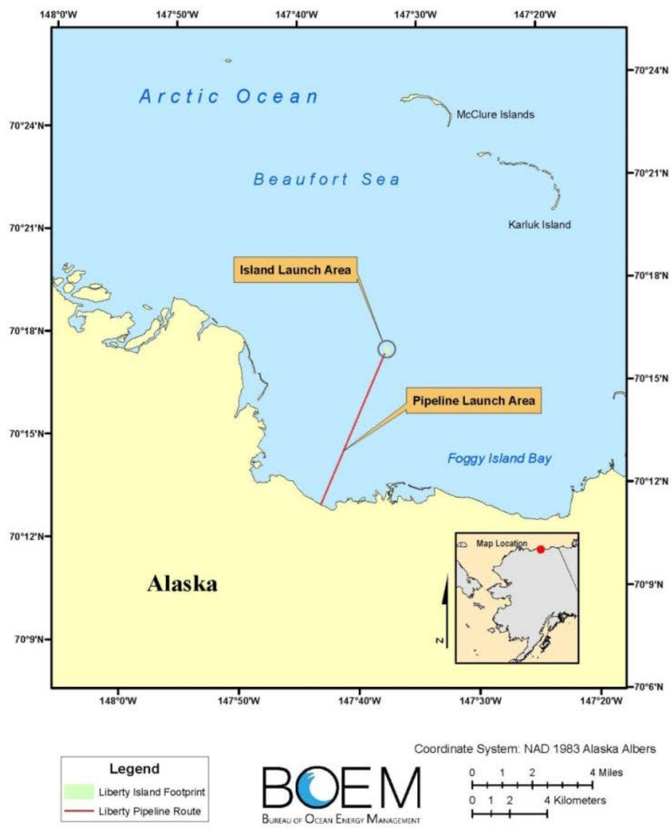
OCS Report
BOEM 2017-086

Oil Spill Risk Analysis: Liberty Development Project in the Beaufort Sea, Alaska



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Oil Spill Risk Analysis: Liberty Development Project in the Beaufort Sea, Alaska

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REPORT AVAILABILITY

To download a PDF file of this report, go to the US Department of the Interior, Bureau of Ocean Energy Management Oil-Spill Risk Analysis webpage (http://www.boem.gov/Environmental-Stewardship/Environmental-Assessment/Oil-Spill-Modeling/Oil-Spill-Risk-Analysis-Reports.aspx).

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ABOUT THE COVER

Hypothetical launch areas and hypothetical pipelines used in the OSRA model for the Liberty Development and Production Plan

Contents

List of Figures

List of Tables

Abbreviations and Acronyms

bbl	barrel (1 barrel = 42 U.S. gallons)
Bbbl	billion barrels (10^9 barrels)
BOEM	Bureau of Ocean Energy Management
BS	boundary segment
cm	centimeter(s)
DPP	Development and Production Plan
EIS	Environmental Impact Statement
ERA	environmental resource area
ft	foot (or feet)
GLS	grouped land segment
GOM	Gulf of Mexico
HAK	Hilcorp, Alaska, LLC
ID	identification
in	inch(es)
km	kilometer(s)
LA	launch area
LDPI	Liberty Development and Production Island
LI	Liberty Island launch area
LOWC	loss of well control
LS	land segment
mi	mile(s)
OCS	Outer Continental Shelf
OSRA	oil spill risk analysis
PL	pipelines
ROMS	Regional Ocean Modeling System
USDOI	United States Department of the Interior

1 Introduction

The U.S. Department of the Interior (USDOI), Bureau of Ocean Energy Management (BOEM), prepared an Environmental Impact Statement (EIS) to analyze the impacts of the Liberty Development and Production Plan (DPP) in the Beaufort Sea, Alaska. The Liberty DPP was submitted by Hilcorp, Alaska, LLC (HAK) on September 8, 2015 and amended on March 17, 2017. HAK proposes to develop the Liberty Prospect by constructing a drilling and production island called the Liberty Development and Production Island (LDPI) approximately 9.0 km (5.6 mi) offshore and transport the oil to shore by pipeline. Because oil spills may occur from activities associated with offshore oil exploration, production, and transportation resulting from the Proposed Action, BOEM conducted a formal oil spill risk analysis (OSRA) to support the EIS. This report summarizes results of the analysis done to estimate the probability of contact, the probability of oil spill occurrence, and the probability of oil spill occurrence and contact to environmental resources from accidental large oil spills occurring from Outer Continental Shelf (OCS) oil- and gas-related activities.

The occurrence of oil spills is fundamentally a matter of probability. There is no certainty regarding the amount of oil that would be produced, or the size or likelihood of a spill that could occur during the estimated life of a given scenario. Neither can the winds, ocean currents or ice that could transport oil spills be known for certain. A probabilistic event, such as an oil spill occurrence or oil spill contact to an environmental resource, cannot be predicted, but an estimate of its likelihood (its probability) can be quantified. An OSRA report quantifies these probabilities.

This OSRA was conducted in three parts, corresponding to different aspects of the overall problem:

1. Calculated the probability of oil spill occurrence, which is based on estimated volumes of oil produced and transported and on the oil spill occurrence rates derived from historic data and a fault tree model
2. Calculated trajectories of oil spills from hypothetical spill locations to locations of various environmental resources, which are simulated using the OSRA model
3. Combined results of the first two parts to estimate the overall oil spill risk if there is oil development in the analyzed areas

2 Framework of the Analysis

Many factors are considered when producing an OSRA report. These include the Proposed Action and its alternatives, the estimated volume of oil resources in the development area, the location of the Proposed Action, and the locations of environmental resources within the study area. Another important factor is the hindcast wind, current, and ice data used to simulate the oil spill trajectories.

2.1 Study Area

As shown in Figure A-1, the study area for this analysis, which extends from 174° E to 130° W and 66º N to 75º N, defines the geographic boundaries that encompass the environmental resources at risk from a hypothetical oil spill from OCS operations in and adjacent to the Proposed Action. The study area is formed by 40 offshore boundary segments and the Beaufort (United States and Canada) and Chukchi Seas (United States and Russia) coastline (Figure A-1). The OSRA model has a resolution of 0.6 km by 0.6 km and a total of 6 million grid cells in the study area.

The study area was chosen to be large enough to allow most hypothetical oil spill trajectories to develop without contacting the offshore boundary segments within 360 days (the maximum elapsed time considered). Although few trajectories might extend beyond the borders of the study area within 360 days, BOEM has tracked and tabulated the contact of these trajectories with the open-ocean boundaries.

As shown in Figure A-2, the Liberty OSRA includes a hypothetical island launch area (LA) and a hypothetical offshore pipeline launch area, herein referred to as "PL," where a large oil spill could originate if it were to occur. The Liberty Island LA, herein referred to as "LI," consists of four launch points representing the approximated midpoints of the four sides of the island. The PL consists of six equally spaced launch points along the offshore pipeline route from the island to the shore.

The development scenario assumes that the oil produced in the Liberty Island LA will be transported to shore via a pipeline with the potential landfall location based on geospatial information provided by the operator.

2.2 Summary of the Proposed Action and Alternatives

The HAK proposes to construct the LDPI to recover petroleum reserves from three Federal leases (OCS-Y-1650, OCS-Y-1585, and OCS-Y-1886) in Foggy Island Bay in the Beaufort Sea, northeast of the Prudhoe Bay Unit and east of the Duck Island Unit. The LDPI is an artificial gravel island with a pipeline to shore. The proposed LDPI is located approximately 5 mi north of the Kadleroshilik River and 7.3 mi southeast of the existing Endicott Satellite Drilling Island. It will be built at a water depth of approximately 5.8 m (19 ft) with the top of the LDPI at 4.6 m (15 ft) or more above the mean lower low water level.

2.3 Estimated Volume of Oil Resources

For this analysis, both benefits and risks are functions of the volume of oil produced and are mutually dependent. For example, greater volumes of produced oil are associated with greater economic benefits, as well as greater risks. If the benefits are evaluated by assuming production of a specific amount of oil, then the corresponding risks should be stated conditionally, such as "the risks are…, given that the volume is…." Any statements about the likelihood of a particular volume of oil being developed also apply to the likelihood of the corresponding benefits and risks.

An estimate of the amount of oil to be produced from a given area is presented in billions of barrels (Bbbl). For the proposed Liberty DPP, crude oil production is assumed to occur over a period of ~22 years. The estimated oil production volume over the life of exploration and production at Liberty DPP is 0.117799 Bbbl. Note that 1 bbl = 1 barrel = 42 U.S. gallons, and 1 Bbbl = 1 billion barrels = 10^9 barrels.

2.4 Environmental Resources Considered in the Analysis

Environmental resources consist of environmental resource areas (ERAs), land segments (LSs), grouped land segments (GLSs), and boundary segments (BSs). ERAs represent areas of social, economic, or biological resources. BOEM Alaska OCS Region analysts designate these resources by working with scientists in other Federal and state agencies, academia, and various stakeholders who provide information about these resources. BOEM analysts also used information from its Environmental Studies Program results, literature reviews, and professional exchange with other scientists to define these resources.

The analysts used geographic information on biological, physical, and socioeconomic resources to map resource locations potentially vulnerable to oil spill contact. There are 124 ERAs. These resource areas represent concentrations of wildlife, habitat, subsistence hunting areas, or subsurface habitats and are shown in Figures A-3a through A-3g. The names or abbreviations of the ERAs, the general resource they represent and their vulnerability (i.e., months of habitat or resource use) are shown in Table B-1. All of the onshore coastal environmental resource locations were represented by one or more partitions of the coastline (LSs). The study area coastline is partitioned into 146 LSs. The locations of these 146 LSs are shown in Figures A-4a through A-4c. The LSs are further grouped into 53 larger geographic areas, or GLSs, and are evaluated as unique environmental resources. Figures A-5a through A-5c show the location of these 53 GLSs. Table B-3 shows the GLSs, their names, the individual LSs that make them up, and the months they are vulnerable to spills.

3 Oil Spill Risk Analysis

Risk analyses may be characterized as "hazard-based" or "risk-based." A hazard-based analysis examines possible events regardless of their low (or high) likelihood. For example, a potential impact would not lose significance, because the risk has been reduced due to an increase in the level of control, such as engineering standards. A risk-based analysis, on the other hand, does take into account the likelihood of the event occurring or the measures that can be taken to mitigate potential impacts.

This OSRA is designed for use as a risk-based assessment. Therefore, the likelihood of oil spills greater than or equal to 1,000 barrels (≥ 1,000 bbl) in size occurring on the OCS plays an integral role in the analysis. In addition to the estimated probability of one or more large spills occurring, the analysis entails an oil spill trajectory simulation. Results from the trajectory analysis estimate where hypothetical spills might travel on the ocean's surface and what resources might be contacted, and these results provide input to the final OSRA step of estimating the combined probability of one or more large spills both occurring and contacting environmental resources. Note that the analysis estimates spill contacts, not impacts. Further measures that are evaluated to determine impacts, such as the natural weathering of oil spills and cleanup activities, are not directly factored into the OSRA but are discussed in the Liberty EIS.

The OSRA was conducted in three parts, corresponding to different aspects of the overall problem:

1. The probability of oil spill occurrence (Section 3.1)
2. The trajectories of oil spills from hypothetical launch points to various environmental resources and the probability of contact to environmental resources from hypothetical oil spill locations (Section 3.2 and 3.3)
3. A combination of the first two analyses to estimate the overall oil spill risk of both spill occurrence and spill contact if there is oil development (Section 3.4)

For this analysis, the OSRA model uses the oil spill occurrence rate derived from the historical oil spill data from the North Sea, Gulf of Mexico (GOM), and the Pacific OCS using a fault tree model.

The second part of the OSRA model initiates oil spill trajectories from hypothetical launch points and computes the conditional probability of spill contact to the environmental resources from these trajectories. The hypothetical launch points represent the approximated midpoints of the four sides of the proposed island and the offshore pipeline route from the island to the shore.

Spill volume is not factored into the oil spill trajectory simulations, because an oil spill’s movement is controlled by the surface winds and currents, not by the spill’s volume.

The trajectories of hypothetical spills can be launched from each hypothetical launch point on a daily basis over a time period of available hindcast (historical) wind and current data, typically exceeding

10 years. The percentage of the trajectories contacting the environmental resources from those tens of thousands of hypothetical trajectories launched is the conditional probability of contact from a spill from a given LA or PL to an environmental resource, including ERAs, LSs, GLSs, or BSs.

The third part of OSRA computes the combined probability of spills both occurring and contacting offshore and coastal environmental resource locations.

3.1 Probability of One or More Large Oil Spills Occurring

The probability of one or more large oil spills occurring assumes that spills occur independently of each other as a Poisson process. The Poisson process is a statistical distribution that is commonly used to model random events. In this analysis, the probability of one or more large oil spills (defined as a spill of ≥ 1,000 bbl) occurring is based on estimated oil production rates from the Liberty DPP area and the oil spill occurrence rates derived from fault tree modeling.

The fault tree method incorporated an analysis of oil spill statistics from the North Sea, GOM, and Pacific OCS to evaluate the estimated oil spill occurrence rates applicable to the Liberty DPP (Bercha Group, Inc. 2016).

3.1.1 Oil Spill Occurrence Rates

Estimates of oil spill occurrence rates are based on historic spill occurrences or fault tree modeling and the estimated volume of oil produced and transported. Oil spill occurrence rates are expressed as the mean number of spills of a given size range per billion barrels (spills/Bbbl) of oil produced or transported. Only spills that are ≥ 1,000 bbl are addressed in the OSRA model, because smaller spills may not persist long enough to conduct a trajectory simulation. However, smaller spills are not ignored; they are addressed in the Liberty EIS without the use of trajectory simulation.

3.1.2 Production Scenario for the Proposed Action

The proposed Liberty Development is a self-contained offshore drilling and production facility located on an artificial gravel island with a pipeline to shore. The infrastructure and facilities that are capable of producing and exporting approximately 60,000 to 70,000 barrels of oil per day to shore will be installed on the island. The plan is to drill a total of 16 wells on the island, which includes 5–8 producing wells, 4–6 water and/or gas injection wells, and up to two disposal wells at surface wellhead spacing of 4.6 m (15 ft) between wellheads. Produced gas would be used for fuel gas, artificial lift, or re-injection into the reservoir. A pipe-in-pipe system, consisting of a 12 in (30.5 cm) sales oil pipeline inside a 16 in (40.6 cm) outer pipe, would be installed offshore to transport the crude oil to shore. The offshore portion of the pipeline would be approximately 9.0 km (5.6 mi) long. Once onshore, the pipe-in-pipe system would transition to a single wall pipeline for transport of the oil overland to the Badami pipeline tie-in point. The overland portion of the pipeline would be approximately 2.4 km (1.5 mi) long. The pipeline system would have control valves at each end, which could be shut in the event of a pipeline break, reducing the overall volume of oil reaching the environment from a pipeline spill.

Associated onshore activities to support the project include use of permitted water sources, construction of gravel pads to support the pipeline tie-in location and Badami ice road crossing, ice roads and ice pad construction, hovercraft shelter, small boat dock, and development of a gravel mine site west of the Kadleroshilik River. Existing North Slope infrastructure, such as the Dalton Highway, support infrastructure at Deadhorse, the Trans-Alaska Pipeline, and the West Dock, would also be used to support this project.

3.1.3 Using Fault Tree Analysis to Estimate Large Spill Rates

BOEM derives large oil spill rates using a fault tree analysis, because there are no recorded large oil spill data in the offshore Arctic. A fault tree analysis is a method for estimating the spill rate resulting from interactions of other events. Fault trees are logical structures that describe the causal relationship between the basic system components and events resulting in system failure.

Two general fault trees were constructed, one for large pipeline spills and one for large platform/well spills. Arctic effects were considered by modifying existing spill causes that occur in other OCS regions, such as trawling accidents, as well as other unique spill causes that occur only in the Arctic. Unique causes of pipeline spills in the Arctic included ice gouging (floating ice gouging into the seafloor), strudel scour (water flowing down through a vertical hole in sea ice and creating a scour depression in the seabed), upheaval buckling (pressure causing pipe to bend upward), thaw settlement (pipe settling as surrounding sediments thaw), and other causes. For platforms, these included ice force, low temperature, and other causes. The estimates of uncertainty in each fault tree event also include the non-Arctic variability such as spill size, spill frequency, and facility parameters, including number of wells drilled, type of wells drilled, number of platforms, number of subsea pipelines, and subsea pipeline length. The consideration of various Arctic effects, non-Arctic variability, and facility parameters in the fault tree analysis is intended to provide a realistic estimate of spill occurrence rates on the Arctic OCS and their uncertainties.

Using the fault tree method, oil spill data from the GOM and Pacific OCS were modified to include both Arctic and non-Arctic variability (Bercha Group, Inc. 2016). It also includes loss of well control frequencies from a recently completed Loss of Well Control (LOWC) study (Bercha Group, Inc. 2014). Using information from both the SINTEF worldwide database and the GOM and Pacific OCS, the LOWC study updated offshore LOWC frequency data through 2011 for the GOM, the Pacific OCS, and the North Sea.

The resulting oil spill occurrence rates (for spills ≥ 1,000 bbl) in the Liberty DPP were calculated by the Bercha Group. The oil spill occurrence rate for spills ≥ 1,000 bbl for all facilities (island and wells, pipelines and all sources) and the 95% confidence intervals on the total oil spill occurrence rate per Bbbl are shown in Table 3-1 below. These rates served as input into the OSRA model.

Table 3-1. Mean Oil Spill Occurrence Rate for Spills ≥ 1,000 bbl

Facility Type	Mean Number of Spills per Bbbl
Island and Wells	0.037
Pipelines	0.020
All Sources	0.058
95% Confidence Interval	0.021–0.105

Source: Bercha Group, Inc. (2016)

3.1.4 Poisson Distribution

The Poisson distribution is used for estimating the probability of one or more large spills occurring in the Liberty DPP area. The probability of oil spills occurring assumes that spills occur independently of each other as a Poisson process. The Poisson distribution is a statistical distribution commonly used to model random events. Using Bayesian techniques, Devanney and Stewart (1974) showed that the probability of *n* oil spill occurrence can be described by a negative binomial distribution. Smith et al. (1982), however, noted that when actual exposure is much less than historical exposure, as is the case here, the negative binomial distribution can be approximated by a Poisson distribution. The Poisson distribution has a significant advantage in the calculation of spill probability, because it is defined by only one parameter. Equation (1) shows how to calculate *p(n)*, which is the probability of *n* spills in the course of handling oil volume *t*:

$$p(n) = \frac{(\lambda t)^n e^{-\lambda t}}{n!} \qquad (1)$$

where *n* is the specific number of spills (*0, 1, 2, ..., n*), *e* is the base of the natural logarithm, λ is the spill rate (in mean number of spills per Bbbl), and *t* is the oil volume (in Bbbl). The spill rate (λ) can be for oil spills from: 1) OCS platforms, 2) pipelines, or 3) both platforms and pipelines. The probability of one or more large spills is equal to one minus the probability of zero spills. It can be calculated from equation (2) as:

$$p(n \geq 1) = 1 - e^{-\lambda t} \qquad (2)$$

3.1.5 Oil Spill Occurrence Probability Estimates

The estimates of oil spill occurrence probability for spills ≥ 1,000 bbl are based on the oil production volume and transportation scenarios over the life of the Liberty DPP and on the large oil spill occurrence rates shown in Table 3-1. BOEM multiplied the large OCS spill rate by the production volume of 0.117799 Bbbl of crude oil (provided by the operator and verified by BOEM) to estimate the mean number of spills. Table 3-2 shows the estimated mean number of large oil spills. The mean number of large spills is estimated to be 0.0024 for pipelines, 0.0044 for the gravel island and wells, and 0.0068 for all sources, over the entire life of the Liberty DPP.

Table 3-2. Mean Number of Large Oil Spills for the Liberty DPP

Facility Type	Mean Number of Large Spills
Island and Wells	0.0044
Pipelines	0.0024
All Sources	0.0068

Using the Poisson distribution, Table 3-3 shows the probability of one or more large spills occurring over the life of the Liberty DPP for platforms, pipelines, and all sources.

Table 3-3. Probability of One or More Large Spills Occurring

Facility Type	Probability
Island and Wells	0.44%
Pipelines	0.24%
All Sources	0.68%

BOEM uses the above mean spill number to determine the Poisson distribution. The chance of no large spills occurring is 99.32%, and the chance of one or more large spills occurring is 0.68%. It is much more likely that no large spills will occur over the life of the Liberty DPP. However, because large spills are an important concern, and no one can estimate the future perfectly, BOEM assumes a large spill occurs and conducts a large oil spill analysis for the development and production activities. This conservative analysis helps to ensure that BOEM does not underestimate potential environmental effects should an unlikely large spill occur.

3.2 The OSRA Model

The OSRA model was designed to track the movements of hypothetical large oil spills and to calculate the potential contacts to the environmental resources that include ERAs, LSs, GLSs, and BSs. The OSRA model, originally developed by Smith et al. (1982), has been enhanced by BOEM over the years (Price et al. 2003, Price et al. 2004, Ji et al. 2011, Li and Johnson 2016). The OSRA model performs five functions:

- Estimates where a hypothetical spill from a particular point would move over a specific period of time using model-simulated historical wind, ice, and current information (Sections 3.2.1 and 3.2.2)
- Tracks each hypothetical spill trajectory versus the environmental resources geographically (Sections 3.2.3 and 3.2.4)
- Counts every time a hypothetical spill contacts environmental resources that include ERAs, LSs, and BSs (Section 3.2.5)
- Estimates the probability of contact based on the total number of hypothetical spill launches from a given point and the number of contacts to each specific environmental resource that includes ERAs, LSs, and BSs (Section 3.3)
- Estimates the combined probabilities of one or more large spills both occurring and contacting environmental resources (Section 3.4)

Finally, Section 3.2.6 describes the products from the OSRA model, and Section 3.2.7 lists factors that are not included in OSRA model and discusses how the exclusion of those factors will affect the model's results.

3.2.1 Model-Simulated Ocean Currents, Ice, and Winds as Inputs to OSRA

This model estimates oil spill trajectories using model-simulated data fields of winds, ice, and ocean currents in the Beaufort and Chukchi Seas.

An oil spill on the ocean surface moves around due to complex ocean surface currents exerting a shear force on the spilled oil from below. For cases where the ice concentration is 80 percent or higher, the model ice velocity is used to calculate the transport of the oil. In addition to the effects of surface currents and ice movements, the prevailing wind exerts an additional shear force on the spill from above, and the combination of the three forces causes the transportation of the oil spill away from its initial spill location.

BOEM uses the results from a coupled ice-ocean general circulation model to simulate oil spill trajectories. The wind-driven and density-induced ocean-flow fields and the ice motion fields are simulated using a three-dimensional, coupled, ice-ocean hydrodynamic model (Curchitser et al. 2013). The model is based on the Regional Ocean Modeling System (ROMS) (Shcheptkin and McWilliams 2005). The ROMS has been coupled to a sea ice model (Budgell 2005), which consists of elastic-viscous-plastic rheology (Hunke and Dukowics 1997, Hunke 2001) and the Mellor and Kantha (1989) thermodynamics. This model simulates flow properties and sea ice evolution for the Arctic with enhanced resolution 5 km in the Chukchi and Beaufort seas during the years 1985–2005. The sea ice model was adapted to represent landfast ice. The coupled ocean-ice model uses six-hourly CORE2 forcing files (Large and Yeager 2009), including winds, air temperature, air pressure, humidity, plus daily solar radiation, to compute the momentum, heat, and salt fluxes. Comparison of model results with observation shows significant skill in the model capability to reproduce observed circulation and sea ice patterns in the Beaufort and Chukchi Seas (Curchitser et al. 2013). BOEM down-scaled the model results to a resolution of approximately 2.5 km in the north-south direction.

BOEM uses the reanalysis (1986–2004) wind fields provided by Curchitser et al. (2013). The wind data are from CORE2 (Large and Yeager 2009) and were interpolated to the coupled ocean model grid at three-hour intervals.

3.2.2 Hypothetical Launch Points

To determine locations where hypothetical oil spills could originate, BOEM used operator-submitted GIS information for the pipeline route and island to estimate launch points from the LAs. The model uses four launch points from the Liberty Island LA (LI) and six equally spaced launch points along the offshore pipeline route (PL) from the island to the shore (Figure A-2). The model launched a trajectory from each of these 10 launch points every 2 days. The hypothetical launch points are grouped into the LI and PL to estimate the probability for spill contacts from oil and gas activities from the Liberty DPP area.

3.2.3 Hypothetical Spill Trajectories

A trajectory can be defined as the path followed by an object moving under the action of given forces. In this case, the forces of surface currents, ice, and wind act on a hypothetical oil spill to produce a modeled trajectory.

The hypothetical oil spill trajectories in OSRA outputs are produced by a temporally and spatially varying ocean current field and superposing on that an empirical wind-induced drift of the hypothetical oil spills (Samuels et al. 1982). Collectively, the trajectories represent a statistical ensemble of simulated oil spill displacements produced by the fields of winds, ocean currents, and ice motion derived from numerical model with observations assimilated.

For this analysis, a total of 3,240 trajectories were simulated from each of 10 launch points over the 18 years (1986–2004) of wind, current and ice data, for a total of 32,400 trajectories. Simulations are performed for three timeframes: annual (January 1–December 31), winter (October 1–June 30), and summer (July 1–September 30). The choice of these timeframes was based on meteorological, climatological, and biological cycles, as well as consultation with BOEM Alaska OCS Region analysts. Curchitser et al. (2013) detail the modeling of each ice motion field and ocean current component. Brief summaries of the methods and assumptions follow.

Trajectories are calculated using equation (3). For cases where the ice concentration is below 80 percent, each trajectory is constructed using vector addition of the ocean current field and 3.5 percent of the instantaneous wind field—a method based on work done by Huang and Monastero (1982), Smith et al. (1982), and Stolzenbach et al. (1977). For cases where the ice concentration is 80 percent or greater, the model ice velocity is used to transport the oil. Equation (3) shows the components of motion that are simulated and used to describe the oil transport:

$$U_{oil} = \begin{cases} Ucurrent + 0.035 * Uwind, if\ ice\ concentration < 80\% \\ Uice, if\ ice\ concentration \geq 80\% \end{cases} \quad (3)$$

Where U_{oil} = oil drift vector

$U_{current}$ = current vector (when ice concentration <80%)

U_{wind} = wind speed at 10 m above the sea surface

U_{ice} = ice vector (when ice concentration ≥80%)

The wind drift factor was estimated to be 0.035, with a variable drift angle ranging from 0^o to 25^o clockwise. The drift angle was computed as a function of wind speed according to the formula in Samuels et al. (1982). The drift angle is inversely related to wind speed.

Depending on the path of the hypothetical oil spill and its surrounding environment, the trajectory is allowed to travel for a minimum of 30 days (if the spill is in open water the entire time) to a maximum of 360 days (if the spill is in the ice the entire time, where ice concentration is 80 percent or greater). For those trajectories that come out of the ice and melt into open water, the trajectory is allowed to travel for a maximum of 30 days. The total combined time that the trajectory can travel in the open water and ice does not exceed 360 days.

For each trajectory simulation, the start time for the first trajectory was the first day of the timeframe (annual, summer, or winter) of the first year of wind, current, and ice data (1986) at 6 a.m. GMT. The summer timeframe consists of July 1–September 30, and the winter timeframe is October 1–June 30. Each subsequent trajectory was started every 2 days at 6 a.m. GMT. For each launch point, a total of 3,240 trajectories were simulated for annual timeframe over the 18 years of wind, current, and ice data (1986–2004). For summer timeframe, a total of 810 trajectories were simulated, and for winter timeframe, a total of 2,430 trajectories were simulated.

3.2.4 Contacts with Environmental Resources

Another portion of the OSRA model tabulates “contacts” by the simulated hypothetical oil spills. A contact occurs when a trajectory touches an environmental resource such as an LS or an ERA.

The model contains the geographical boundaries of a variety of identified environmental features. The shoreline segments proximate to their locations identify onshore resources. Offshore resources are identified by the area of surface waters overlying their locations.

At every integration time step, the OSRA model monitors the locations of the simulated spills and counts the number of oil spill contacts to LSs and the locations of onshore and offshore ERAs. A contact to an LS will stop the trajectory of an oil spill; no rewashing is assumed in this model. However, contacts to the transparent (non-land) offshore ERAs will not stop the respective trajectories.

3.2.5 Estimating Probability of Contacts

After specified periods of time, the OSRA model will divide the total number of contacts to the environmental resources, such as LSs or ERAs, by the total number of hypothetical spills initiated in the model from a given hypothetical launch point. These ratios are the estimated conditional probabilities of oil spill contact from a given hypothetical launch point. For Liberty DPP, the probability of oil spill contact to an environmental resource is computed for designated oil spill travel times at 1, 3, 10, 30, 90, and 360 days.

3.2.6 OSRA Model Output

The outputs of the OSRA model are a series of conditional and combined probabilities of a contact, and occurrence and contact between a hypothetical spill in a specific area and an ERA, BS, or specific LS or GLS. The detailed discussion of conditional and combined probabilities is in Sections 3.3 and 3.4. Those probabilities are presented in Tables C-1 through C-11 in Appendix C.

The tables in Appendix C are arranged to address conditional probabilities of different seasonal timeframes in this order: 1) annual, 2) summer, and 3) winter.

Within each season, the probability is reported by ERAs, LSs, GLSs and BSs within 1, 3, 10, 30, 90, and 360-day time periods. These tables are followed by the combined probabilities associated with ERAs, LSs, and GLSs. The analysts at BOEM used the probabilities in these tables to analyze the effects of large oil spills in the EIS.

3.2.7 Factors Not Considered in the OSRA Model

It is important to note that the modeled and assessed scenarios in this report are unmitigated events to provide a conservative basis for environmental effects assessment. There are factors not explicitly considered by the OSRA model that can affect the transport of spilled oil as well as the dimensions, volume, and nature of the oil spills contacting environmental resources. These include possible cleanup operations, physical or biological weathering of oil spills, or the spreading and splitting of oil spills. The OSRA analysts have chosen to take a more environmentally conservative approach by presuming persistence of spilled oil over the selected time duration of the trajectories. These assumptions make the OSRA model’s calculated probabilities conservative as they do not take into account the prevention and response measures that will be in place to prevent and reduce the potential effects and consequences of an accidental event.

3.3 Conditional Probabilities of Contact

The probability that an oil spill will contact a specific environmental resource within a given time of travel from a certain location or spill point is termed a conditional probability, the condition being that a spill is assumed to have occurred. Each trajectory was allowed to continue for as long as 360 days. However, if the hypothetical spill contacted an LS sooner than 360 days after the start of the spill, the spill trajectory was terminated, and the contact was recorded.

The trajectories simulated by the model represent only hypothetical pathways of oil spills; they do not involve any direct consideration of cleanup, dispersion, or weathering processes that could alter the quantity or properties of oil that might eventually contact the environmental resources. However, an implicit analysis of weathering and decay can be considered by noting the ages of the simulated oil spills when they contact environmental resources. Conditional probabilities of contact with environmental resources within 1, 3, 10, 30, 90 and 360 days of travel time were calculated for each of the hypothetical spill sites by the model to serve as input into the final calculation of the combined probabilities (Tables C-1 through C-9).

3.4 Combined Probabilities of Contact

Combined probabilities are the chance of one or more large spills occurring and contacting the environmental resources over the scenario life of the Proposed Action. They are estimated using the conditional probabilities, the large oil spill occurrence, the estimated volume of oil to be produced, and the assumed transportation scenarios. These are combined through matrix multiplication to estimate the mean number of one or more large spills from operations in and adjacent to the proposed development area occurring and of any of these spills making a contact to the environmental resources. The combined probabilities for this analysis of the Proposed Action are presented in Appendix C, Tables C-10 and C-11.

In calculating the combined probabilities of both oil spill contact and oil spill occurrence, the following steps are performed:

1. To address the probability of spill contact for a set of $\boldsymbol{n}_{\mathbf{t}}$ environmental resources and $\boldsymbol{n}_{\mathbf{l}}$ hypothetical launch points, the conditional probabilities can be represented in a matrix form. Let [**C**] be a $\boldsymbol{n}_{\mathbf{t}} \times \boldsymbol{n}_{\mathbf{l}}$ matrix, where each element $\boldsymbol{c}_{\boldsymbol{i,j}}$ is the probability that an oil spill will contact

environmental resource $\boldsymbol{i}$, given that a spill occurs at launch point $\boldsymbol{j}$. Note that hypothetical launch points can represent potential starting points of spills from production areas or from transportation routes.

2. Oil spill occurrence can be represented by another matrix [**S**]. With $\boldsymbol{n_l}$ hypothetical launch points and $\boldsymbol{n_s}$ production sites, the dimensions of [**S**] are $\boldsymbol{n_l} \times \boldsymbol{n_s}$. Let each element $\boldsymbol{s_{j,k}}$ be the estimated mean number of spills occurring at hypothetical launch point $\boldsymbol{j}$ owing to production of a unit volume (1 Bbbl) of oil at site $\boldsymbol{k}$. These spills can result from either production or transportation. The element $\boldsymbol{s_{j,k}}$ can be determined as a function of the volume of oil (spills/Bbbl). Each column of [**S**] corresponds to one production site and one transportation route. If alternative and mutually exclusive transportation routes are considered for the same production site, they can be represented by additional columns of [**S**], thus increasing $\boldsymbol{n_s}$.

3. The unit risk matrix [**U**] is defined as:

$$[U] = [C] \times [S]$$

[**U**] has dimensions $\boldsymbol{n_t} \times \boldsymbol{n_s}$. Each element $\boldsymbol{u_{i,k}}$ corresponds to the estimated mean number of spills occurring and contacting environmental resource $\boldsymbol{i}$, owing to the production of a unit volume (1 Bbbl) of oil at site $\boldsymbol{k}$.

4. To convert this number into a number that reflects the expected oil production volume, a value for volume must be included. With [**U**], the mean contacts to each environmental resource are estimated, given a set of oil volumes at each site. Let [**V**] be a vector of dimension $\boldsymbol{n_s}$ where each element $\boldsymbol{v_k}$ corresponds to the volume of oil expected to be found at production site $\boldsymbol{k}$. Then, if [L] is a vector of dimension $\boldsymbol{n_t}$, where each element $\boldsymbol{\lambda_i}$ corresponds to the mean number of contacts to environmental resource $\boldsymbol{i}$, the formula is:

$$[L] = [U] \times [V]$$

Thus, estimates of the mean number of oil spills that are likely to occur and contact the environmental resources can be calculated. (Note that, as a statistical parameter, the mean number can assume a fractional value even though fractions of oil spills have no physical meaning.)

4 Discussion

Conditional probabilities are expressed as a percent chance. This means that the probability (a fractional number between 0 and 1) is multiplied by 100 and expressed as a percentage. Conditional probabilities assume a large spill has occurred and the transport of the spilled oil depends only on the winds, ice, and ocean currents in the study area.

Conditional probabilities of contact were estimated for 1, 3, 10, 30, 90, and 360 days for annual and both summer and winter seasons (Appendix C). Summer spills are spills are defined as those that begin anytime from July 1 through September 30. Therefore, if any contact to an ERA or LS is made by a trajectory that began before the end of summer season, it is considered a summer contact and is counted along with the rest of the contacts from spills launched in the summer. BOEM estimates the conditional probability of contact from spills that start in winter, freeze into the landfast ice, and melt out in the spring. Winter spills are defined as spills that begin any time from October 1 through June 30, melt out of the ice, and contact an ERA or LS during the open-water period. Therefore, if any contact to an ERA or LS is made by a trajectory that began before the end of the winter season, it is considered a winter contact and is counted along with the rest of the contacts from spills launched in the winter.

4.1 Comparisons Between Spill Location and Season

The primary differences of contact between hypothetical launch points (LI and PL) are geographic, in the perspective of west to east or nearshore versus offshore, and temporal in terms of how long it takes to contact. Hypothetical launch points at offshore locations take longer to contact the coast and nearshore ERAs, if contact occurs at all. Winter spill contact to nearshore and coastal resources is less often and, to a lesser extent than summer spill contacts, due to the effect of landfast ice in place from October to June.

4.2 Comparisons Through Time

For ERAs near the shoreline, the annual conditional probabilities (Table C-1) generally increase from day 1 to day 10 until the trajectories hit landfast ice, and then they remain relatively the same for day 30, day 90, and day 360 (e.g., ERAs 9, 77, 78, 85, 88, 92, 93, 97, 101). The detailed discussions of the conditional and combined probabilities are in Sections 4.2.1 and 4.2.2

4.2.1 Comparisons of the Conditional Probabilities of Contact

The conditional probability for Shaviovik River (ERA 106) is greater than 99.5% for both the proposed LDPI and pipeline, because all launch points are inside this ERA. For Boulder Patch Area (ERA 75), the conditional probabilities of contact from pipelines are greater than 99.5% but the conditional probabilities of contact from proposed LDPI range from 55% to 57% through time. This is due to the fact that the launch points for wells are all inside ERA 75, but pipelines are outside of the ERA 75. In general, the conditional probabilities of contact to ERAs are larger in summer (Table C-4) and smaller in winter (Table C-7), and more ERAs are contacted in summer than in winter. The conditional probabilities of contact to offshore ERAs are much lower (e.g., ERAs 24–28, 30–32,111–124).

For land segments, annual conditional probabilities of contact (Table C-2) are highest at LS 105 and 106, which are closest to the launch points. The conditional probabilities of contact to LS 105 and 106 in summer and winter (Table C-5 and C-8) are similar to that of annual. Contacts to these LSs at later time remain identical after day 10 when trajectories hit landfast ice. Contacts to other LSs are in the range of 1% to 8% depending on time of contacts.

For GLSs (Table C-3, C-6, and C-9), the conditional probabilities of contact are generally larger in summer than in winter. Not surprisingly, the United States Beaufort Coast (GLS 198) has the highest conditional probability of contact among all the GLS. The Foggy Island Bay (GLS 179) has the second highest conditional probability of contact.

4.2.2 Comparisons of the Combined Probabilities of Contact

The combined probabilities of contact to ERAs, LSs, and GLSs (Table C-10 and C-11) are very low. Combined probabilities represent oil spill occurring and contacting ERAs, LSs, and GLSs. Although the conditional probability of contact to Shaviovik River is greater than 99.5%, when it was multiplied by a very small oil spill occurrence rate, it only results in a combined probability of 1%.

5 References

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Appendix A: Oil Spill Risk Analysis Figures

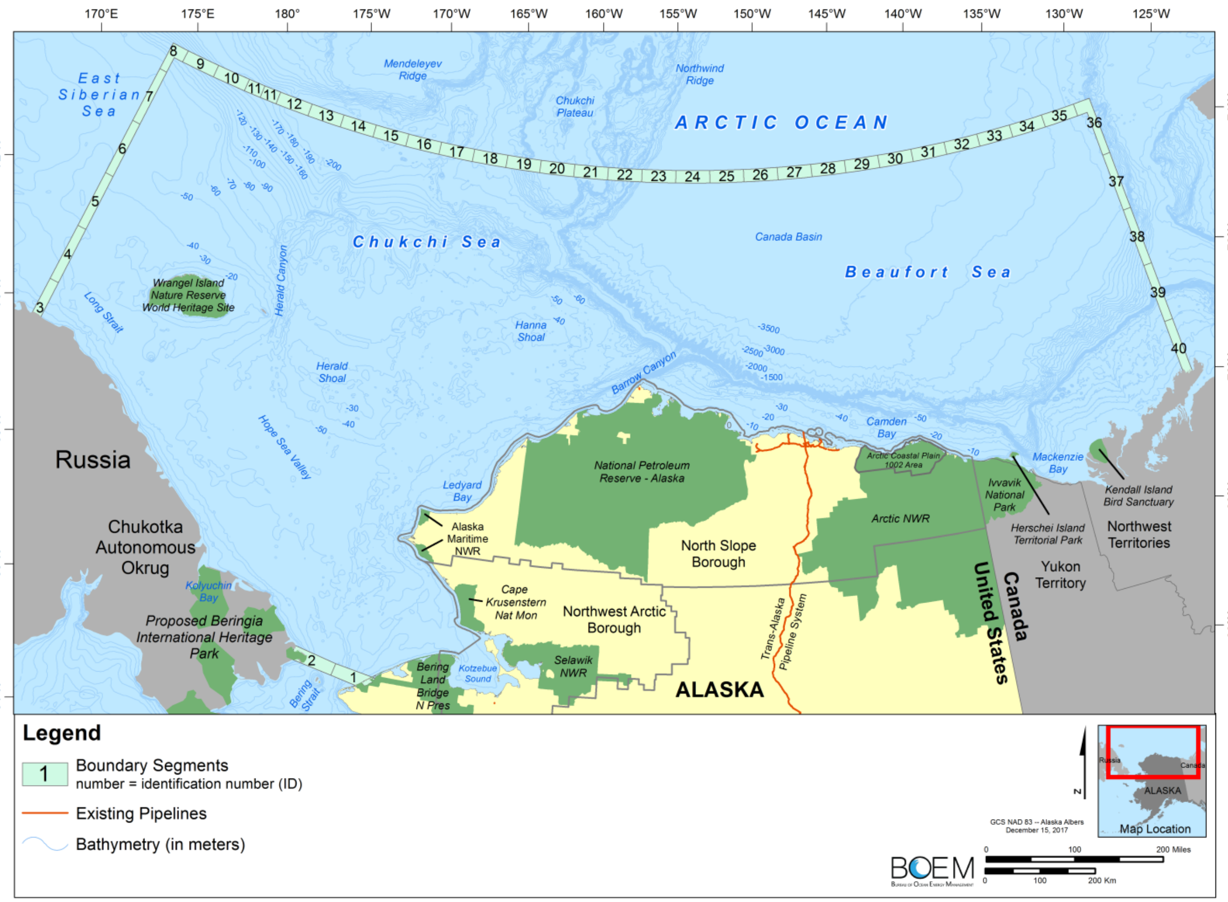

Figure A-1: Study Area and Boundary Segments Used in the OSRA Model

Figure A-2: Hypothetical Launch Areas and Hypothetical Pipelines Used in the OSRA Model

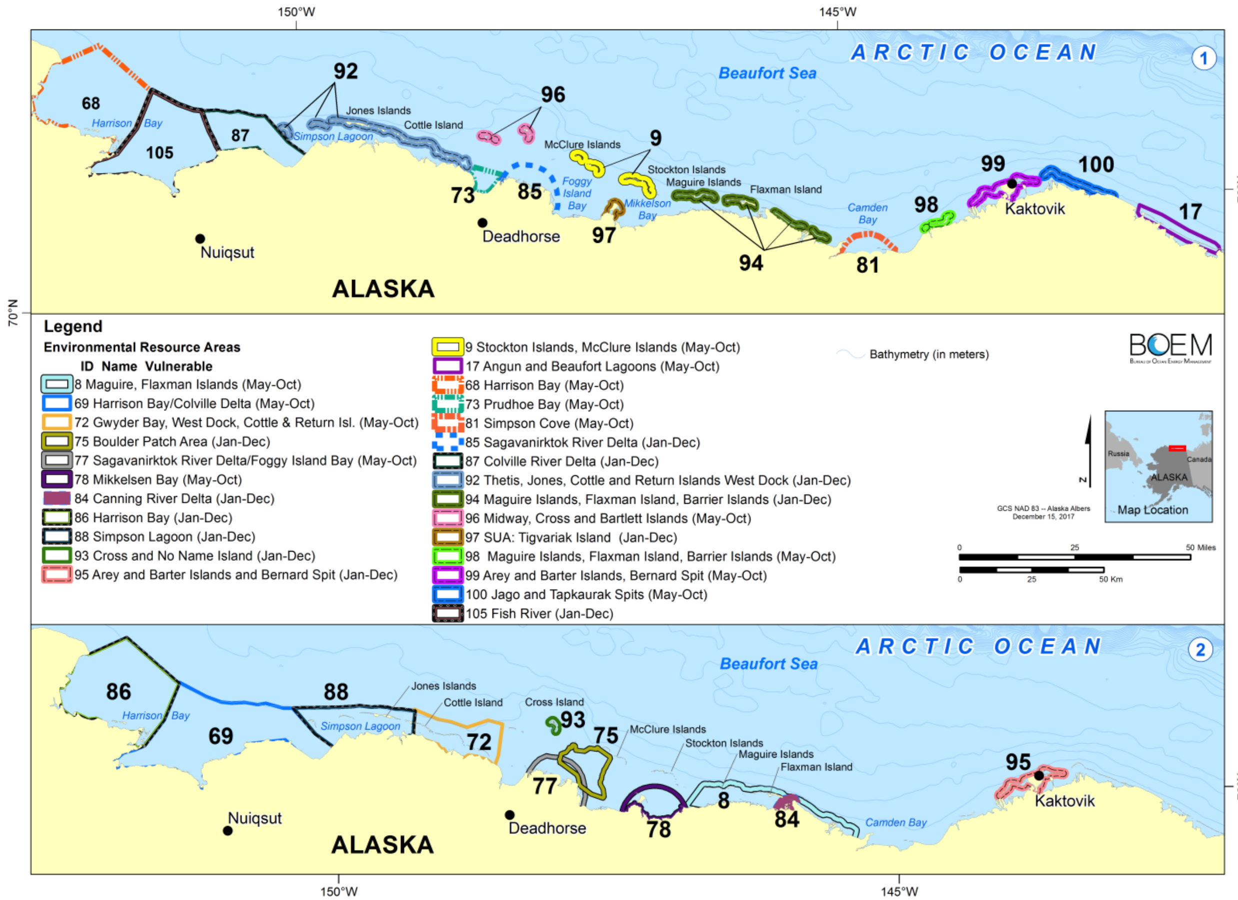

Figure A-3a: Environmental Resource Areas Used in the OSRA Model (Set 1 of 7)

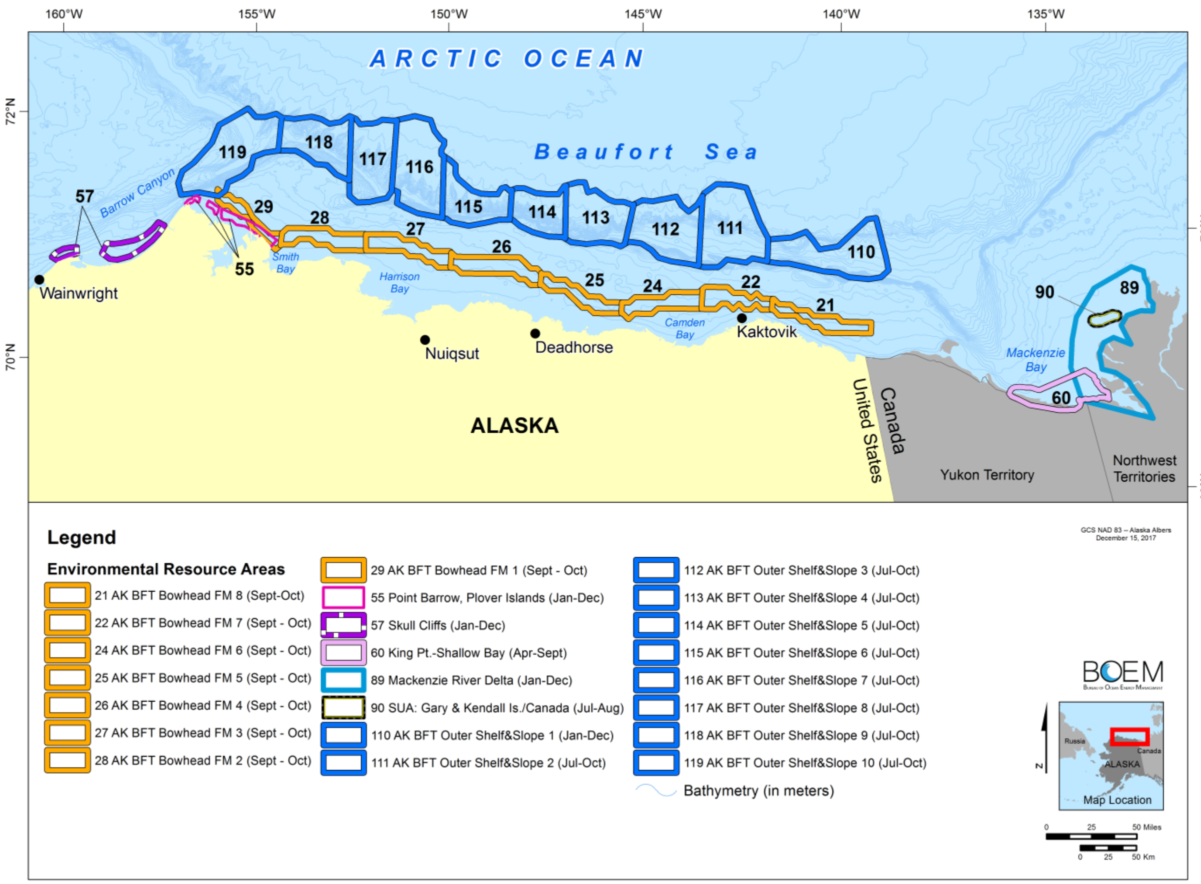

Figure A-3b: Environmental Resource Areas Used in the OSRA Model (Set 2 of 7)

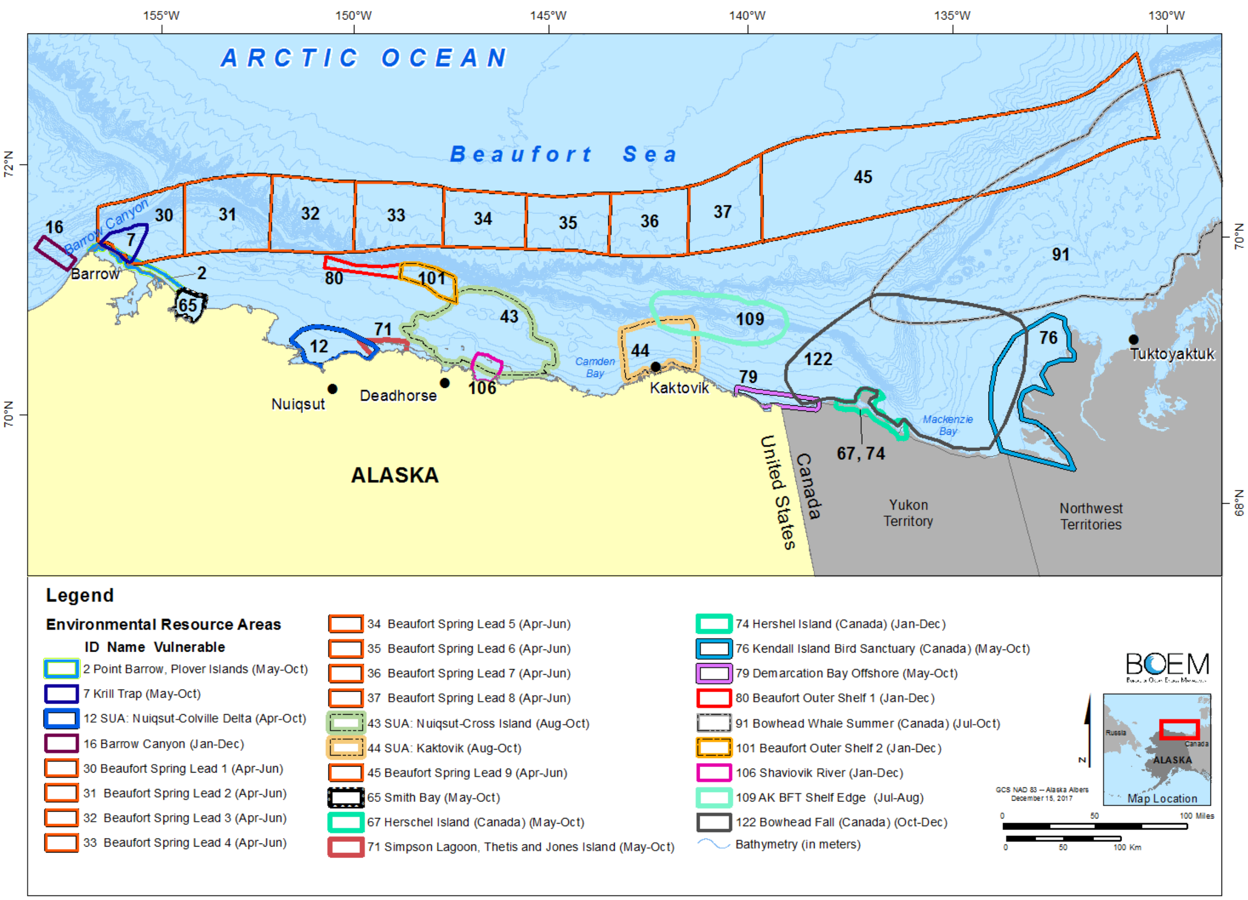

Figure A-3c: Environmental Resource Areas Used in the OSRA Model (Set 3 of 7)

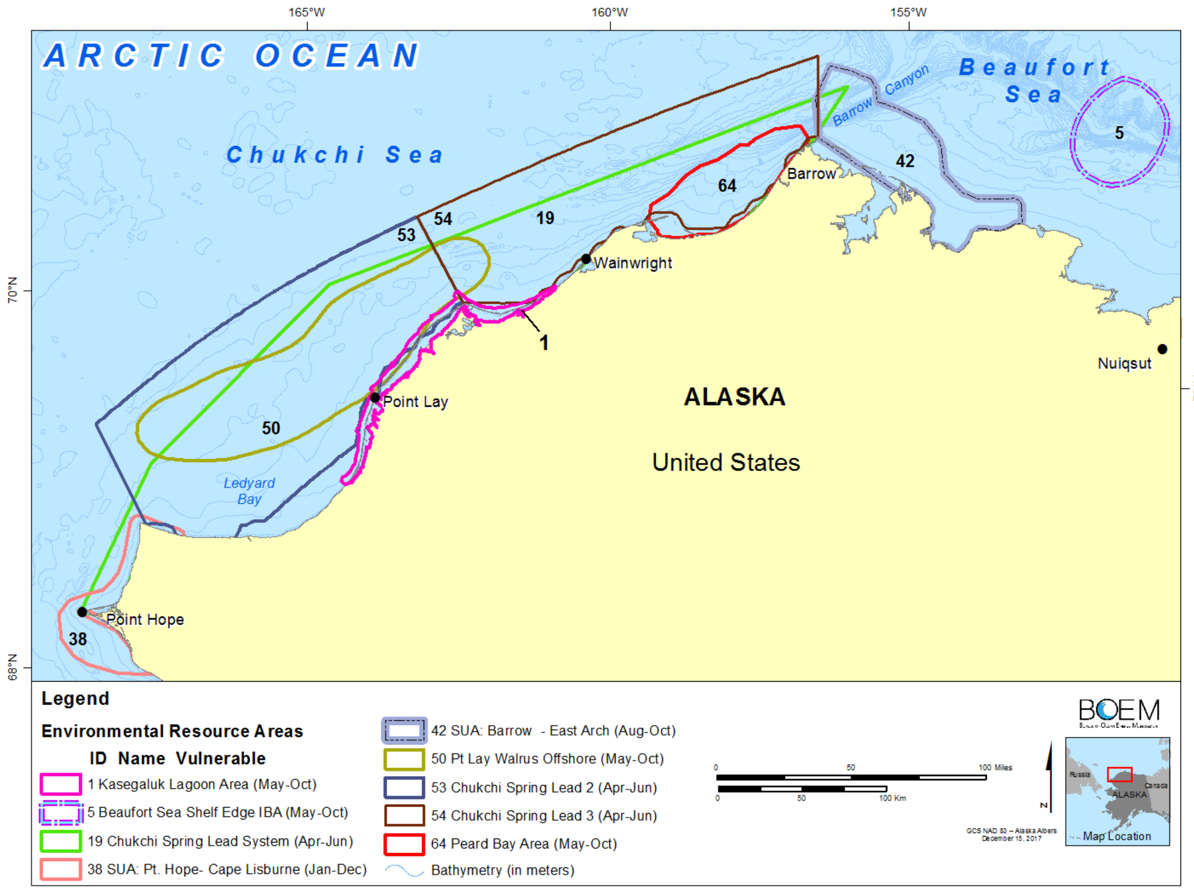

Figure A-3d: Environmental Resource Areas Used in the OSRA Model (Set 4 of 7)

Figure A-3e: Environmental Resource Areas Used in the OSRA Model (Set 5 of 7)

Figure A-3f: Environmental Resource Areas Used in the OSRA Model (Set 6 of 7)

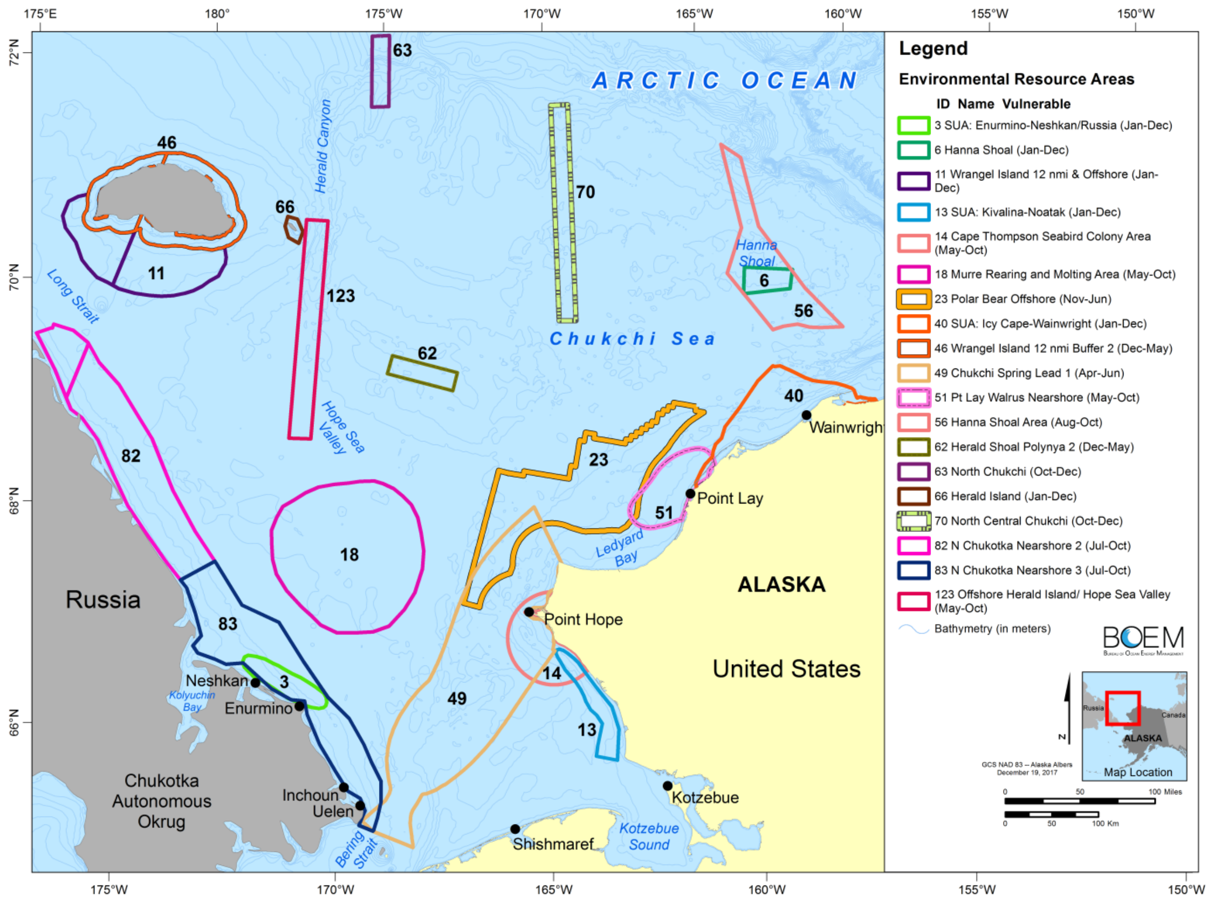

Figure A-3g: Environmental Resource Areas Used in the OSRA Model (Set 7 of 7)

Figure A-4a: Land Segments Used in the OSRA Model (Set 1 of 3)

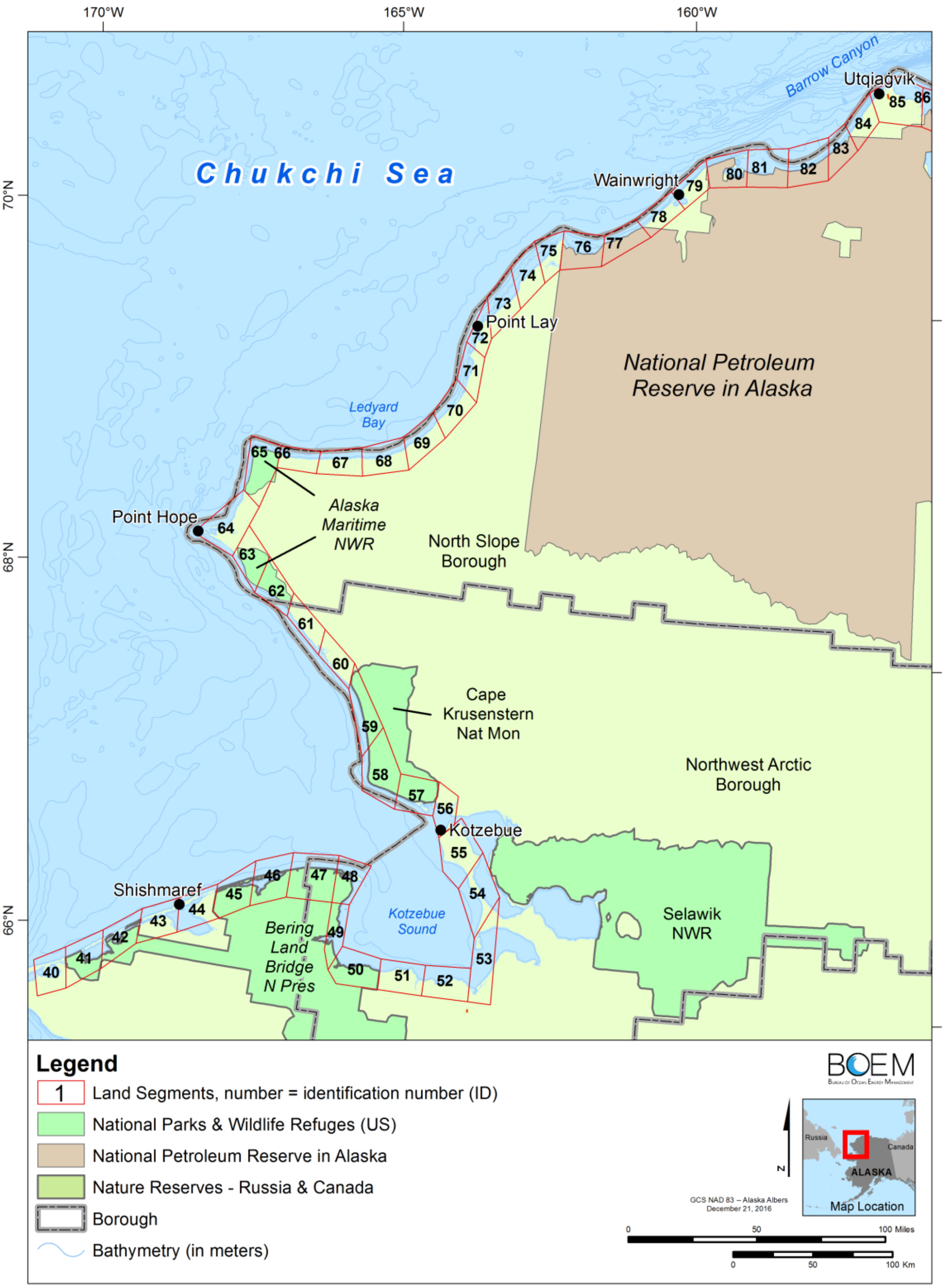

Figure A-4b: Land Segments Used in the OSRA Model (Set 2 of 3)

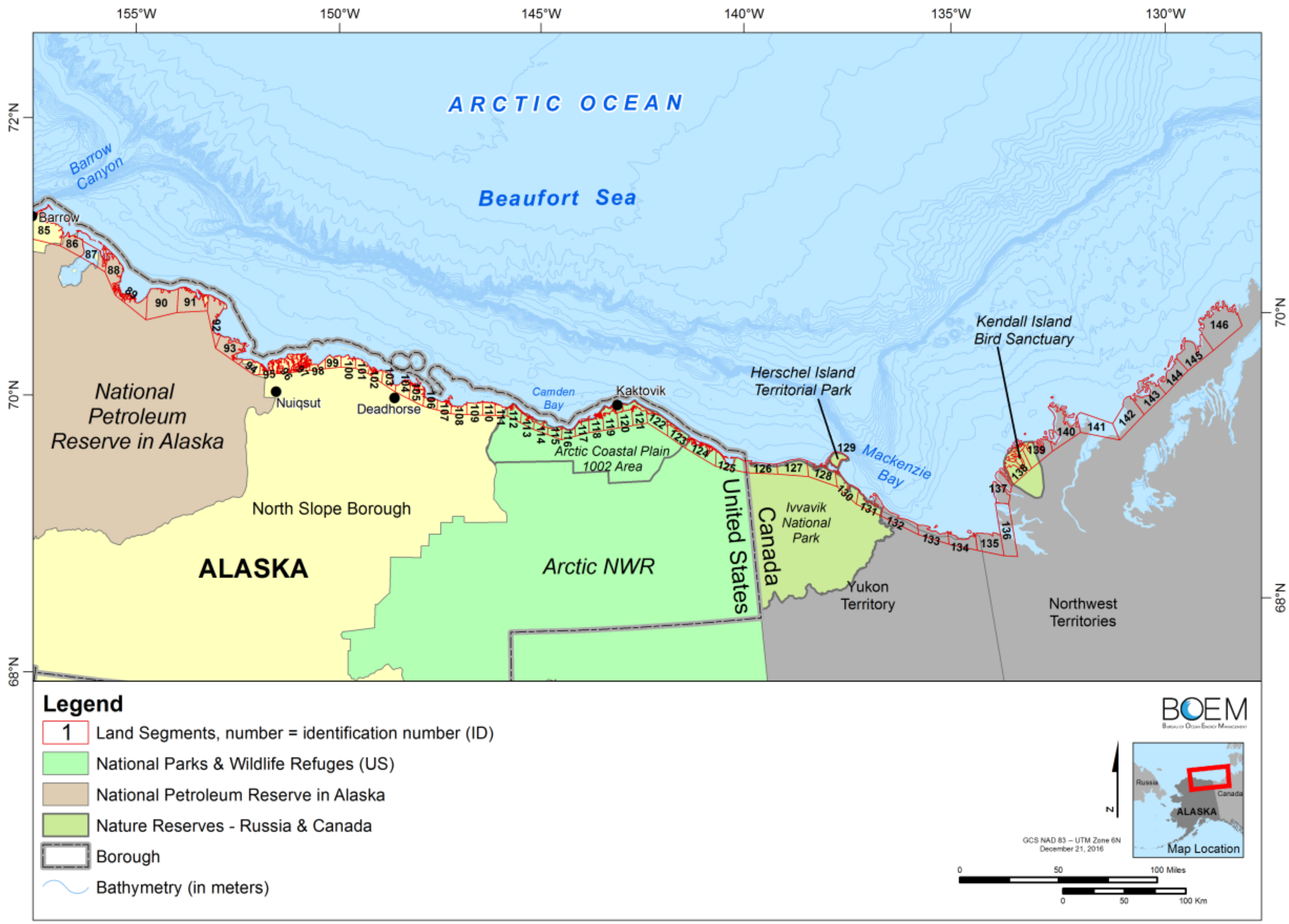

Figure A-4c: Land Segments Used in the OSRA Model (Set 3 of 3)

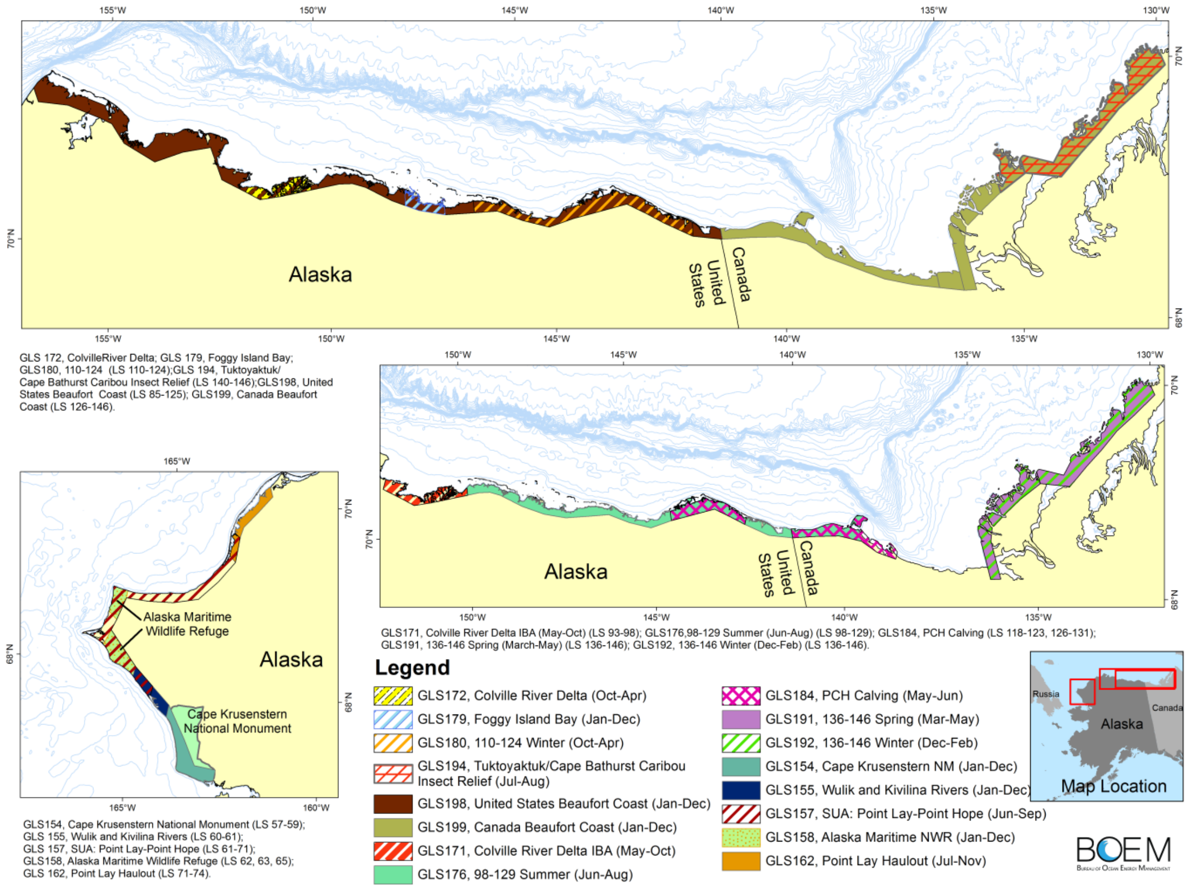

Figure A-5a: Grouped Land Segments Used in the OSRA Model (Set 1 of 3)

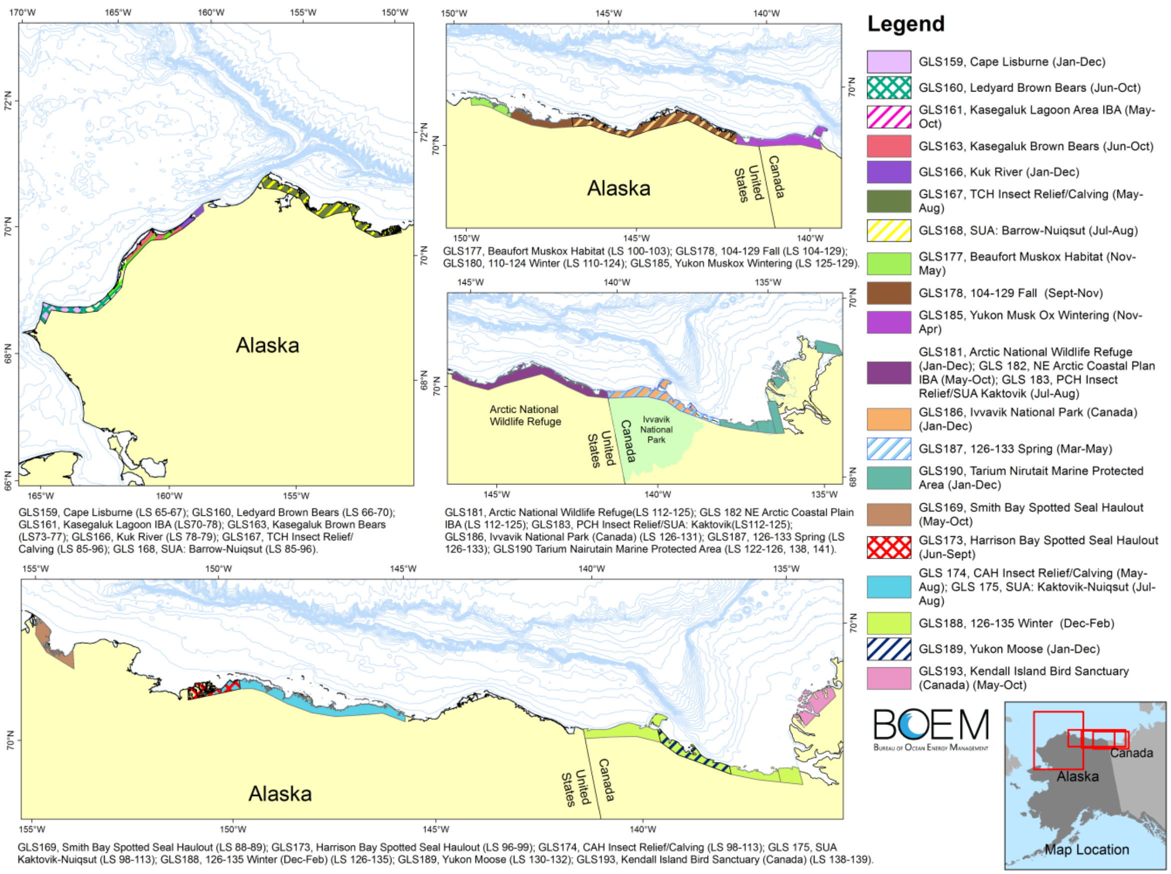

Figure A-5b: Grouped Land Segments Used in the OSRA Model (Set 2 of 3)

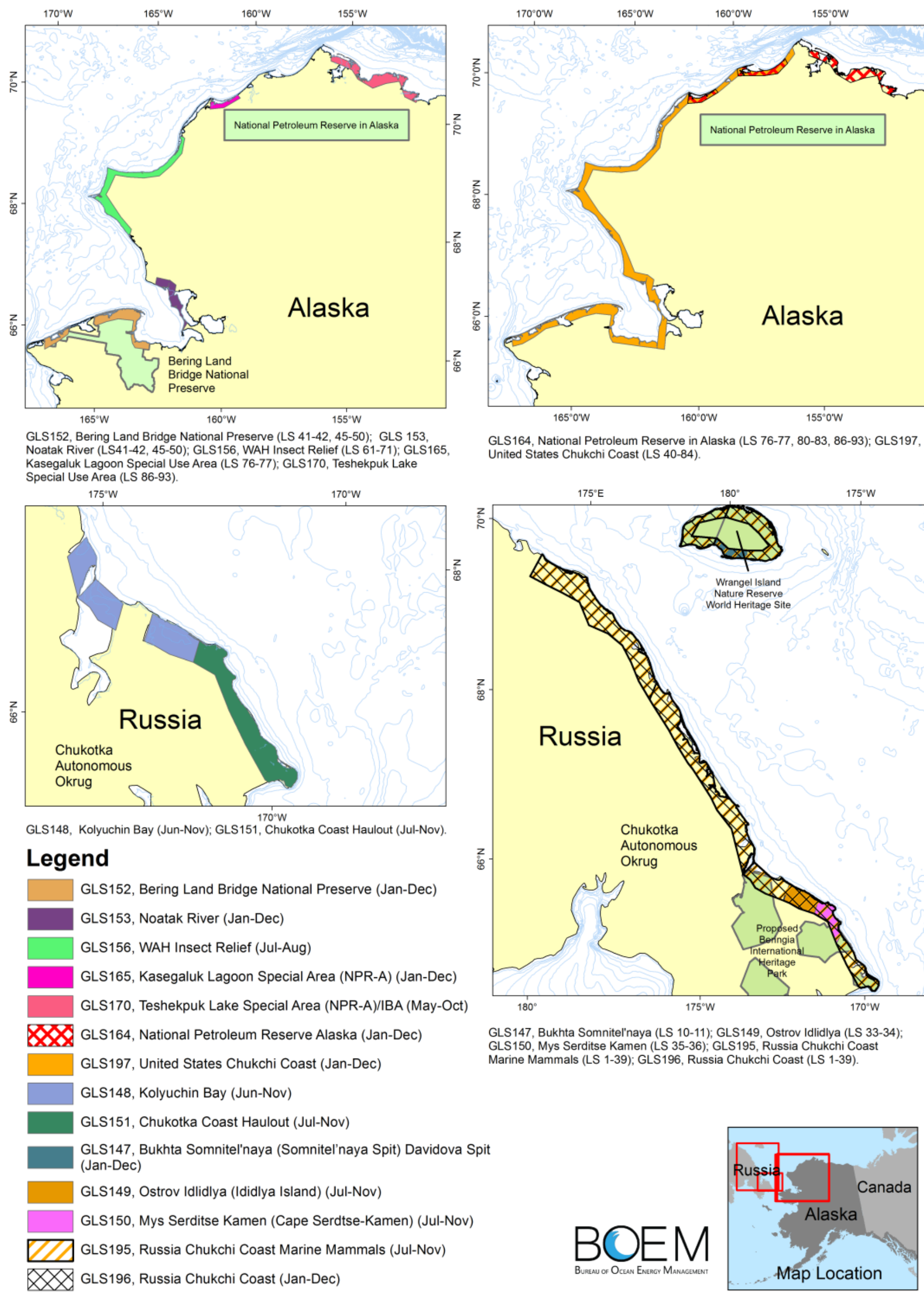

Figure A-5c: Grouped Land Segments Used in the OSRA Model (Set 3 of 3)

Appendix B: Environmental Resource Areas, Land Segments, and Grouped Land Segments

Table B-1. Environmental Resource Areas Used in the OSRA Model (Identification Number (ID), Name, Type, Vulnerability, and Map)

ID	Name	General Resource	Vulnerability	Map
1	Kasegaluk Lagoon Area	Birds, Barrier Island, Marine Mammals	May–Oct	A-3d
2	Point Barrow, Plover Islands	Birds, Barrier Island	May–Oct	A-3c
3	SUA: Enurmino–Neshkan/Russia	Subsistence	Jan–Dec	A-3g
4	SUA:Inchoun–Uelen/Russia	Subsistence	Jan–Dec	A-3f
5	Beaufort Sea Shelf Edge IBA	Birds	May–Oct	A-3d
6	Hanna Shoal	Lower Trophics, Seals	Jan–Dec	A-3g
7	Krill Trap	Lower Trophics	May–Oct	A-3c
8	Maguire and Flaxman Islands	Birds, Barrier Island	May–Oct	A-3a-2
9	Stockton and McClure Islands	Birds, Barrier Island	May–Oct	A-3a-1
10	Ledyard Bay SPEI Critical Habitat Unit	Birds	May–Oct	A-3f
11	Wrangel Island 12 nmi & Offshore	Marine Mammals	Jan–Dec	A-3g
12	SUA: Nuiqsut–Colville River Delta	Subsistence	Apr–Oct	A-3c
13	SUA: Kivalina–Noatak	Subsistence, Whales	Jan–Dec	A-3g
14	Cape Thompson Seabird Colony Area	Birds	May–Oct	A-3g
15	Cape Lisburne Seabird Colony Area	Birds, Marine Mammals	May–Oct	A-3f
16	Barrow Canyon	Lower Trophics	Jan–Dec	A-3c
17	Angun and Beaufort Lagoons	Birds, Barrier Island	May–Oct	A-3a-1
18	Murre Rearing and Molting Area	Birds	May–Oct	A-3g
19	Chukchi Spring Lead System	Birds	Apr–Jun	A-3d
20	East Chukchi Offshore	Whales	Sept–Oct	A-3f
21	AK BFT Bowhead FM 1	Whales	Sept–Oct	A-3b
22	AK BFT Bowhead FM 2	Whales, Marine Mammals	Sept–Oct	A-3b
23	Polar Bear Offshore	Marine Mammals	Nov–Jun	A-3g
24	AK BFT Bowhead FM 3	Whales	Sept–Oct	A-3b
25	AK BFT Bowhead FM 4	Whales, Fish	Sept–Oct	A-3b
26	AK BFT Bowhead FM 5	Whales	Sept–Oct	A-3b
27	AK BFT Bowhead FM 6	Whales	Sept–Oct	A-3b
28	AK BFT Bowhead FM 7	Whales, Marine Mammals	Sept–Oct	A-3b
29	AK BFT Bowhead FM 8	Whales, Marine Mammals	Sept–Oct	A-3b
30	Beaufort Spring Lead 1	Whales	Apr–Jun	A-3c
31	Beaufort Spring Lead 2	Whales, Marine Mammals, Fish	Apr–Jun	A-3c
32	Beaufort Spring Lead 3	Whales	Apr–Jun	A-3c
33	Beaufort Spring Lead 4	Whales	Apr–Jun	A-3c
34	Beaufort Spring Lead 5	Whales	Apr–Jun	A-3c
35	Beaufort Spring Lead 6	Whales	Apr–Jun	A-3c
36	Beaufort Spring Lead 7	Whales	Apr–Jun	A-3c
37	Beaufort Spring Lead 8	Whales, Fish	Apr–Jun	A-3c
38	SUA: Pt. Hope–Cape Lisburne	Subsistence, Marine Mammals, Fish	Jan–Dec	A-3d
39	SUA: Pt. Lay–Kasegaluk Lagoon	Subsistence, Marin Mammals, Fish	Jan–Dec	A-3e
40	SUA: Icy Cape–Wainwright	Subsistence, Fish	Jan–Dec	A-3g
41	SUA: Barrow–Chukchi	Subsistence, Fish	Apr–May	A-3e
42	SUA: Barrow–East Arch	Subsistence, Fish	Aug–Oct	A-3d
43	SUA: Nuiqsut–Cross Island	Subsistence, Fish	Aug–Oct	A-3c
44	SUA: Kaktovik	Subsistence, Fish	Aug–Oct	A-3c
45	Beaufort Spring Lead 9	Whales	Apr–Jun	A-3c
46	Wrangel Island 12 nmi Buffer 2	Marine Mammals	Dec–May	A-3g
47	Hanna Shoal Walrus Use Area	Marine Mammals, Fish	May–Oct	A-3e
48	Chukchi Lead System 4	Marine Mammals	Dec–May	A-3e
49	Chukchi Spring Lead 1	Whales, Fish	Apr–June	A-3g
50	Pt Lay Walrus Offshore	Marine Mammals	May–Oct	A-3d
51	Pt Lay Walrus Nearshore	Marine Mammals, Fish	May–Oct	A-3g
52	Russian Coast Walrus Offshore	Marine Mammals	May–Nov	A-3f
53	Chukchi Spring Lead 2	Whales, Fish	Apr–Jun	A-3d
54	Chukchi Spring Lead 3	Whales, Fish	Apr–Jun	A-3d

ID	Name	General Resource	Vulnerability	Map
55	Point Barrow, Plover Islands	Marine Mammals, Barrier Islands, Fish	Jan–Dec	A-3b
56	Hanna Shoal Area	Whales, Fish	Aug–Oct	A-3g
57	Skull Cliffs	Lower Trophics, Fish	Jan–Dec	A-3b
58	Russian Coast Walrus Nearshore	Marine Mammals, Fish	May–Nov	A-3f
59	Ostrov Kolyuchin	Marine Mammals, Fish	Jul–Nov	A-3f
60	SUA: King Point–Shallow Bay (Canada)	Subsistence, Whales, Fish	Apr–Sep	A-3b
61	Point Lay–Barrow BH GW SFF	Whales	Jul–Oct	A-3f
62	Herald Shoal Polynya 2	Marine Mammals	Dec–May	A-3g
63	North Chukchi	Whales	Oct–Dec	A-3g
64	Peard Bay Area	Birds, Marine Mammals, Fish	May–Oct	A-3d
65	Smith Bay	Birds, Marine Mammals, Whales	May–Oct	A-3c
66	Herald Island	Marine Mammals	Jan–Dec	A-3g
67	Herschel Island (Canada)	Birds, Fish,	May–Oct	A-3c
68	Harrison Bay	Birds, Marine Mammals	May–Oct	A-3a-1
69	Harrison Bay/Colville Delta	Birds, Marine Mammals	May–Oct	A-3a-2
70	North Central Chukchi	Whales, Fish	Oct–Dec	A-3g
71	Simpson Lagoon, Thetis and Jones Island	Birds, Fish	May–Oct	A-3c
72	Gwyder Bay, West Dock, Cottle and Return Islands	Birds, Fish	May–Oct	A-3a-2
73	Prudhoe Bay	Birds	May–Oct	A-3a-1
74	Herschel Island (Canada)	Polar Bear, Fish	Jan–Dec	A-3c
75	Boulder Patch Area	Lower Trophics, Marine Mammals	Jan–Dec	A-3a-2
76	Kendall Island Bird Sanctuary (Canada)	Birds	May–Oct	A-3c
77	Sagavanirktok River Delta/Foggy Island Bay	Birds	May–Oct	A-3a-2
78	Mikkelsen Bay	Birds	May–Oct	A-3a-2
79	Demarcation Bay Offshore	Birds	May–Oct	A-3c
80	Beaufort Outer Shelf 1	Lower Trophics, Fish	Jan–Dec	A-3c
81	Simpson Cove	Birds	May–Oct	A-3a-1
82	North Chukotka Nearshore 2	Whales	Jul–Oct	A-3g
83	North Chukotka Nearshore 3	Whales	Jul–Oct	A-3g
84	Canning River Delta	Fish	Jan–Dec	A-3a-2
85	Sagavanirktok River Delta	Fish, Marine Mammals	Jan–Dec	A-3a-1
86	Harrison Bay	Fish	Jan–Dec	A-3a-1
87	Colville River Delta	Fish	Jan–Dec	A-3e
88	Simpson Lagoon	Fish	Jan–Dec	A-3a-1
89	Mackenzie River Delta	Fish	Jan–Dec	A-3b
90	SUA: Gary and Kendall Islands (Canada)	Subsistence	Jul–Aug	A-3b
91	Bowhead Whale Summer (Canada)	Whales	Jul–Oct	A-3c
92	Thetis, Jones, Cottle & Return Islands	Marine Mammals, Barrier Islands	Jan–Dec	A-3a-1
93	Cross and No Name Islands	Marine Mammals, Barrier Islands, Fish	Jan–Dec	A-3a-2
94	Maguire Flaxman & Barrier Islands	Marine Mammals, Barrier Islands	Jan–Dec	A-3a-1
95	Arey and Barter Islands and Bernard Spit	Marine Mammals, Barrier Islands, Fish	Jan–Dec	A-3a-2
96	Midway, Cross and Bartlett Islands	Birds, Fish	May–Oct	A-3a-1
97	SUA: Tigvariak Island	Subsistence, Fish	Jan–Dec	A-3a-1
98	Anderson Point Barrier Islands	Birds, Barrier Island, Fish	May–Oct	A-3a-1
99	Arey and Barter Islands, Bernard Spit	Birds, Barrier Island, Fish	May–Oct	A-3a-1
100	Jago and Tapkaurak Spits	Birds, Barrier Island, Fish	May–Oct	A-3a-1
101	Beaufort Outer Shelf 2	Lower Trophics, Fish	Jan–Dec	A-3c
102	Opilio Crab EFH	Opilio Crab Habitat (EFH) , Fish	Jan–Dec	A-3f
103	Saffron Cod EFH	Saffron Cod Habitat (EFH) , Fish	Jan–Dec	A-3e
104	Ledyard Bay–Icy Cape IBA	Birds, Fish	May–Oct	A-3e
105	Fish Creek	Fish	Jan–Dec	A-3a-1
106	Shaviovik River	Fish	Jan–Dec	A-3c
107	Point Hope Offshore	Whales, Fish	Jun–Sep	A-3f
108	Barrow Feeding Aggregation	Whales, Fish	Sep–Oct	A-3f
109	AK BFT Shelf Edge	Whales, Fish	Jul–Aug	A-3c
110	AK BFT Outer Shelf&Slope 1	Whales, Fish	Jul–Oct	A-3b
111	AK BFT Outer Shelf&Slope 2	Whales, Fish	Jul–Oct	A-3b

ID	Name	General Resource	Vulnerability	Map
112	AK BFT Outer Shelf&Slope 3	Whales, Fish	Jul–Oct	A-3b
113	AK BFT Outer Shelf&Slope 4	Whales, Fish	Jul–Oct	A-3b
114	AK BFT Outer Shelf&Slope 5	Whales	Jul–Oct	A-3b
115	AK BFT Outer Shelf&Slope 6	Whales, Fish	Jul–Oct	A-3b
116	AK BFT Outer Shelf&Slope 7	Whales, Fish	Jul–Oct	A-3b
117	AK BFT Outer Shelf&Slope 8	Whales	Jul–Oct	A-3b
118	AK BFT Outer Shelf&Slope 9	Whales, Fish	Jul–Oct	A-3b
119	AK BFT Outer Shelf&Slope 10	Whales, Fish	Jul–Oct	A-3b
120	Chukchi Gray Whale Fall (Russia)	Whales	Sep–Oct	A-3e
121	Cape Lisburne–Pt Hope	Whales, Fish	Jun–Sep	A-3e
122	Bowhead Fall (Canada)	Whales, Fish	Oct–Dec	A-3c
123	Offshore Herald Island/Hope Sea Valley	Whales, Fish	Oct–Dec	A-3g
124	Chukchi Sea Nearshore IBA	Birds, Fish	May–Oct	A-3f

Table B-2. Land Segments Used in the OSRA Model (ID and Geographic Place Names)

ID	Geographic Place Names	ID	Geographic Place Names
1	Mys Blossom, Mys Fomy, Khishchnikov, Neozhidannaya, Laguna Vaygan	46	Cowpack Inlet, Cowpack River, Kalik River, Kividlo, Singeak, Singeakpuk River, White Fish Lake
2	Mys Gil'der, Ushakovskiy, Mys Zapadnyy	47	Kitluk River, Northwest Corner Light, West Fork Espenberg River
3	Mys Florens, Gusinaya	48	Cape Espenberg, Espenberg, Espenberg River
4	Mys Ushakova, Laguna Drem-Khed	49	Kungealoruk Creek, Kougachuk Creek, Pish River
5	Mys Evans, Neizvestnaya, Bukhta Pestsonaya	50	Clifford Point, Cripple River, Goodhope Bay, Goodhope River, Rex Point, Sullivan Bluffs
6	Ostrov Mushtakova	51	Cape Deceit, Deering, Kugruk Lagoon, Kugruk River, Sullivan Lake, Toawlevic Point
7	Kosa Bruch	52	Motherwood Point, Ninemile Point, Willow Bay
8	Klark, Mys Litke, Mys Pillar, Skeletov, Mys Uering	53	Kiwalik, Kiwalik Lagoon, Middle Channel Kiwalk River, Minnehaha Creek, Mud Channel Creek, Mud Creek
9	Nasha, Mys Proletarskiy, Bukhta Rodzhers	54	Baldwin Peninsula, Lewis Rich Channel
10	Reka Berri, Bukhta Davidova, , Khishchnika, Reka Khishchniki	55	Cape Blossom, Pipe Spit
11	Bukhta Somnitel'naya	56	Kinuk Island, Kotzebue, Noatak River
12	Zaliv Krasika, Mamontovaya, Bukhta Predatel'skaya	57	Aukulak Lagoon, Igisukruk Mountain, Noak, Mount, Sheshalik, Sheshalik Spit
13	Mys Kanayen, Mys Kekurnyy, Mys Shalaurova, Veyeman	58	Cape Krusenstern, Eigaloruk, Evelukpalik River, Kasik Lagoon, Krusenstern Lagoon,
14	Innukay, Laguna Innukay, Umkuveyem, Mys Veuman	59	Imik Lagoon, Ipiavik Lagoon, Kotlik Lagoon, Omikviorok River
15	Laguna Adtaynung, Mys Billingsa, Ettam, Gytkhelen, Laguna Uvargina	60	Imikruk Lagoon, Imnakuk Bluff, Kivalina, Kivalina Lagoon, Singigrak Spit, Kivalina River, Wulik River
16	Mys Emmatagen, Mys Enmytagyn, Uvargin	61	Asikpak Lagoon,Cape Seppings,Kavrorak Lagoon,Pusaluk Lagoon,Seppings Lagoon
17	Enmaat'khyr, Kenmankautir, Mys Olennyy, Mys Yakan, Yakanvaam, Yakan	62	Atosik Lagoon,Chariot,Ikaknak Pond,Kisimilok Mountain,Kuropak Creek,Mad Hill
18	Mys Enmykay, Laguna Olennaya, Pil'khikay, Ren, Rovaam, Laguna Rypil'khin	63	Akoviknak Lagoon, Cape Thompson, Crowbill Point, Igilerak Hill, Kemegrak Lagoon
19	Laguna Kuepil'khin, Leningradskiy	64	Aiautak Lagoon, Ipiutak Lagoon, Kowtuk Point, Kukpuk River, Pingu Bluff, Point Hope, Sinigrok Point, Sinuk
20	Polyarnyy, Kuekvun', Notakatryn, Pil'gyn, Tynupytku	65	Buckland, Cape Dyer, Cape Lewis, Cape Lisburne
21	Laguna Kinmanyakicha, Laguna Pil'khikay, Amen, Pil'khikay, Bukhta Severnaya, Val'korkey	66	Ayugatak Lagoon
22	Ekiatan', Laguna Ekiatan, Kelyun'ya, Mys Shmidta, Rypkarpyy	67	Cape Sabine, Pitmegea River
23	Emuem, Kemuem, Koyvel'khveyergin, Laguna Tengergin, Tenkergin	68	Agiak Lagoon, Punuk Lagoon
24	No place names	69	Cape Beaufort, Omalik Lagoon
25	Laguna Amguema, Ostrov Leny, Yulinu	70	Kuchaurak Creek, Kuchiak Creek
26	Ekugvaam, Reka Ekugvam, Kepin, Pil'khin	71	Kukpowruk River, Naokok, Naokok Pass, Sitkok Point
27	Laguna Nut, Rigol'	72	Epizetka River, Kokolik River, Point Lay, Siksrikpak Point
28	Kamynga, Ostrov Kardkarpko, Kovlyuneskin, Mys Vankarem, Vankarema, Laguna Vankarem	73	Akunik Pass, Tungaich Point, Tungak Creek
29	Akanatkhyrgyn, Nutpel'men, Mys Onman, Vel'may	74	Kasegaluk Lagoon, , Solivik Island, Utukok River
30	Laguna Kunergin, Nutepynmyn, Pyngopil'khin, Laguna Pyngopil'khin	75	Akeonik, Icy Cape, Icy Cape Pass
31	Alyatki, Zaliv Tasytkhin, Kolyuchin Bay	76	Akoliakatat Pass, Avak Inlet, Tunalik River
32	Mys Dzhenretlen, Eynenekvyk, Lit'khekay-Polar Station	77	Mitliktavik, Nivat Point, Nokotlek Point, Ongorakvik River
33	Neskan, Laguna Neskan, Mys Neskan	78	Kilmantavi, Kuk River, Point Collie, Sigeakruk Point,
34	Emelin, Ostrov Idlidlya, I, Memino, Tepken,	79	Point Belcher, Wainwright, Wainwright Inlet
35	Enurmino, Mys Keylu, Netakeniskhvin, Mys Neten,	80	Eluksingiak Point, Igklo River, Kugrua Bay
36	Mys Chechan, Mys Ikigur, Keniskhvik, Mys Serditse Kamen	81	Peard Bay, Point Franklin, Seahorse Islands, Tachinisok Inlet
37	Chegitun, Utkan, Mys Volnistyy	82	Skull Cliff

ID	Geographic Place Names	ID	Geographic Place Names
38	Enmytagyn, Inchoun, Inchoun, Laguna Inchoun, Mitkulino, Uellen, Mys Unikyn	83	Nulavik, Loran Radio Station
39	Cape Dezhnev, Mys Inchoun, Naukan, Mys Peek, Uelen, Laguna Uelen, Mys Uelen	84	Walakpa River, Will Rogers and Wiley Post Memorial
40	Ah-Gude-Le-Rock, Dry Creek, Lopp Lagoon, Mint River	85	Barrow, Browerville, Elson Lagoon
41	Ikpek, Ikpek Lagoon, Pinguk River, Yankee River	86	Dease Inlet, Plover Islands, Sanigaruak Island
42	Arctic Lagoon, Kugrupaga Inlet, Nuluk River	87	Igalik Island, Kulgurak Island, Kurgorak Bay, Tangent Point
43	Sarichef Island, Shishmaref Airport	88	Cape Simpson, Piasuk River, Sinclair River, Tulimanik Island
44	Cape Lowenstern, Egg Island, Shishmaref, Shishmaref Inlet	89	Ikpikpuk River, Point Poleakoon, Smith Bay
45	No place names	90	Drew Point, Kolovik, McLeod Point,
91	Lonely AFS Airport, Pitt Point, Pogik Bay, Smith River	119	Arey & Barter Island
92	Cape Halkett, Esook Trading Post, Garry Creek	120	Kaktovik, Jago Lagoon, Bernard Spit
93	Atigaru Point, Eskimo Islands, Harrison Bay, Kalikpik River, Saktuina Point	121	Jago Spit & River, Tapkaurak Spit & Lagoon
94	Tingmeachsiovik River	122	Griffin Point, Oruktalik Lagoon
95	Fish Creek, Nechelik Channel, Colville River Delta	123	Angun Point, Beaufort Lagoon
96	Tolaktovut Point, Colville River	124	Icy Reef, Kongakut River, Siku Lagoon
97	Kupigruak Channel, Colville River	125	Demarcation Bay & Point
98	Kalubik Creek	126	Clarence Lagoon, Backhouse River
99	Oliktok Point, Ugnuravik River	127	Komakuk Beach, Fish Creek
100	Milne Point, Simpson Lagoon	128	Nunaluk Spit, Firth River
101	Beechy & Back Pt., Sakonowyak R.	129	Herschel Island
102	Kuparuk River, Point Storkersen	130	Ptarmagin Bay
103	Point McIntyre, West Dock, Putuligayuk R.	131	Stokes and Kay Pt., Phillips Bay
104	Prudhoe Bay, Heald Pt.	132	Sabine Point
105	Point Brower, Sagavanirktok R., Duck I.	133	Shingle Point, Escape Reef
106	Foggy Island Bay, Kadleroshilik R.	134	Tent Island & Shoalwater Bay
107	Tigvariak Island, Shaviovik R.	135	Shallow Bay, West Channel
108	Mikkelsen Bay, Badami Airport	136	Tiktalik Channel
109	Bullen, Gordon & Reliance Points	137	Outer Shallow Bay, Olivier Islands
110	Pt. Hopson & Sweeney, Thomson	138	Middle Channel, Gary Island
111	Staines R., Lion Bay	139	Kendall Island
112	Brownlow Point, West Canning River	140	North Point, Pullen Island
113	Canning & Tamayariak River	141	Hendrickson Island, Kugmallit Bay
114	Collinson Point, Konganevik Point	142	Tuktoyaktuk, Tuktoyaktuk Harbour
115	Collinson Point, Konganevik Point	143	Warren Point
116	Marsh and Carter Creek	144	Hutchison Bay
117	Anderson Point, Sadlerochit River	145	McKinley Bay, Atkinson Point
118	Sabine Point	146	Kidney Lake, Nuvorak Point

Key: ID = identification (number)

Table B-3. Grouped Land Segments Used in the OSRA Report (ID, Geographic Names, Land Segments ID, Vulnerability, and Map)

GLS ID	Grouped Land Segment Name	Land Segment IDs	Vunerability	MAP
147	Bukhta Somnitel'naya (Somnitel'naya Spit), Davidova Spit	10–11	Jan–Dec	A-5c
148	Kolyuchin Bay	30–31, 33–34	Jun–Nov	A-5c
149	Ostrov Idlidlya (Ididlya Island)	33–34	Jul–Nov	A-5c
150	Mys Serditse Kamen (Cape Serdtse-Kamen)	35–36	Jul–Nov	A-5c
151	Chukotka Coast Haulout	35–39	Jul–Nov	A-5c
152	Bering Land Bridge National Preserve	41–42, 45–50	Jan–Dec	A-5c
153	Noatak River	54–57	Jan–Dec	A-5c
154	Cape Krusenstern National Monument	57–59	Jan–Dec	A-5a
155	Wulik and Kivilina Rivers	60–61	Jan–Dec	A-5a
156	WAH Insect Relief	61–71	Jul–Aug	A-5c
157	SUA: Point Lay–Point Hope	61–71	Jun–Sep	A-5a
158	Alaska Maritime National Wildlife Refuge	62–63, 65	Jan–Dec	A-5a
159	Cape Lisburne	65–66, 67	Jan–Dec	A-5b
160	Ledyard Brown Bears	65–70	Jun–Oct	A-5b
161	Kadegaluk Lagoon Area IBA	70–78	May–Oct	A-5b
162	Point Lay Haulout	71–74	Jul–Nov	A-5a
163	Kasegaluk Brown Bears	73–77	Jun–Oct	A-5b
164	National Petroleum Reserve-Alaska	76–77, 80–83, 86–93	Jan–Dec	A-5c
165	Kasegaluk Lagoon Special Area (NPR-A)	76–77	Jan–Dec	A-5c
166	Kuk River	78–79	Jan–Dec	A-5b
167	TCH Insect Relief/Calving	85–96	May–Aug	A-5b
168	SUA: Barrow–Nuiqsut	85–96	Jul–Aug	A-5b
169	Smith Bay Spotted Seal Haulout	88–89	May–Oct	A-5b
170	Teshekpuk Lake Special Area (NPR-A)/IBA	86–93	May–Oct	A-5c
171	Colville River Delta IBA	93–98	May–Oct	A-5a
172	Colville River Delta	94–97	Oct–Apr	A-5a
173	Harrison Bay Spotted Seal Haulout	96–99	Jun–Sep	A-5b
174	CAH Insect Relief/ Calving	98–113	May–Aug	A-5b
175	SUA: Kaktovik–Nuiqsut	98–113	Jul–Aug	A-5b
176	98–129 Summer	98–129	Jun–Aug	A-5a
177	Beaufort Muskox Habitat	100–103	Nov–May	A-5b
178	104–129 Fall	104–129	Sep–Nov	A-5b
179	Foggy Island Bay	105–107	Jan–Dec	A-5a
180	110–124 Winter	110–124	Oct–Apr	A-5a
181	Arctic National Wildlife Refuge	112–125	Jan–Dec	A-5b
182	Northeast Arctic Coastal Plain IBA	112–125	May–Oct	A-5b
183	PCH Insect Relief/SUA Kaktovik	112–125	Jul–Aug	A-5b
184	PCH Calving	118–123, 126–131	May–Jun	A-5a
185	Yukon Musk Ox Wintering	125–129	Nov–Apr	A-5b
186	Ivvavik National Park (Canada)	126–131	Jan–Dec	A-5b
187	126–133 Spring	126–133	Mar–May	A-5b
188	126–135 Winter	126–135	Dec–Feb	A-5b
189	Yukon Moose	130–132	Jan–Dec	A-5b
190	Tarium Nirutait Marine Protected Area	122–136,138, 141	Jan–Dec	A-5b
191	136–146 Spring	136–146	Mar–May	A-5a
192	136–146 Winter	136–146	Dec–Feb	A-5a
193	Kendall Island Bird Sanctuary (Canada)	138–139	May–Oct	A-5b
194	Tuktoyaktuk/Cape Bathurst Caribou Insect Relief	140–146	Jul–Aug	A-5a
195	Russia Chukchi Coast Marine Mammals	1–39	Jul–Nov	A-5c
196	Russia Chukchi Coast	1–39	Jan–Dec	A-5c
197	United States Chukchi Coast	40–84	Jan–Dec	A-5c
198	United States Beaufort Coast	85–125	Jan–Dec	A-5a
199	Canada Beaufort Coast	126–146	Jan–Dec	A-5a

Notes: CAH: Central Arctic Herd; IBS: Important Bird Area; NPR-A: National Petroleum Reserve-Alaska; PCH: Porcupine Caribou Herd; SUA: Subsistence Use Area; TCH: Teshekpuk Caribou Herd; WAH: Western Arctic Herd

Appendix C: Oil Spill Risk Analysis Conditional and Combined Probability Tables

Tables C-1 through C-9 represent conditional probabilities (expressed as percent chance) that a large oil spill starting at a particular location (LA or PL) will contact a certain location (ERA, LS, BS, or GLS). The tables are further organized as annual or seasonal (winter, summer). Tables C-1 through C-3 represent annual conditional probabilities while Tables C-4 through C-9 represent seasonal conditional probabilities. Tables C-10 through C-11 represent combined probabilities (expressed as percent chance) of one or more large spills, and the estimated number of spills (mean), occurring and contacting a resource over the assumed life of the project.

If the chance of contacting a given resource area is greater than 99.5%, it is shown with a double asterisk (**). If the chance of oil contacting a resource area is less than 0.5%, it is shown with a dash (-). Resource areas with a less than 0.5% chance of contact from all LAs and PLs are not shown.

Table C-1 represents the annual conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain ERA within 1, 3, 10, 30, 90, or 360 days:

Table C-1. Conditional Probabilities of a Large Oil Spill Contacting an Environmental Resource Area—Annual Timeframe

ID	Environmental Resource Name	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
0	Land	22	51	52	72	72	84	84	90	88	93	88	93
2	Point Barrow Plover Islands	-	-	-	-	-	-	-	-	1	-	1	-
5	Beaufort Sea Shelf Edge IBA	-	-	-	-	-	-	1	1	2	1	2	1
7	Krill Trap	-	-	-	-	-	-	-	-	1	-	1	-
8	Maguire and Flaxman Islands	-	-	1	-	2	1	2	1	2	1	2	1
9	Stockton and McClure Islands	-	-	3	2	6	4	6	4	6	4	6	4
12	SUA: Nuiqsut–Colville River Delta	-	-	-	-	1	-	2	1	3	1	3	1
24	AK BFT Bowhead FM 3	-	-	-	-	-	-	1	1	1	1	1	1
25	AK BFT Bowhead FM 4	-	-	-	-	2	1	2	1	2	1	2	1
26	AK BFT Bowhead FM 5	-	-	-	-	1	1	2	1	2	1	2	1
27	AK BFT Bowhead FM 6	-	-	-	-	-	-	1	1	1	1	1	1
28	AK BFT Bowhead FM 7	-	-	-	-	-	-	1	-	1	1	1	1
30	Beaufort Spring Lead 1	-	-	-	-	-	-	-	-	1	-	1	-
31	Beaufort Spring Lead 2	-	-	-	-	-	-	-	-	1	-	1	-
32	Beaufort Spring Lead 3	-	-	-	-	-	-	-	-	1	-	1	-
42	SUA: Barrow–East Arch	-	-	-	-	-	-	1	-	1	1	1	1
43	SUA: Nuiqsut–Cross Island	4	1	8	4	10	5	10	5	11	5	11	5
55	Point Barrow–Plover Islands	-	-	-	-	-	-	1	-	2	1	2	1
61	Point Lay–Barrow BH GW SFF	-	-	-	-	-	-	-	-	1	-	1	-
65	Smith Bay	-	-	-	-	-	-	-	-	1	-	1	-
68	Harrison Bay	-	-	-	-	1	-	2	1	3	1	3	1
69	Harrison Bay/Colville Delta	-	-	-	-	-	-	1	1	2	1	2	1
71	Simpson Lagoon Thetis and Jones Island	-	-	-	-	2	1	3	1	3	2	3	2
72	Gwyder Bay West Dock Cottle and Return Islands	-	-	3	1	6	2	7	3	7	3	7	3
73	Prudhoe Bay	-	-	1	-	2	1	2	1	2	1	2	1
75	Boulder Patch Area	**	55	**	57	**	57	**	57	**	57	**	57
77	Sagavanirktok River Delta/Foggy Island Bay	20	20	28	26	32	28	33	28	33	28	33	28
78	Mikkelsen Bay	1	1	5	4	6	4	6	5	6	5	6	5
80	Beaufort Outer Shelf 1	-	-	-	-	-	-	3	2	4	3	4	3
84	Canning River Delta	-	-	-	-	1	1	1	1	1	1	1	1
85	Sagavanirktok River Delta	38	39	55	49	61	54	62	54	63	54	63	54
86	Harrison Bay	-	-	-	-	1	-	3	1	4	2	4	2
87	Colville River Delta	-	-	-	-	1	-	1	1	2	1	2	1

ID	Environmental Resource Name	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
88	Simpson Lagoon	-	-	-	-	3	1	5	2	6	3	6	3
92	Thetis, Jones, Cottle & Return Islands	-	-	2	1	7	3	10	4	10	4	10	4
93	Cross and No Name Island	-	-	1	-	3	2	4	2	4	2	4	2
94	Maguire Flaxman & Barrier Islands	-	-	1	-	2	1	3	2	3	2	3	2
96	Midway Cross and Bartlett Islands	-	-	1	-	3	1	4	2	4	2	4	2
97	SUA: Tigvariak Island	1	1	5	5	7	6	8	6	8	6	8	6
101	Beaufort Outer Shelf 2	-	-	-	-	1	-	3	2	6	3	6	3
103	Saffron Cod EFH	-	-	-	-	-	-	-	-	1	-	1	-
105	Fish Creek	-	-	-	-	-	-	2	1	3	1	3	1
106	Shaviovik River	**	**	**	**	**	**	**	**	**	**	**	**
108	Barrow Feeding Aggregation	-	-	-	-	-	-	1	-	1	1	1	1
111	AK BFT Outer Shelf & Slope 2	-	-	-	-	-	-	-	-	1	-	1	-
112	AK BFT Outer Shelf & Slope 3	-	-	-	-	-	-	1	1	1	1	1	1
113	AK BFT Outer Shelf & Slope 4	-	-	-	-	-	-	1	1	2	1	2	1
114	AK BFT Outer Shelf & Slope 5	-	-	-	-	-	-	1	1	2	1	2	1
115	AK BFT Outer Shelf & Slope 6	-	-	-	-	-	-	1	1	2	1	2	1
116	AK BFT Outer Shelf & Slope 7	-	-	-	-	-	-	-	-	1	1	1	1
117	AK BFT Outer Shelf & Slope 8	-	-	-	-	-	-	-	-	1	1	1	1
118	AK BFT Outer Shelf & Slope 9	-	-	-	-	-	-	-	-	1	-	1	-
119	AK BFT Outer Shelf & Slope 10	-	-	-	-	-	-	-	-	1	-	1	-
124	Chukchi Sea Nearshore IBA	-	-	-	-	-	-	-	-	1	-	1	-

Table C-2 represents the annual conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain LS within 1, 3, 10, 30, 90, or 360 days:

Table C-2. Conditional Probabilities of a Large Oil Spill Contacting a Land Segment—Annual Timeframe

ID	Land Segment	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
85	Barrow, Browerville, Elson Lag.	-	-	-	-	-	-	-	-	1	-	1	-
88	Cape Simpson, Piasuk River	-	-	-	-	-	-	-	-	1	1	1	1
92	Cape Halkett, Garry Creek	-	-	-	-	-	-	2	1	3	1	3	1
93	Atigaru Pt., Eskimo Isl., Kogru R.	-	-	-	-	-	-	1	-	1	1	1	1
100	Milne Point, Simpson Lagoon	-	-	-	-	-	-	1	-	1	-	1	-
101	Beechy & Back Pt., Sakonowyak R.	-	-	-	-	1	-	2	1	2	1	2	1
102	Kuparuk River, Point Storkersen	-	-	-	-	1	-	2	1	2	1	2	1
103	Point McIntyre, West Dock, Putuligayuk R.	-	-	-	-	2	1	3	1	3	1	3	1
104	Prudhoe Bay, Heald Pt.	1	-	3	1	4	2	5	2	5	2	5	2
105	Point Brower, Sagavanirktok R., Duck I.	14	13	24	19	28	21	29	21	29	22	29	22
106	Foggy Island Bay, Kadleroshilik R.	6	37	17	47	21	50	21	50	21	50	21	50
107	Tigvariak Island, Shaviovik R.	1	1	5	4	7	5	7	6	7	6	7	6
108	Mikkelsen Bay, Badami Airport	-	-	1	1	3	2	3	2	3	2	3	2
109	Bullen, Gordon & Reliance Points	-	-	1	-	2	1	3	1	3	1	3	1
110	Pt. Hopson & Sweeney, Thomson	-	-	-	-	1	-	1	1	1	1	1	1
111	Staines R., Lion Bay	-	-	-	-	-	-	-	-	1	-	1	-
112	Brownlow Point, West Canning River	-	-	-	-	-	-	-	-	1	-	1	-

Table C-3 represents the annual conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain GLS within 1, 3, 10, 30, 90, or 360 days:

Table C-3. Conditional Probabilities of a Large Oil Spill Contacting a Grouped Land Segment—Annual Timeframe

ID	Grouped Land Segment	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
164	National Petroleum Reserve-Alaska	-	-	-	-	-	-	4	2	7	3	7	3
167	TCH Insect Relief/Calving	-	-	-	-	-	-	2	1	3	2	3	2
168	SUA: Barrow–Nuiqsut	-	-	-	-	-	-	1	1	2	1	2	1
169	Smith Bay Spotted Seal Haulout	-	-	-	-	-	-	-	-	1	-	1	-
170	Teshekpuk Lake Special Area (NPR-A)/IBA	-	-	-	-	-	-	2	1	4	2	4	2
171	Colville River Delta IBA	-	-	-	-	-	-	1	1	2	1	2	1
174	CAH Insect Relief/ Calving	7	16	17	24	25	28	27	30	27	30	27	30
175	SUA: Kaktovik–Nuiqsut	4	8	8	12	12	14	13	14	13	14	13	14
176	98–129 Summer	6	14	14	20	21	24	23	25	24	25	24	25
177	Beaufort Muskox Habitat	-	-	-	-	3	1	4	2	4	2	4	2
178	104–129 Fall	6	15	13	20	17	23	18	23	18	23	18	23
179	Foggy Island Bay	22	51	46	70	56	76	57	77	57	77	57	77
180	110–124 Winter	-	-	-	-	1	1	2	1	2	2	2	2
181	Arctic National Wildlife Refuge	-	-	-	-	1	1	2	1	2	2	2	2
182	Northeast Arctic Coastal Plain IBA	-	-	-	-	-	-	1	1	1	1	1	1
198	United States Beaufort Coast	22	51	52	72	72	84	84	90	88	93	88	93

Table C-4 represents the summer conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain ERA within 1, 3, 10, 30, 90, or 360 days:

Table C-4. Conditional Probabilities of a Large Oil Spill Contacting an Environmental Resource Area—Summer Timeframe

ID	Environmental Resource Area Name	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
0	Land	25	53	54	74	74	85	85	91	88	93	88	93
2	Point Barrow Plover Islands	-	-	-	-	-	-	1	-	2	1	2	1
5	Beaufort Sea Shelf Edge IBA	-	-	-	-	-	-	3	2	4	2	4	2
7	Krill Trap	-	-	-	-	-	-	-	-	1	1	1	1
8	Maguire and Flaxman Islands	-	-	2	1	3	2	4	2	4	2	4	2
9	Stockton and McClure Islands	-	-	6	3	9	6	10	6	10	6	10	6
12	SUA: Nuiqsut–Colville River Delta	-	-	-	-	2	1	6	3	6	3	6	3
20	East Chukchi Offshore	-	-	-	-	-	-	-	-	1	-	1	-
22	AK BFT Bowhead FM 2	-	-	-	-	-	-	1	-	1	1	1	1
24	AK BFT Bowhead FM 3	-	-	-	-	1	-	2	2	2	2	2	2
25	AK BFT Bowhead FM 4	-	-	1	-	4	2	5	3	5	3	5	3
26	AK BFT Bowhead FM 5	-	-	-	-	3	1	5	3	6	3	6	3
27	AK BFT Bowhead FM 6	-	-	-	-	1	-	3	2	4	2	4	2
28	AK BFT Bowhead FM 7	-	-	-	-	-	-	2	1	3	1	3	1
29	AK BFT Bowhead FM 8	-	-	-	-	-	-	-	-	1	1	1	1
42	SUA: Barrow–East Arch	-	-	-	-	-	-	2	1	4	2	4	2
43	SUA: Nuiqsut–Cross Island	10	3	21	10	25	13	26	13	26	14	26	14
44	SUA: Kaktovik	-	-	-	-	-	-	1	-	1	1	1	1
55	Point Barrow–Plover Islands	-	-	-	-	-	-	1	-	2	1	2	1
61	Point Lay–Barrow BH GW SFF	-	-	-	-	-	-	-	-	2	1	2	1
65	Smith Bay	-	-	-	-	-	-	1	1	1	1	1	1
68	Harrison Bay	-	-	-	-	1	-	5	3	6	3	6	3
69	Harrison Bay/Colville Delta	-	-	-	-	1	-	4	2	5	3	5	3
71	Simpson Lagoon Thetis and Jones Island	-	-	-	-	3	1	6	3	6	4	6	4

ID	Environmental Resource Area Name	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
72	Gwyder Bay West Dock Cottle and Return Islands	-	-	5	1	12	5	14	6	14	6	14	6
73	Prudhoe Bay	-	-	1	-	4	2	5	2	5	2	5	2
75	Boulder Patch Area	**	54	**	56	**	56	**	56	**	56	**	56
77	Sagavanirktok River Delta/Foggy Island Bay	42	43	60	55	67	59	68	59	68	59	68	59
78	Mikkelsen Bay	2	2	8	6	10	8	10	8	10	8	10	8
80	Beaufort Outer Shelf 1	-	-	-	-	-	-	2	1	3	2	3	2
84	Canning River Delta	-	-	-	-	1	-	1	-	1	-	1	-
85	Sagavanirktok River Delta	42	43	60	55	67	59	68	59	68	59	68	59
86	Harrison Bay	-	-	-	-	1	-	5	3	6	3	6	3
87	Colville River Delta	-	-	-	-	1	-	2	1	3	2	3	2
88	Simpson Lagoon	-	-	-	-	3	1	6	3	6	4	6	4
92	Thetis, Jones, Cottle & Return Islands	-	-	2	1	8	3	10	4	11	5	11	5
93	Cross and No Name Island	-	-	1	-	3	2	4	2	4	2	4	2
94	Maguire Flaxman & Barrier Islands	-	-	-	-	2	1	2	1	2	1	2	1
96	Midway Cross and Bartlett Islands	-	-	3	1	7	3	8	4	8	4	8	4
97	SUA: Tigvariak Island	1	1	4	4	6	5	6	5	6	5	6	5
101	Beaufort Outer Shelf 2	-	-	-	-	1	-	4	3	6	4	6	4
103	Saffron Cod EFH	-	-	-	-	-	-	-	-	1	-	1	-
105	Fish Creek	-	-	-	-	-	-	3	2	4	2	4	2
106	Shaviovik River	**	**	**	**	**	**	**	**	**	**	**	**
108	Barrow Feeding Aggregation	-	-	-	-	-	-	1	-	4	2	4	2
110	AK BFT Outer Shelf & Slope 1	-	-	-	-	-	-	-	-	1	-	1	-
111	AK BFT Outer Shelf & Slope 2	-	-	-	-	-	-	1	1	1	1	1	1
112	AK BFT Outer Shelf & Slope 3	-	-	-	-	-	-	2	1	2	2	2	2
113	AK BFT Outer Shelf & Slope 4	-	-	-	-	-	-	4	2	4	3	4	3
114	AK BFT Outer Shelf & Slope 5	-	-	-	-	1	-	4	2	4	3	4	3
115	AK BFT Outer Shelf & Slope 6	-	-	-	-	-	-	2	1	3	2	3	2
116	AK BFT Outer Shelf & Slope 7	-	-	-	-	-	-	1	1	2	1	2	1
117	AK BFT Outer Shelf & Slope 8	-	-	-	-	-	-	1	1	2	2	2	2
118	AK BFT Outer Shelf & Slope 9	-	-	-	-	-	-	1	-	2	1	2	1
119	AK BFT Outer Shelf & Slope 10	-	-	-	-	-	-	1	-	2	1	2	1
124	Chukchi Sea Nearshore IBA	-	-	-	-	-	-	-	-	2	1	2	1

Table C-5 represents the summer conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain LS within 1, 3, 10, 30, 90, or 360 days:

Table C-5. Conditional Probabilities of a Large Oil Spill Contacting a Land Segment—Summer Timeframe

ID	Land Segment	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
85	Barrow, Browerville, Elson Lag.	-	-	-	-	-	-	-	-	1	-	1	-
88	Cape Simpson, Piasuk River	-	-	-	-	-	-	1	1	2	1	2	1
91	Lonely, Pitt Pt., Pogik Bay, Smith R	-	-	-	-	-	-	-	-	1	-	1	-
92	Cape Halkett, Garry Creek	-	-	-	-	-	-	2	1	3	2	3	2
93	Atigaru Pt., Eskimo Isl., Kogru R.	-	-	-	-	-	-	2	1	3	2	3	2
97	Kupigruak Channel, Colville River	-	-	-	-	-	-	1	-	1	1	1	1
99	Oliktok Point, Ugnuravik River	-	-	-	-	-	-	1	-	1	-	1	-
100	Milne Point, Simpson Lagoon	-	-	-	-	1	-	1	-	1	1	1	1
101	Beechy & Back Pt., Sakonowyak R.	-	-	-	-	1	-	2	1	2	1	2	1
102	Kuparuk River, Point Storkersen	-	-	-	-	1	-	2	1	2	1	2	1
103	Point McIntyre, West Dock, Putuligayuk R.	-	-	1	-	3	1	3	1	3	1	3	1
104	Prudhoe Bay, Heald Pt.	1	-	3	1	5	2	5	2	5	2	5	2
105	Point Brower, Sagavanirktok R., Duck I.	17	15	27	21	32	24	33	24	33	24	33	24
106	Foggy Island Bay, Kadleroshilik R.	6	37	17	48	20	49	20	49	20	49	20	49
107	Tigvariak Island, Shaviovik R.	1	1	4	3	5	4	5	4	5	4	5	4
108	Mikkelsen Bay, Badami Airport	-	-	1	1	2	1	2	1	2	1	2	1
109	Bullen, Gordon & Reliance Points	-	-	1	-	1	1	1	1	1	1	1	1
110	Pt. Hopson & Sweeney, Thomson	-	-	-	-	1	-	1	1	1	1	1	1
112	Brownlow Point, West Canning River	-	-	-	-	1	-	1	-	1	-	1	-

Table C-6 represents the summer conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain GLS within 1, 3, 10, 30, 90, or 360 days:

Table C-6. Conditional Probabilities of a Large Oil Spill Contacting a Grouped Land Segment—Summer Timeframe

ID	Grouped Land Segment	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
164	National Petroleum Reserve-Alaska	-	-	-	-	-	-	6	3	9	5	9	5
167	TCH Insect Relief/Calving	-	-	-	-	-	-	4	2	5	3	5	3
168	SUA: Barrow–Nuiqsut	-	-	-	-	-	-	4	2	5	3	5	3
169	Smith Bay Spotted Seal Haulout	-	-	-	-	-	-	1	1	2	1	2	1
170	Teshekpuk Lake Special Area (NPR-A)/IBA	-	-	-	-	-	-	6	3	8	5	8	5
171	Colville River Delta IBA	-	-	-	-	-	-	3	2	4	3	4	3
173	Harrison Bay Spotted Seal Haulout	-	-	-	-	-	-	1	1	1	1	1	1
174	CAH Insect Relief/ Calving	12	27	28	40	40	46	42	47	42	47	42	47
175	SUA: Kaktovik–Nuiqsut	12	27	28	40	40	46	42	47	42	47	42	47
176	98–129 Summer	12	27	28	40	40	46	43	48	43	48	43	48
178	104–129 Fall	12	26	25	34	30	37	30	37	30	37	30	37
179	Foggy Island Bay	24	53	48	72	57	77	58	78	58	78	58	78
181	Arctic National Wildlife Refuge	-	-	-	-	1	-	1	-	1	-	1	-
182	Northeast Arctic Coastal Plain IBA	-	-	-	-	1	-	1	-	1	-	1	-
183	PCH Insect Relief/SUA Kaktovik	-	-	-	-	-	-	1	-	1	-	1	-
198	United States Beaufort Coast	25	53	54	74	74	85	85	91	88	93	88	93

Table C-7 represents the winter conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain ERA within 1, 3, 10, 30, 90, or 360 days

Table C-7. Conditional Probabilities of a Large Oil Spill Contacting an Environmental Resource Area—Winter Timeframe

ID	Environmental Resource Area	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
0	Land	22	51	51	72	72	84	84	90	88	93	88	93
2	Point Barrow Plover Islands	-	-	-	-	-	-	-	-	1	-	1	-
5	Beaufort Sea Shelf Edge IBA	-	-	-	-	-	-	-	-	1	1	1	1
8	Maguire and Flaxman Islands	-	-	-	-	2	1	2	1	2	1	2	1
9	Stockton and McClure Islands	-	-	3	1	4	3	5	3	5	3	5	3
12	SUA: Nuiqsut–Colville River Delta	-	-	-	-	1	-	1	-	2	1	2	1
25	AK BFT Bowhead FM 4	-	-	-	-	1	1	1	1	1	1	1	1
26	AK BFT Bowhead FM 5	-	-	-	-	1	-	1	1	1	1	1	1
27	AK BFT Bowhead FM 6	-	-	-	-	-	-	1	-	1	-	1	-
28	AK BFT Bowhead FM 7	-	-	-	-	-	-	1	-	1	-	1	-
30	Beaufort Spring Lead 1	-	-	-	-	-	-	-	-	1	-	1	-
31	Beaufort Spring Lead 2	-	-	-	-	-	-	1	-	1	1	1	1
32	Beaufort Spring Lead 3	-	-	-	-	-	-	1	-	1	-	1	-
34	Beaufort Spring Lead 5	-	-	-	-	-	-	-	-	1	-	1	-
35	Beaufort Spring Lead 6	-	-	-	-	-	-	-	-	1	-	1	-
42	SUA: Barrow–East Arch	-	-	-	-	-	-	-	-	1	-	1	-
43	SUA: Nuiqsut-Cross Island	2	1	4	2	5	2	5	2	5	3	5	3
48	Chukchi Lead System 4	-	-	-	-	-	-	1	-	1	-	1	-
55	Point Barrow–Plover Islands	-	-	-	-	-	-	1	-	1	1	1	1
65	Smith Bay	-	-	-	-	-	-	-	-	1	-	1	-
68	Harrison Bay	-	-	-	-	-	-	1	-	2	1	2	1
69	Harrison Bay/Colville Delta	-	-	-	-	-	-	1	-	1	1	1	1
71	Simpson Lagoon Thetis and Jones Island	-	-	-	-	1	-	2	1	2	1	2	1
72	Gwyder Bay West Dock Cottle and Return Islands	-	-	2	-	4	1	5	2	5	2	5	2
73	Prudhoe Bay	-	-	-	-	1	-	1	1	1	1	1	1
75	Boulder Patch Area	**	55	**	57	**	58	**	58	**	58	**	58
77	Sagavanirktok River Delta/Foggy Island Bay	13	12	18	16	21	17	21	18	21	18	21	18
78	Mikkelsen Bay	1	1	3	3	4	3	4	3	4	3	4	3
80	Beaufort Outer Shelf 1	-	-	-	-	1	-	3	2	5	3	5	3
84	Canning River Delta	-	-	-	-	1	1	1	1	1	1	1	1
85	Sagavanirktok River Delta	37	38	53	47	59	52	61	53	61	53	61	53
86	Harrison Bay	-	-	-	-	1	-	3	1	4	2	4	2
87	Colville River Delta	-	-	-	-	1	-	1	1	2	1	2	1
88	Simpson Lagoon	-	-	-	-	4	1	5	2	6	2	6	2
92	Thetis, Jones, Cottle & Return Islands	-	-	2	1	7	2	10	4	10	4	10	4
93	Cross and No Name Island	-	-	1	-	3	2	4	2	4	2	4	2
94	Maguire Flaxman & Barrier Islands	-	-	1	-	2	2	3	2	4	2	4	2
95	Arey and Barter Islands and Bernard Spit	-	-	-	-	-	-	1	1	1	1	1	1
96	Midway Cross and Bartlett Islands	-	-	1	-	2	1	2	1	2	1	2	1
97	SUA: Tigvariak Island	2	1	6	5	8	6	9	7	9	7	9	7
101	Beaufort Outer Shelf 2	-	-	-	-	1	-	3	2	5	3	5	3
103	Saffron Cod EFH	-	-	-	-	-	-	-	-	1	-	1	-
105	Fish Creek	-	-	-	-	-	-	1	1	2	1	2	1
106	Shaviovik River	**	**	**	**	**	**	**	**	**	**	**	**
112	AK BFT Outer Shelf & Slope 3	-	-	-	-	-	-	-	-	1	1	1	1
113	AK BFT Outer Shelf & Slope 4	-	-	-	-	-	-	-	-	1	1	1	1

ID	Environmental Resource Area	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
114	AK BFT Outer Shelf & Slope 5	-	-	-	-	-	-	1	-	1	1	1	1
115	AK BFT Outer Shelf & Slope 6	-	-	-	-	-	-	-	-	1	1	1	1
116	AK BFT Outer Shelf & Slope 7	-	-	-	-	-	-	-	-	1	1	1	1

Table C-8 represents the winter conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain LS within 1, 3, 10, 30, 90, or 360 days:

Table C-8. Conditional Probabilities of a Large Oil Spill Contacting a Land Segment—Winter Timeframe

ID	Land Segment	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
88	Cape Simpson, Piasuk River	-	-	-	-	-	-	-	-	1	-	1	-
92	Cape Halkett, Garry Creek	-	-	-	-	-	-	2	1	3	1	3	1
93	Atigaru Pt., Eskimo Isl., Kogru R.	-	-	-	-	-	-	-	-	1	-	1	-
100	Milne Point, Simpson Lagoon	-	-	-	-	-	-	1	-	1	-	1	-
101	Beechy & Back Pt., Sakonowyak R.	-	-	-	-	2	1	2	1	2	1	2	1
102	Kuparuk River, Point Storkersen	-	-	-	-	1	-	2	1	2	1	2	1
103	Point McIntyre, West Dock, Putuligayuk R.	-	-	-	-	2	1	3	1	3	1	3	1
104	Prudhoe Bay, Heald Pt.	1	-	2	1	4	1	4	2	4	2	4	2
105	Point Brower, Sagavanirktok R., Duck I.	14	13	23	18	27	20	28	21	28	21	28	21
106	Foggy Island Bay, Kadleroshilik R.	6	36	17	47	21	50	22	50	22	50	22	50
107	Tigvariak Island, Shaviovik R.	1	1	5	4	7	6	8	6	8	6	8	6
108	Mikkelsen Bay, Badami Airport	-	-	2	1	3	2	4	2	4	2	4	2
109	Bullen, Gordon & Reliance Points	-	-	1	-	2	1	3	2	3	2	3	2
110	Pt. Hopson & Sweeney, Thomson	-	-	-	-	1	-	1	1	1	1	1	1
111	Staines R., Lion Bay	-	-	-	-	-	-	-	-	1	1	1	1
112	Brownlow Point, West Canning River	-	-	-	-	-	-	-	-	1	-	1	-

Table C-9 represents the winter conditional probabilities (expressed as percent chance) that a large oil spill starting at the proposed LDPI or pipeline will contact a certain GLS within 1, 3, 10, 30, 90, or 360 days:

Table C-9. Conditional Probabilities of a Large Oil Spill Contacting a Grouped Land Segment—Winter Timeframe

ID	Grouped Land Segment	1 day LI	1 day PL	3 days LI	3 days PL	10 days LI	10 days PL	30 days LI	30 days PL	90 days LI	90 days PL	360 days LI	360 days PL
164	National Petroleum Reserve-Alaska	-	-	-	-	-	-	3	1	6	3	6	3
167	TCH Insect Relief/Calving	-	-	-	-	-	-	1	-	2	1	2	1
168	SUA: Barrow–Nuiqsut	-	-	-	-	-	-	-	-	1	-	1	-
170	Teshekpuk Lake Special Area (NPR–A)/IBA	-	-	-	-	-	-	1	-	2	1	2	1
171	Colville River Delta IBA	-	-	-	-	-	-	-	-	1	-	1	-
174	CAH Insect Relief/ Calving	6	13	14	19	20	22	22	24	22	24	22	24
175	SUA: Kaktovik0Nuiqsut	1	2	2	3	3	3	3	3	3	3	3	3
176	98–129 Summer	4	9	10	13	14	16	16	17	17	18	17	18
177	Beaufort Muskox Habitat	-	-	1	-	4	1	5	2	5	2	5	2
178	104–129 Fall	4	11	9	16	13	18	14	18	14	19	14	19

ID	Grouped Land Segment	1 day	1 day	3 days	3 days	10	10	30	30	90	90	360	360
179	Foggy Island Bay	21	51	46	69	55	76	57	77	57	77	57	77
180	110–124 Winter	-	-	-	-	1	1	2	2	3	2	3	2
181	Arctic National Wildlife Refuge	-	-	-	-	1	1	2	2	2	2	2	2
182	Northeast Arctic Coastal Plain IBA	-	-	-	-	-	-	1	1	1	1	1	1
190	Tarium Nirutait Marine Protected Area	-	-	-	-	-	-	-	-	1	-	1	-
198	United States Beaufort Coast	22	51	51	72	72	84	84	90	88	92	88	92
199	Canada Beaufort Coast	-	-	-	-	-	-	-	-	1	-	1	-

Tables C-10 through C-11 represent combined probabilities (expressed as percent chance), over the assumed life of the Proposed Action of one or more spills ≥1,000 bbl, and the estimated number of spills (mean), occurring and contacting a certain ERA or GLS. All individual LSs had less than a 0.5% chance of contact and are not shown.

Table C-10. Combined Probabilities and Estimated Mean Number of Spills Occurring and Contacting Environmental Resource Areas

ERA ID	Environmental Resource Area Name	1 day		3 days		10 days		30 days		90 days		360 days	
		%	mean	%	mean	%	mean	%	mean	%	mean	%	mean
0	Land	-	-	-	-	1	0.01	1	0.01	1	0.01	1	0.01
75	Boulder Patch Area	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01
106	Shaviovik River	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01	1	0.01

Table C-11. Combined Probabilities and Estimated Mean Number of Spills Occurring and Contacting Grouped Land Segments

GLS ID	Grouped Land Segment Name	1 day		3 days		10 days		30 days		90 days		360 days	
		%	mean	%	mean	%	mean	%	mean	%	mean	%	mean
198	United States Beaufort Coast	-	-	-	-	1	0.01	1	0.01	1	0.01	1	0.01

Department of the Interior (DOI)

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

Bureau of Ocean Energy Management (BOEM)

The mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.

BOEM Environmental Studies Program

The mission of the Environmental Studies Program is to provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments. The proposal, selection, research, review, collaboration, production, and dissemination of each of BOEM's Environmental Studies follows the DOI Code of Scientific and Scholarly Conduct, in support of a culture of scientific and professional integrity, as set out in the DOI Departmental Manual (305 DM 3).