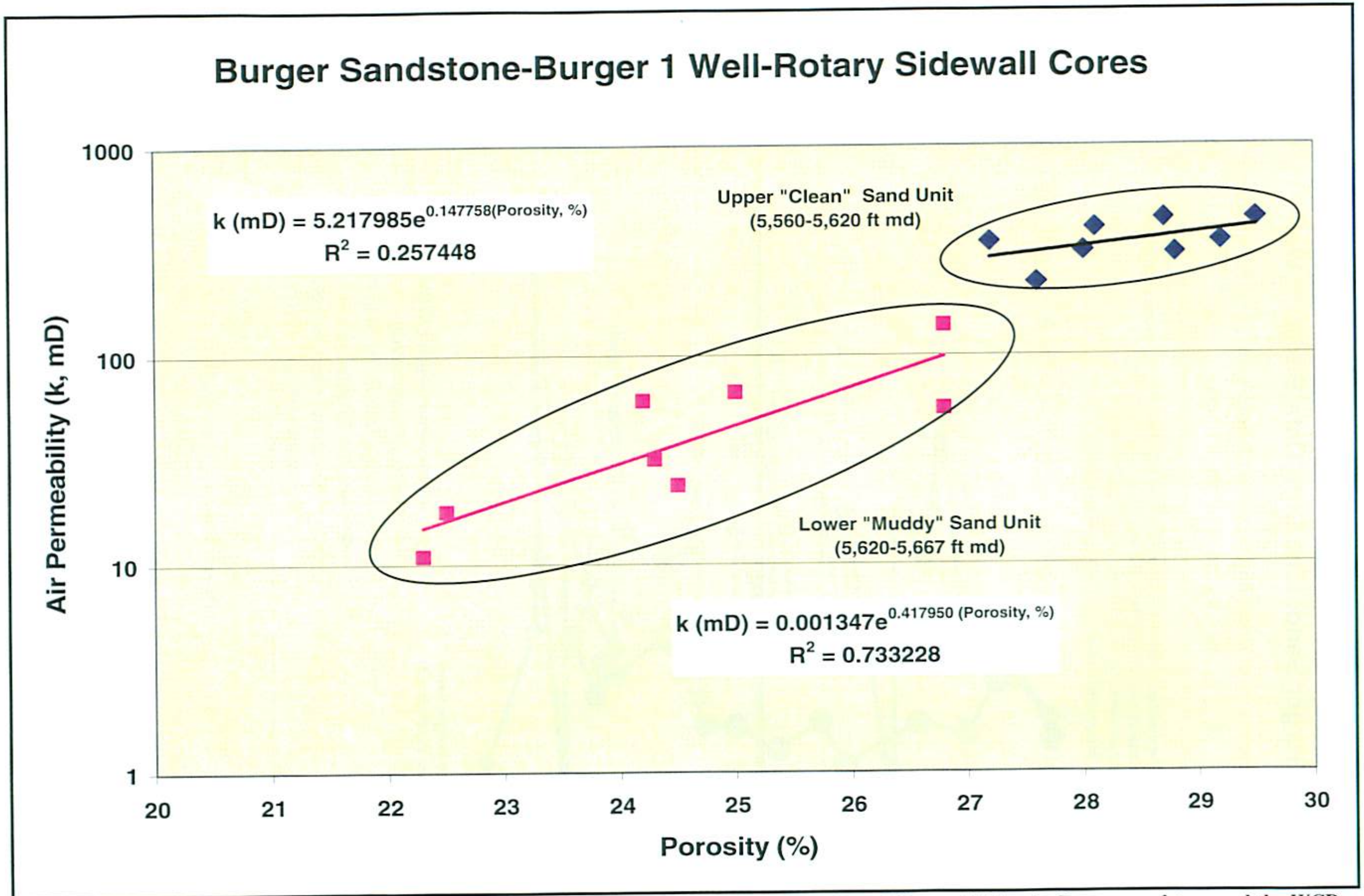


**Figure 4.** Rotary sidewall core data for the Burger sandstone used to calibrate a log-based permeability model for the Burger sandstone and the WCD reservoir anticipated at the Burger J proposed exploratory well. The sandstone is divided into two members that include an upper clay-free member and a lower clay-rich member. The upper member contains most of the "pay" or potential hydrocarbon flow units.

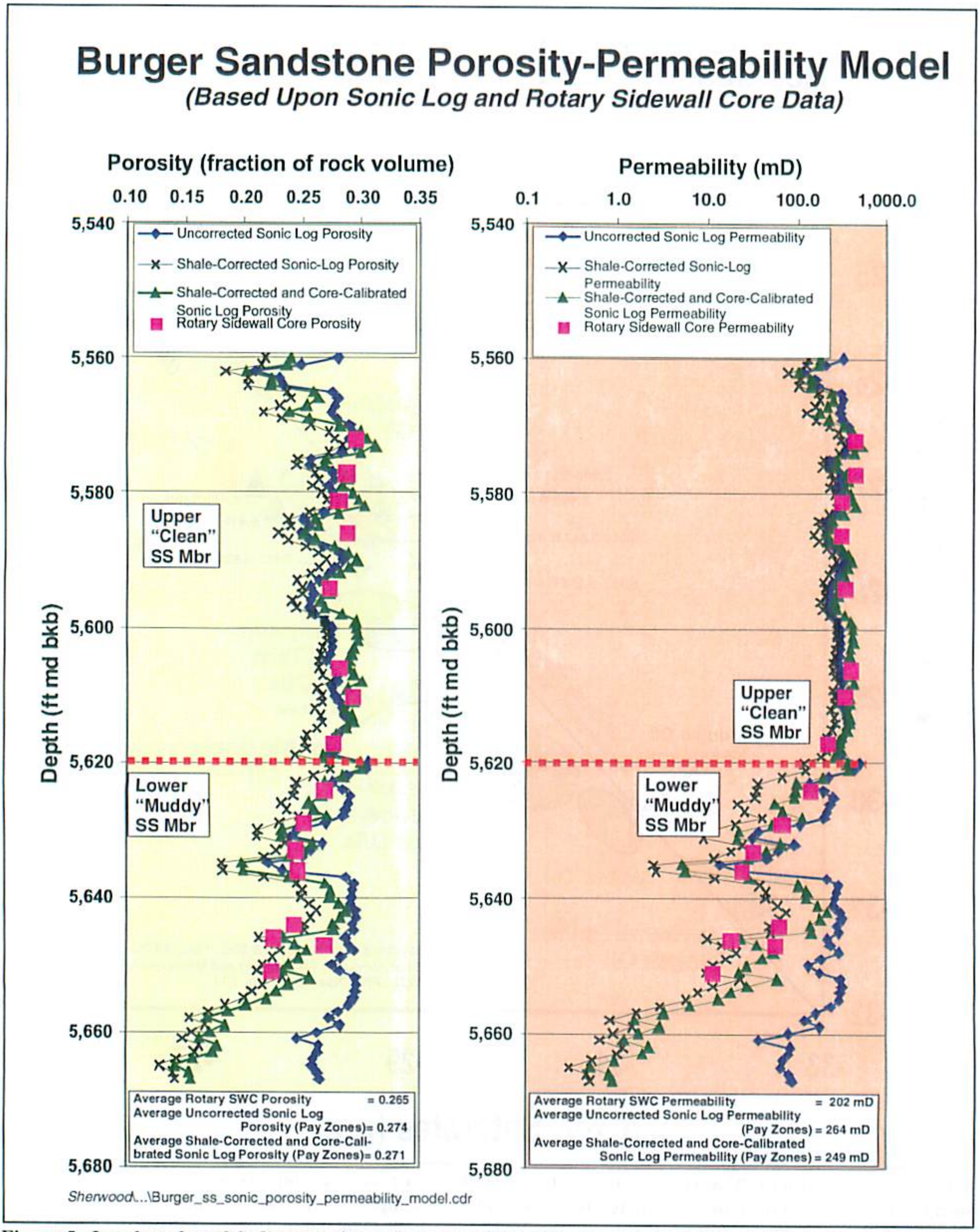


**Figure 5. Log-based models for porosity and permeability of the Burger sandstone calibrated by rotary sidewall core data. Arithmetic averages for these models (porosity, 0.271; permeability, 249 mD) were adopted to characterize the Burger sandstone WCD flow unit at the proposed Burger J exploration well.**

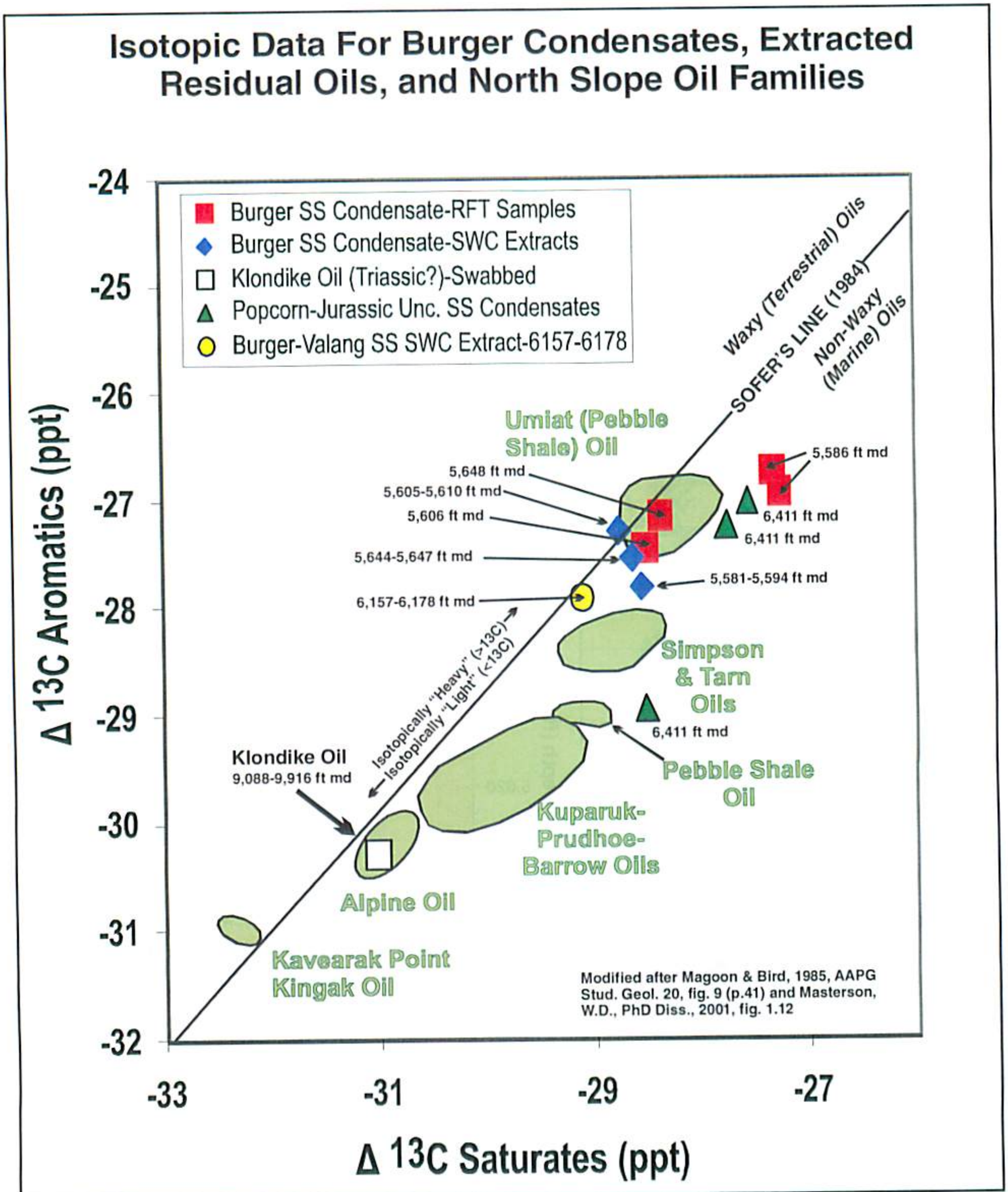


Figure 6. $\Delta^{13}C$ (ratio to $^{12}C$ as compared to a standard) data for petroleum liquids recovered by RFT sampling devices and for liquids extracted from sidewall core samples in the Burger 1 well. Burger petroleum liquids compare most favorably to the 36-37.2° API oils (Molenaar, 1982, p. 547) at the Umiat field near the Colville River in the National Petroleum Reserve-Alaska.

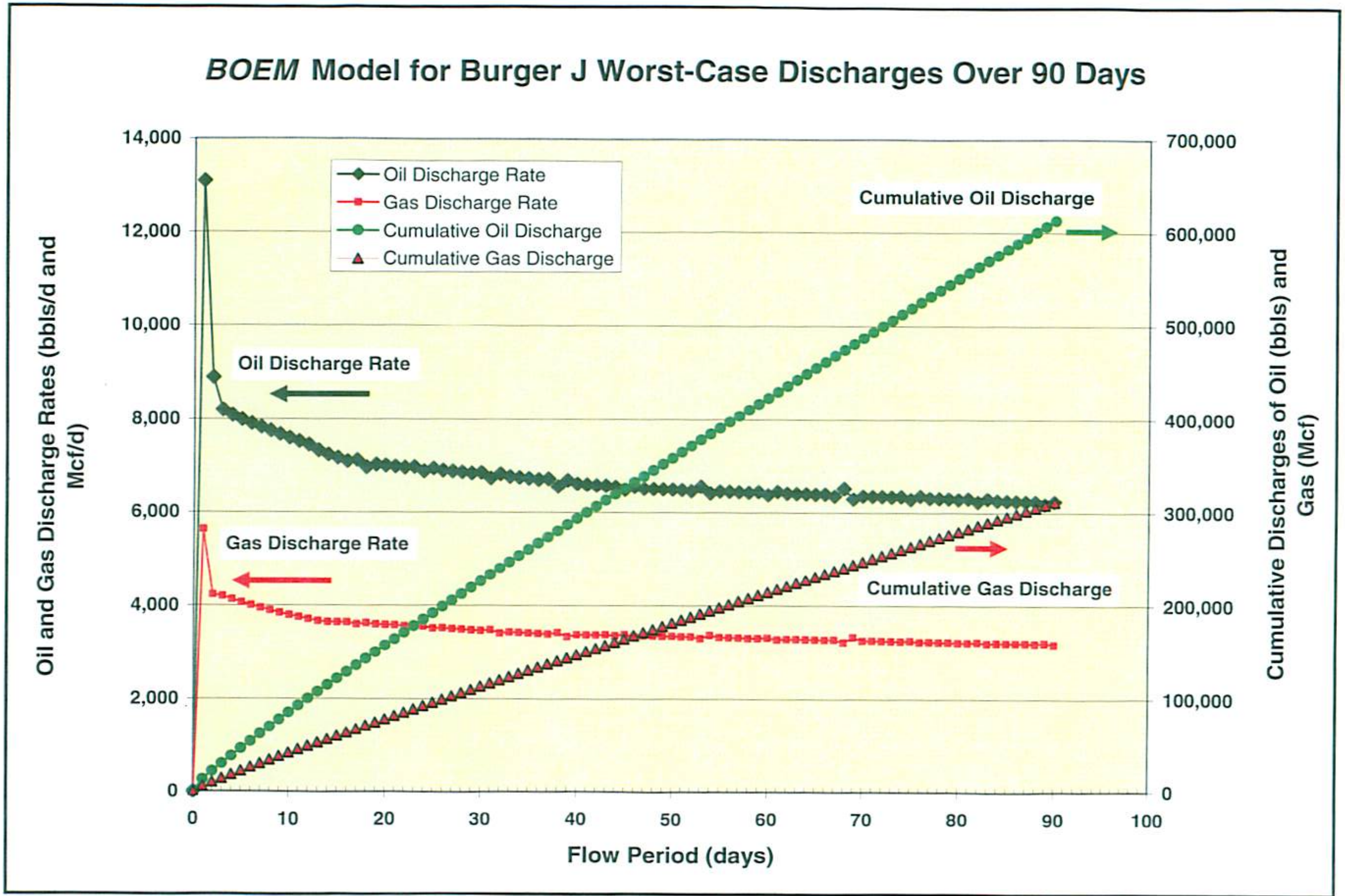


**Figure 7.** Chart of discharge forecast for *BOEMRE* WCD model for 90-day sustained blowout at proposed *Shell GOMI* Burger J exploration well (2011 *Shell GOMI* Chukchi Sea exploration plan [Shell [2011]).

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.