Shell Exploration & Production

United States Department of Interior
Alaska OCS Region
Bureau of Ocean Energy Management
Attn: David Johnston
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Anchorage AK 99503-5823

Shell
3601 C Street, Suite 1000
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November 6, 2013

Re: Submittal of the Revised Chukchi Sea Exploration Plan - Revision 2

Dear Mr. Johnston,

Shell Gulf of Mexico Inc. (Shell) is hereby submitting this Revised Chukchi Sea Exploration Plan ("EP Revision 2") pursuant to 30 CFR 550.285.

Shell's initial Chukchi Sea Exploration Plan was submitted in 2009 and approved by the Bureau of Ocean Energy Management, Regulation, and Enforcement in 2010 ("Original EP"). In May 2011, Shell submitted a revised Chukchi Sea Exploration Plan, which was approved by the Bureau of Ocean Energy Management (BOEM) in December 2011. For purposes of this submittal, Shell refers to the 2011 approved EP as "EP Revision 1." In this EP Revision 2, Shell proposes limited changes to EP Revision 1.

As listed under 30 CFR 550.285(b), this EP Revision 2 submittal includes "…information related to or affected by the proposed changes, including information on changes in expected environmental impacts." Shell has structured the EP Revision 2 so that the various sections and appendices are labeled or number the same as what is in the previous EP Revision 1. A slight departure from this is Appendix F, the Environmental Impact Analysis ("EIA"). In accordance with 30 CFR § 550.285(b), Shell limited EP Revision 2 to only the changes or information affected by the changes. As a result, Shell organized the EIA of EP Revision 2 toward only those changes, or information affected by those changes to the Chukchi Sea exploration drilling program.

If there are any questions or comments, please contact me at (907) 646-7112 or via email at Susan.Childs@Shell.com

Thank you.

Susan Childs

Susan Childs
Alaska Venture Support Integrator, Manager

Attachments:

Eight copies of the Revised Chukchi Sea Exploration Plan – Revision 2

Air Quality Modeling digital files

PUBLIC INFORMATION

Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea, Alaska

Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915

Revision 1 (May 2011)
Revision 2 (November 2013)

Submitted to:

U.S. Department of the Interior
Bureau of Ocean Energy Management
Alaska OCS Region

Submitted by:

Shell Gulf of Mexico Inc.
3601 C Street, Suite 1000
Anchorage, AK 99503

Table of Contents – Revisions Only

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LIST OF REVISED TABLES

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LIST OF ACRONYMS

ACS	Arctic Containment System
ADNR	Alaska Department of Natural Resources
AQRP	Air Quality Regulatory Program
bbl(s)	barrel(s)
BOEM	Bureau of Ocean Energy Management
BOP	Blowout preventer
BSEE	Bureau of Safety and Environmental Enforcement
CDPF	Catalytic diesel particulate filters
CFR	Code of Federal Regulations
CO	Carbon monoxide
dB	Decibels
Discoverer	M/V Noble Discoverer
DP	Dynamic positioning
EP Revision 1	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, approved by BOEM December 15, 2011 (Shell 2011b)
EP Revision 2	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, October 2013 (Shell 2013a)
EPA	Environmental Protection Agency
ft	Foot, feet
H_2S	Hydrogen sulfide
in	Inch
IRA	Kotzebue Tribal Government
KIC	Kikiktagruk Inupiat Corporation
km	Kilometer(s)
m	Meter(s)
mi	Mile
MLC	Mudline cellar
M/V	Motor vessel
NAD	North American Datum
NMFS	National Marine Fisheries Service
NOx	Nitrogen oxides
NPDES GP	National Pollutant Discharge Elimination System General Permit
NSB	North Slope Borough
NWAB	Northwest Arctic Borough
PM, PM_{10}	Particulate matter, less than 10 microns
RKB	Rotary Kelly bushing
OCS	Outer Continental Shelf
OSR	Oil spill response
OST	Oil storage tanker
OSV	Offshore supply vessel
Partial well	Portion of the well consisting of the MLC, structural and conductor casing; same as ‘top hole’
POC	Plan of Cooperation
RS/FO	Regional Supervisor Field Operations
SCR	Selective catalytic reduction
Shell	Shell Gulf of Mexico Inc.
SO_2	Sulfur dioxide
TD	Total depth
Top hole	Portion of the well consisting of the MLC, structural and conductor casing; same as ‘partial well’
ULSD	Ultra low sulfur diesel
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
VOC	Volatile organic compounds
WCD	Worst case discharge
ZVSP	Zero-offset vertical seismic profiling

Section 1.0 REVISED EXPLORATION PLAN CONTENTS

Shell Gulf of Mexico Inc. (Shell) has an approved Outer Continental Shelf (OCS) Exploration Plan (EP)[1] to drill six wells at the Burger Prospect in the Chukchi Sea using the drillship M/V *Noble Discoverer* (*Discoverer*). EP Revision 1 was approved by BOEM on December 15, 2011. In accordance with the terms and conditions of BOEM's prior approval of EP Revision 1, Shell plans to continue exploration drilling operations at its Burger Prospect (Figures 1.b-1 and 1.b-2 in EP Revision 1).

The primary changes in this exploration drilling program revision are noted in Table 1-1.

Table 1-1 Comparison of the Exploration Drilling Program Under Shell's Approved EP Revision 1 and EP Revision 2

Parameter	Approved EP Revision 1 (Exploration Drilling Started 2012)	EP Revision 2 (November 2013)
Support Vessels	Ice Management vessel Anchor handler 2 Offshore Supply Vessels (OSV) Shallow water landing craft Oil spill response vessel Oil spill response tug and barge Oil spill tanker for recovered liquids Oil spill containment tug/barge Oil spill containment Anchor handler	Additional vessels: Tug and barge – resupply OSV - resupply Tug - support Science (Oceanographic Research) vessel – discharge monitoring Ice Management Vessel Anchor Handler OSR tug and barge - nearshore response Changes in current vessels: Increase the size of the current 2 OSVs
Aircraft	S-92 or EC225 for crew change S-61, S92 or EC225 for search and rescue	Additional S-92 Helicopter (or similar) for crew change
Aircraft Flights	Approximately 12 round trips/week for crew change	Up to 40 round trips/week for crew changes to accommodate weather and operational constraints; one round trip daily from Deadhorse-Barrow-Deadhorse to accommodate crew changes
Drilling Discharges from the Mudline Cellar	MLC size was 21 ft in diameter by approximately 40 ft deep	MLC could be as large as 29.5 ft in diameter by 50 ft deep
Drilling Discharges from Structural Casing String	Structural casing string was planned to be 36-in diameter	Structural casing may be drilled at a larger diameter
Discharges from BOP Testing	Estimated at 54 bbls/well	Shell assumes that each test of the BOP may require a retest so the amount of BOP fluid discharged is doubled to 108 bbls/well.
Cooling Drilling Fluids	Drilling fluids to be cooled	Drilling fluids will not be cooled
National Pollutant Discharge Elimination System (NPDES) Authorizations	Burger drill sites were authorized under NPDES General Permit AKG-28-0000	Notices of Intent to discharge certain wastes at the Burger drill sites will be filed under the new NPDES GP AKG-28-8100
Drilling Fluid Components	List of approved components are in Table 6.c-1 of EP Revision 1	Additional drilling components have been added and are in Tables 6.c-1 and 6.c-2 of EP Revision 2
Shorebase	Barrow – 75 person man camp	Barrow - expansion of man camp to a capacity of 200 persons; add a kitchen unit to the man camp; add hangar space for an additional helicopter
Relief Well Unit	*Kulluk*	*Polar Pioneer*
Air Emissions Authorization	Air emissions approved by EPA under authorization R10OCS/PSD-AK-09-01	The drilling vessel air emissions to be evaluated by BOEM under its regulations
Arctic Containment System Location	Centrally located in the Chukchi Sea or Beaufort Sea	Located in or near Goodhope Bay within Kotzebue Sound

[1] Shell's initial Chukchi Sea Exploration Plan was submitted in 2009 and approved by the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) in 2010 ("Original EP"). In May 2011, Shell submitted a revised Chukchi Sea Exploration Plan, which was approved by the Bureau of Ocean Energy Management (BOEM) in December 2011. For purposes of this submittal, Shell refers to the 2011 approved EP as "EP Revision 1." In this November 2013 Revised Chukchi Sea Exploration Plan ("EP Revision 2"), Shell proposes limited changes to EP Revision 1.

As required by 30 CFR 550.212-228, details of the planned revisions to approved EP Revision 1 are provided herein. This submission is a plan revision; however, Shell acknowledges that, pursuant to 30 CFR 550.285(c), the impacts previously identified and evaluated in Shell's EP Revision 1 and BOEM's December 2011 Environmental Assessment and Finding of No Significant Impact are different than the impacts potentially resulting from this plan revision, and that this plan revision is subject to all of the procedures under 30 CFR 550.231 through 30 CFR 550.235.

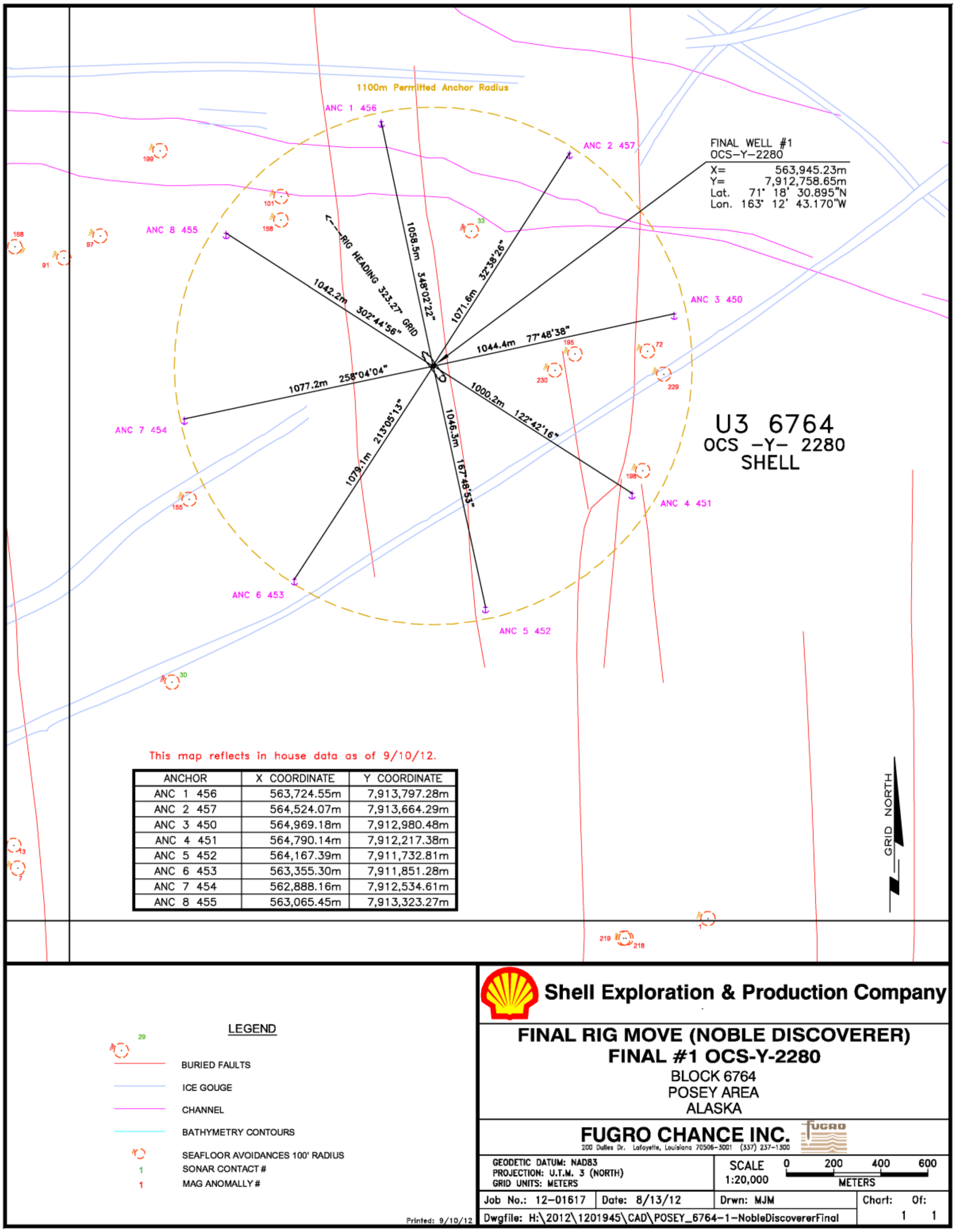
a) Description, Objectives, and Schedule for the Exploration Drilling Program

During the 2012 exploration drilling season, Shell initiated drilling at the Burger A well. The well is drilled to a measured depth of 1505' rotary Kelly bushing (RKB) and is temporarily abandoned according to the Bureau of Safety and Environmental Enforcement (BSEE) regulations at 30 CFR 250.1721-1723.

Shell plans to drill exploration wells to total depth (TD) below objective depth at each of six previously identified and analyzed drill sites at the Burger Prospect (see Table 1.b-1 and Figure 1.b-2 of EP Revision 1). It is anticipated that this work will take place over a number of drilling seasons. Shell plans to first drill the Burger A well to TD and then move on to the other previously approved locations. Depending on operational conditions, Shell may elect to construct mudline cellars (MLC) and/or upper hole segments (i.e., "partial well" or "top hole") at any of the approved drill sites at the Burger Prospect. Any well on which drilling is suspended would be secured in compliance with BSEE regulations and with the approval of the Regional Supervisor/Field Operations (RS/FO), whether permanently abandoned (30 CFR 250.1710 through 1717) or temporarily abandoned (30 CFR 250.1721-1723). Shell may pre-set anchors at one or more drill site(s) in advance of the drillship arriving and may over winter anchors for future drilling seasons.

Included in EP Revision 2 are updated proposed anchor radii figures for the drill sites at Burger F, J, R, S, and V (Figures 1.b-4 through 1.b-8) and the exact anchor locations for Burger A (Figure 1.b-3). These mooring radii for Burger F, J, R, S and V are similar to what were presented in EP Revision 1; however the exact anchor locations are not included. Anchor locations will be determined prior to the start of drilling activities.

Figure 1.b-3 Drillship Final Anchor Locations - Burger A



ANCHOR	X COORDINATE	Y COORDINATE
ANC 1 456	563,724.55m	7,913,797.28m
ANC 2 457	564,524.07m	7,913,664.29m
ANC 3 450	564,969.18m	7,912,980.48m
ANC 4 451	564,790.14m	7,912,217.38m
ANC 5 452	564,167.39m	7,911,732.81m
ANC 6 453	563,355.30m	7,911,851.28m
ANC 7 454	562,888.16m	7,912,534.61m
ANC 8 455	563,065.45m	7,913,323.27m

Figure 1.b-4 Bathymetry and Planned Drillship Anchor Radius - Burger F

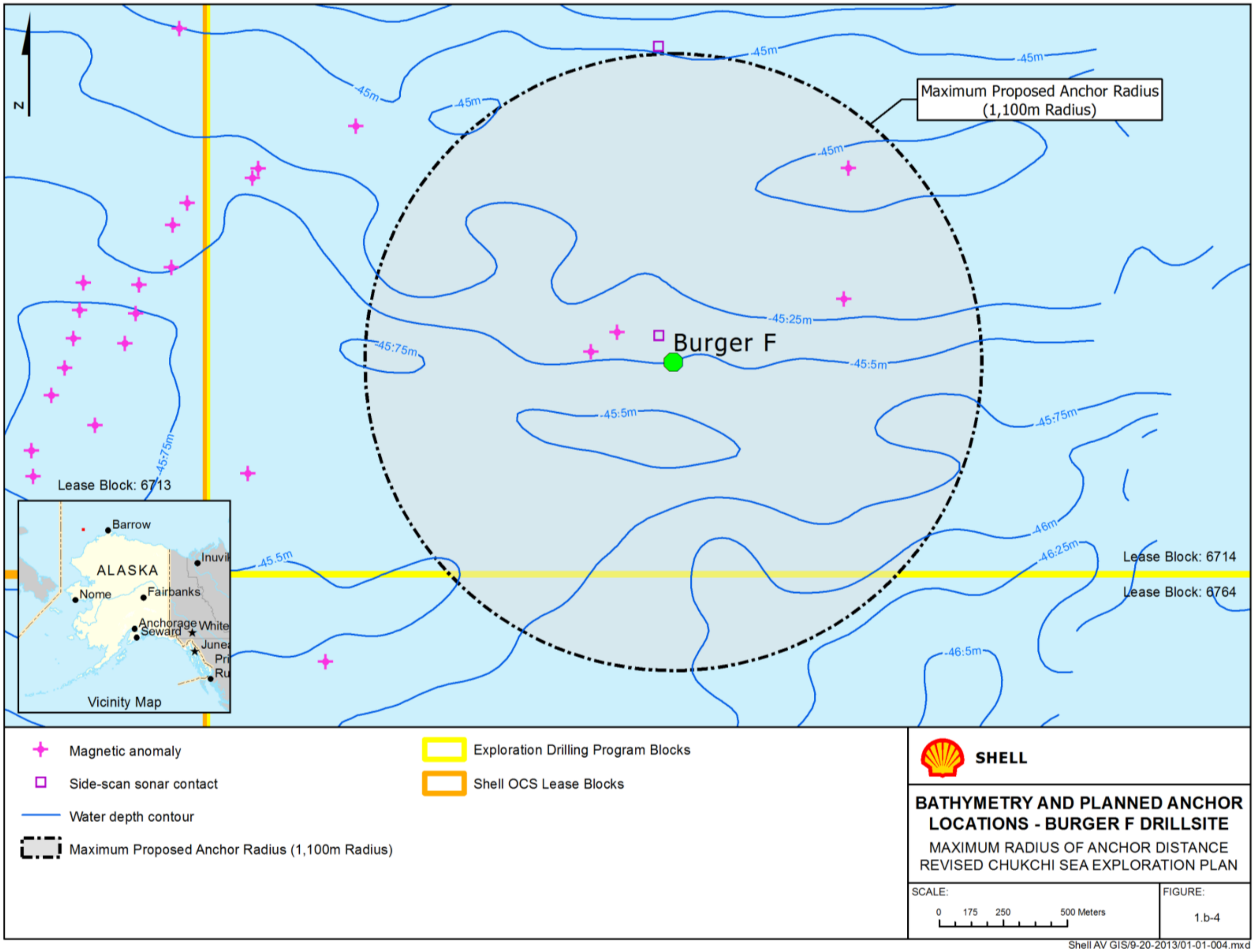


Figure 1.b-5 Bathymetry and Planned Drillship Anchor Radius - Burger J

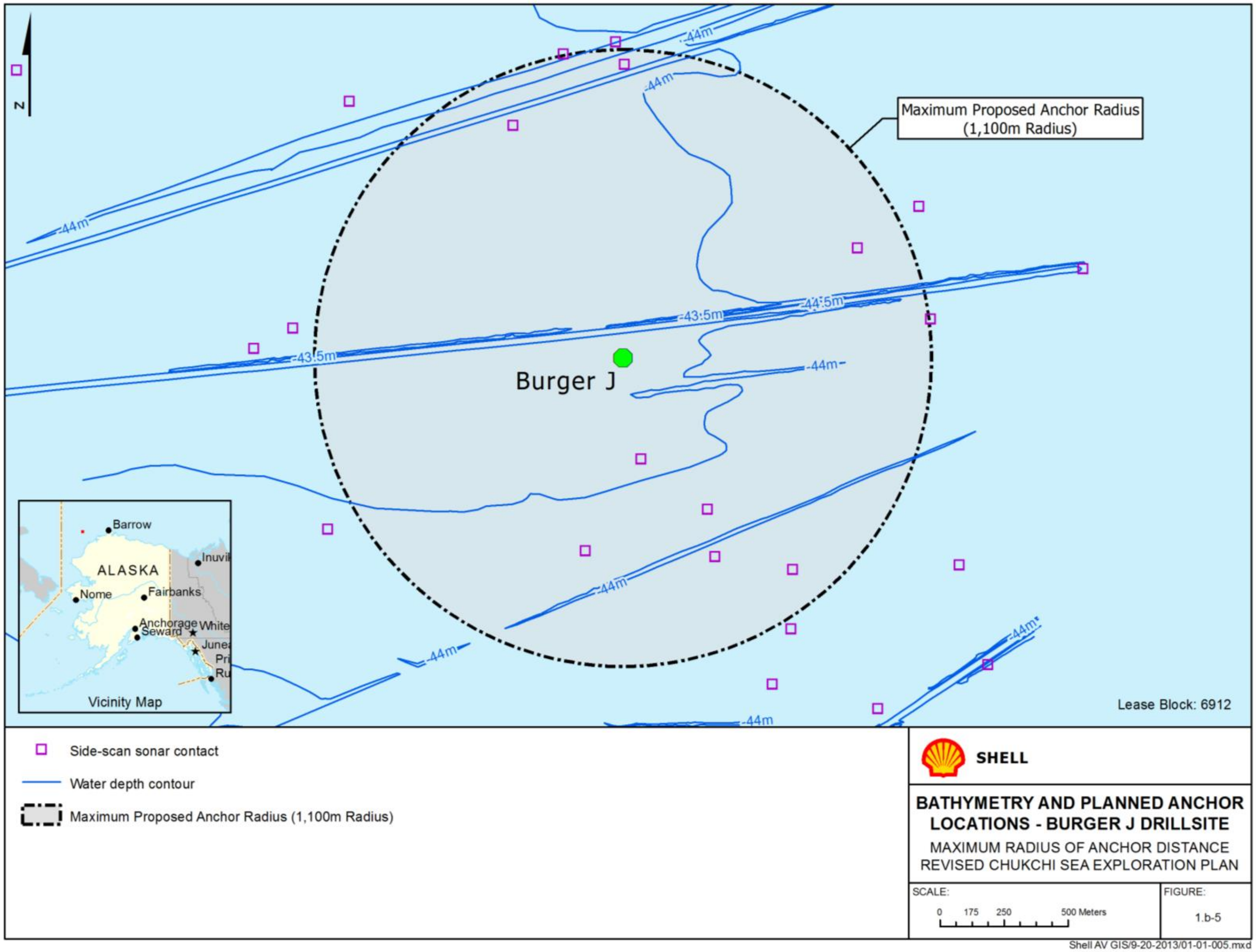


Figure 1.b-6 Bathymetry and Planned Drillship Anchor Radius - Burger R

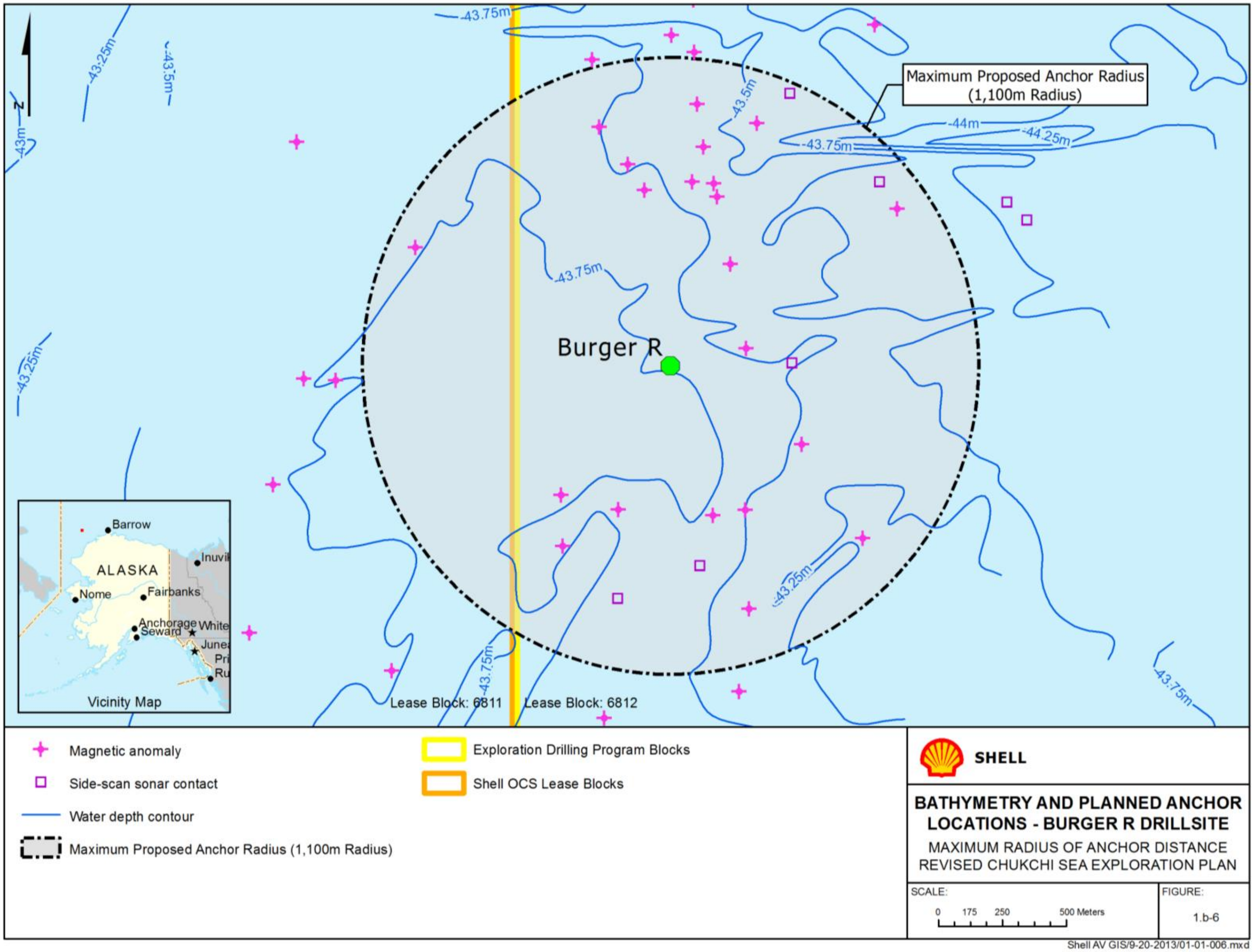


Figure 1.b-7 Bathymetry and Planned Drillship Anchor Radius - Burger S

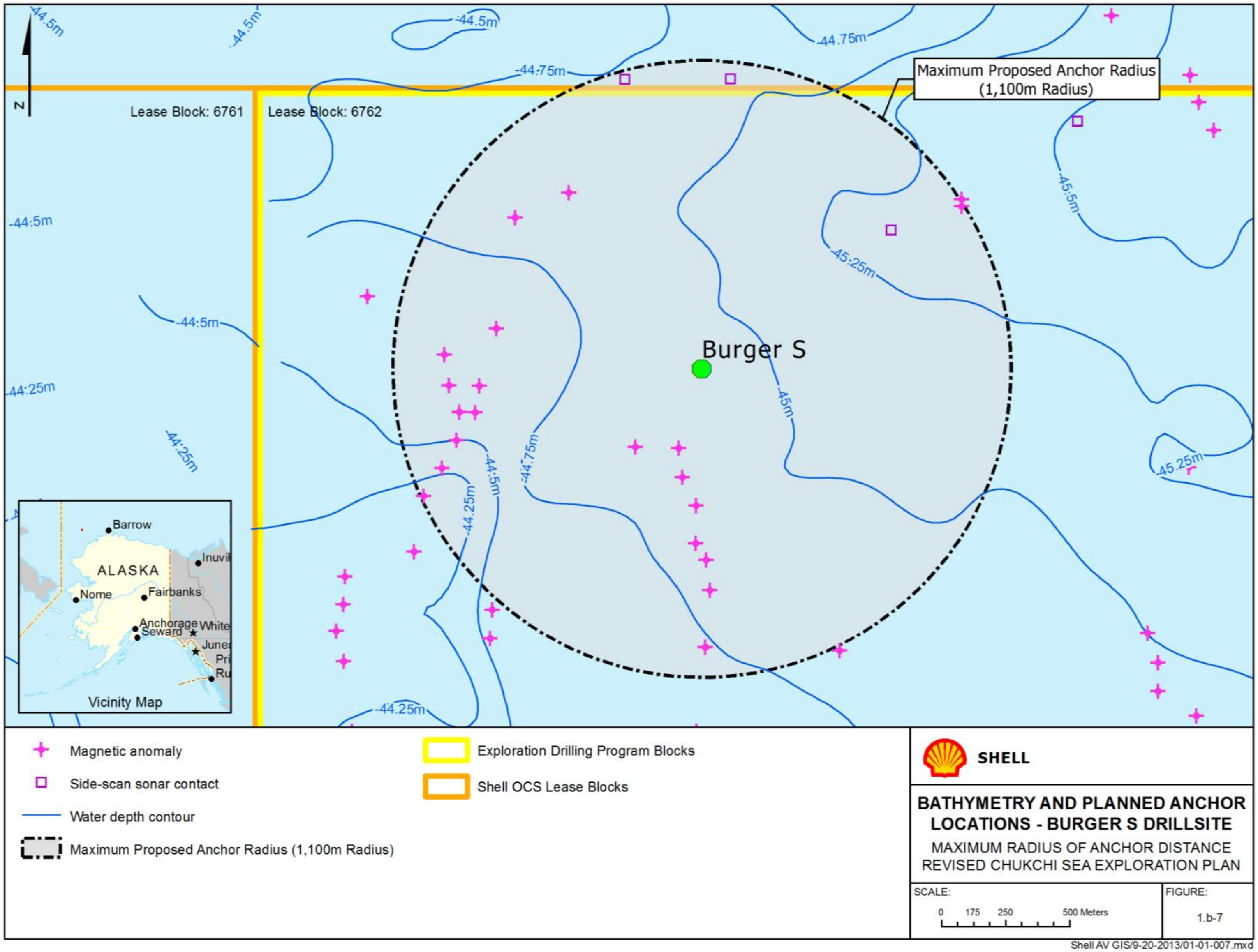
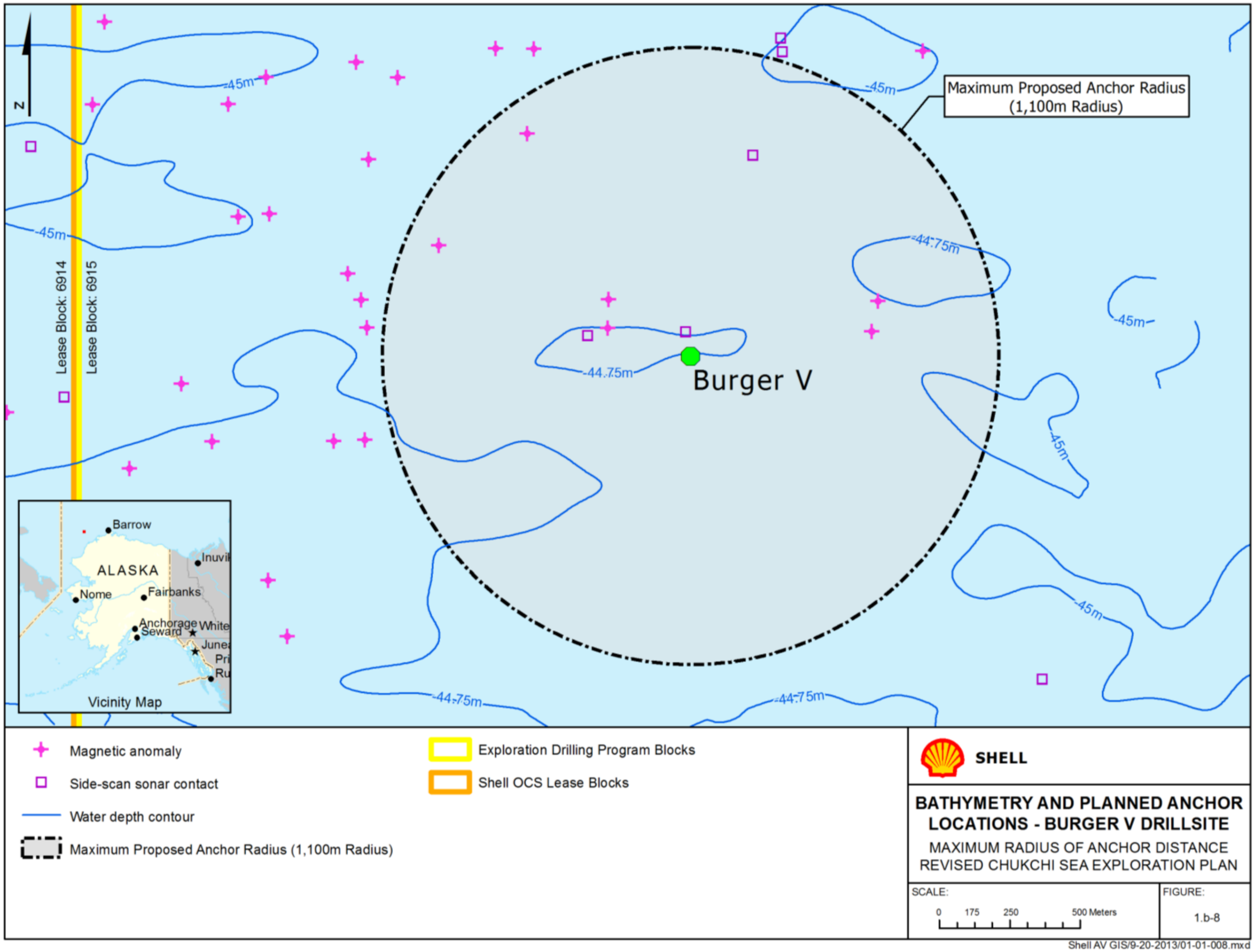


Figure 1.b-8 Bathymetry and Planned Drillship Anchor Radius - Burger V



Section 2.0 GENERAL INFORMATION

a) Application and Permits

Table 2.a-1 lists various required permits and authorizations and/or permit revisions for the wells to be drilled at the Burger Prospect. Some permits have already been obtained, and some existing permits require renewal or extension.

Table 2.a-1 Permit Applications Pending or Approved

Permits & Authorizations	Agency	Submittal Date	Authorization Date
Exploration Plan	BOEM	Revisions submitted in this document	Initial authorization was 12/9/2009; EP revision authorization on 12/15/11
Oil Spill Response Plan	BSEE	Amendment submitted 1/26/12	2/17/12
Permit to Drill	BSEE	Burger A, F, J, R, S and V documents submitted spring/summer 2012;	Burger A[1] – 8/30/12 Burger J[1] – 9/27/12 Burger V[1] – 10/18/12
National Pollutant Discharge Elimination System	EPA	Required notice to be filed following this EP revision being deemed submitted by BOEM	General permit coverage confirmed prior to the initiation of the exploration drilling program
Marine Mammal Protection Act Incidental Harassment Authorization	NMFS	Application to be filed following this EP Revision 2 being deemed submitted by BOEM	Approval required prior to the initiation of the exploration drilling program
Marine Mammal Protection Act Letter of Authorization	USFWS	Application to be filed following this EP Revision 2 being deemed submitted by BOEM	Approval required prior to the initiation of the exploration drilling program
Section 10/404 Nationwide Permit #8	USACE	Burger A, F, J, R, S, and V submitted 12/13/12	Burger A, F, J, R, S, and V - 1/28/13
Land Use Permit – Relief Well Unit moored in Dutch Harbor	ADNR	Application to be filed following this EP Revision 2 being deemed submitted by BOEM	Approval required prior to the initiation of the exploration drilling program
Land Use Permit - Arctic Containment System – moored in Goodhope Bay, Kotzebue Sound	ADNR	Application to be filed following this EP Revision 2 being deemed submitted by BOEM	Approval required prior to the initiation of the exploration drilling program

[1]authorized to drill to the base of the 20” casing as defined in the APD authorizations
ADNR – Alaska Department of Natural Resources
BOEM – Bureau of Ocean Energy Management
BSEE – Bureau of Safety and Environmental Enforcement
EPA = U.S. Environmental Protection Agency
NMFS = National Marine Fisheries Service
USFWS = U.S. Fish and Wildlife Service
USACE = U.S. Army Corps of Engineers

b) Drilling Fluids

Based on technical analyses of drilling operations executed during the 2012 drilling season and revised estimates of drilling fluid to cuttings ratio, Shell has revised both the volumes of drilling fluids and their constituent components in order to drill each of the proposed wells to TD.

During the drilling of the top hole portion of each well (MLC, structural and conductor casing), approximately 30,015 bbls of drilling fluid will be used. This fluid is predominantly seawater or brine with minor constituents and contingency products added (see Table 6.c-1).

The exploration drilling activities will use approximately 6492 to 7791 bbl of water based drilling fluids and cuttings per well (Table 2.b-1) after the riser is established for the Burger wells. This volume includes circulating and reserve pit volumes of drilling fluids and cuttings. Table 6.c-2 in Section 6 lists the water based drilling fluids constituents and contingency products.

Table 2.b-1 Quantity and Averaged Discharge Rates of Water Based Drilling Fluids After the Riser is Established.

Drill Site	Drilling Fluid Quantity before Riser Installed (Top Hole portion)	Discharge Rate[1] (bbl/hr)	Drilling Fluid Quantity after Riser Installed	Discharge Rate[2] (bbl/hr)
Burger A	completed	na	7188 bbl	75 bbl/hr
Burger F	30,014	283	7188 bbl	75 bbl/hr
Burger J	30,011	283	6492 bbl	66 bbl/hr
Burger R	30,006	283	7372 bbl	77 bbl/hr
Burger S	30,012	283	7359 bbl	90 bbl/hr
Burger V	30,012	283	7791 bbl	83 bbl/hr

[1] drilling fluids only, no cuttings volume included; assume discharge occurs only during drilling of this section, estimated at 105.8 hrs
[2] drilling fluids only, no cuttings volume included; assume discharge occurs only during drilling of this section, estimated at 89.5 hrs

Reservoir fluids will be sampled from any Burger wells drilled to total depth, but the wells will not be flow tested and no oil or gas will be produced.

d) New or Unusual Technology

In compliance with 30 CFR 550.213(d), Shell will use a well capping stack and containment system as described in EP Revision 1 (Section 9f).

g) Blowout Scenario

Relief Well Drilling Unit – Availability, Constraints, and Days to Drill and Kill Flow

The *Discoverer* will serve as its own primary relief well drilling vessel in the unlikely event of a well control incident while drilling at the Burger Prospect (see Section 1c of EP Revision 1 for a detailed description of the drilling vessel). If the *Discoverer* is capable of drilling its own relief well, drilling operations could begin in as little as three days, with the relief well drilled and flow from the blowout being killed in about 31 days. If the *Discoverer* cannot be used to drill the relief well, a second drilling unit, the *Polar Pioneer*, would be brought in for that purpose. The *Polar Pioneer*, which will be supported by an anchor handler, will be located in Dutch Harbor and could be mobilized to the Burger Prospect, moored, drill a relief well and kill flow in 38 days.

Section 3.0 GEOLOGICAL AND GEOPHYSICAL INFORMATION

NO REVISIONS

Section 4.0 HYDROGEN SULFIDE INFORMATION

NO REVISIONS

Section 5.0 BIOLOGICAL, PHYSICAL, AND SOCIOECONOMIC INFORMATION

a) Biological Environment Reports

During the 2012 drilling season, Shell collected marine mammal data in the Chukchi and Beaufort Seas. The following is a 90-day report that details the marine mammal monitoring and mitigation that occurred.

Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M.L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort Seas, July–November 2012: Draft 90-Day Report. D.W. Funk, C.M. Reiser, and W.R. Koski, editors. LGL Rep. P1272D–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Offshore Inc, Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK, USA. 266 p. + app.

c) Socioeconomic Study Reports

The following subsistence advisor reports have been prepared since EP Revision 1 was approved. The 2012 report is final and the 2013 report is currently in draft form. The reports contain subsistence information gathered by subsistence advisors in each of the Chukchi Sea villages including Barrow, Wainwright, Point Hope and Point Lay.

UMIAQ 2012. 2011 Subsistence Advisor Program, North Slope Alaska. Report prepared by UMIAQ, Anchorage, AK for Shell Exploration and Production, Anchorage AK.

UMIAQ 2013. 2012 Subsistence Advisor Program, North Slope Alaska. DRAFT Report prepared by UMIAQ, Anchorage, AK for Shell Exploration and Production, Anchorage AK.

Section 6.0 SOLID AND LIQUID WASTE AND DISCHARGE INFORMATION

b) Ocean Discharges and Disposal Methods

In Table 6.a-1, Shell has revised the discharge volumes and rates for water based drilling fluids and drill cuttings (discharge 001 under EPA NPDES GP AKG-28-8100) and mud, cuttings and cement at the seafloor (discharge 013) for the *Discoverer* at Burger A, based on Shell's experiences in 2012. The projected drilling fluid discharge volumes from the sections of the well below the conductor casing have also increased as a result of a proposed increase in drilling fluid to cuttings ratio. The amount of BOP fluid discharged at the seafloor has been doubled from 54 bbl/well to an estimated 108 bbl/well. This increase is necessary to accommodate a possible retest of the BOP. These updated volume estimates are still well within the limitations outlined in the GP AKG-28-8100. For all other NPDES discharges (002, 003, 004, 005, 009, 010, 011, and 012), the volumes and rates remain as estimated in EP Revision 1.

In Tables 6.a-2 through 6.a-6 (for Burger F, J, R, S, and V), the projected volume of cuttings listed under NPDES discharge 013 are increased from those estimates in the EP Revision 1 as a result of the possible use of a 29.5 ft diameter bit to excavate the MLC to a depth of 50 ft. EP Revision 1 assumes a diameter of 21 ft and a depth of 40 ft. Also, the top section of the well (structural casing) may also increase in diameter, which would result in increased discharges.Depending on the timing of drilling a well to TD, if a top hole or MLC is drilled and then temporarily abandoned, it may be necessary to clean out debris that have slumped or settled into the MLC before the well is re-entered.

The following tables present the revised discharge volumes and rates.

Table 6.a-1 Past and Projected Generated Wastes, Disposal, and Ocean Discharges from Burger A

Type of Waste	Composition	Past and Projected Generated Amount / Discharge Rate	Treatment / Storage/ Disposed
Drill cuttings from MLC plus 36- in. and 26- in. holes	drill cuttings; minor amounts of cement	Past discharge while drilling in 2012 estimated at 5007 bbls 47.3 bbl/hr while drilling – cuttings only, dilution with seawater not included	Discharged at the seafloor - NPDES Discharge 013
Water based mud (WBM) drilling fluids & cuttings with adhered WBM	water based drilling fluids and cuttings	Projected at 6731 bbl; average 75 bbl/hr discharge while drilling[1]; 1500 bbl reserve drilling fluids discharged at 1000 bbl/hr at the end of the well	Discharged to sea through disposal caisson – NPDES Discharge 001
Blowout preventer (BOP) fluid	Water, glycol, water soluble lubricant	Projected at 108 bbl (6 tests at 18 bbl/test – this volume includes a retest after each test)	Discharged at the seafloor at the BOP – NPDES Discharge 006

[1] total drilling time is estimated at 90 hrs for this section (hole sections drilled after the riser is established).

Table 6.a-2 Projected Generated Wastes, Disposal, and Ocean Discharges from Burger F

Type of Waste	Composition	Projected Generated Amount / Discharge Rate	Treatment / Storage/ Disposed
Drill cuttings and fluids from MLC, structural cased and conductor cased sections; minor cement	Drilling fluid (predominantly seawater); drill cuttings; minor amounts of cement	40,587 bbl; 384 bbl/hr while drilling[1]	Discharged at the seafloor - NPDES Discharge 013
WBM drilling fluids & cuttings with adhered WBM	water based drilling fluids and cuttings	Projected at 6731 bbl; average 75 bbl/hr discharge while drilling[2]; 1500 bbl reserve drilling fluids discharged at 1000 bbl/hr at the end of the well	Discharged to sea through disposal caisson – NPDES Discharge 001
Blowout preventer fluid	Water, glycol, water soluble lubricant	Projected at 108 bbl (6 tests at 18 bbl/test – this volume includes a retest after each test)	Discharged at the seafloor at the BOP – NPDES Discharge 006

[1] total drilling time is estimated at 106 hr for this top hole section.
[2] total drilling time is estimated at 90 hr for this section (hole sections drilled after the riser is established).

Table 6.a-3 Projected Generated Wastes, Disposal, and Ocean Discharges from Burger J

Type of Waste	Composition	Projected Generated Amount / Discharge Rate	Treatment / Storage/ Disposed
Drill cuttings from MLC, structural cased and conductor cased sections	Mostly cuttings; drilling fluids for the structural and conductor cased sections will included minor amounts of additives	40,583 bbl; 384 bbl/hr while drilling[1]	Discharged at the seafloor - NPDES Discharge 013
WBM drilling fluids & cuttings with adhered WBM	water based drilling fluids and cuttings	5908 bbl; average 66 bbl/hr discharge while drilling[2]; 1500 bbl reserve drilling fluids discharged at 1000 bbl/hr at the end of the well	Discharged to sea through disposal caisson – NPDES Discharge 001
Blowout preventer fluid	Water, glycol, water soluble lubricant	Projected at 108 bbl (6 tests at 18 bbl/test – this volume includes a retest after each test)	Discharged at the seafloor at the BOP – NPDES Discharge 006

[1] total drilling time is estimated at 106 hr for this top hole section.
[2] total drilling time is estimated at 90 hr for this section (hole sections drilled after the riser is established).

Table 6.a-4 Projected Generated Wastes, Disposal, and Ocean Discharges from Burger R

Type of Waste	Composition	Projected Generated Amount / Discharge Rate	Treatment / Storage/ Disposed
Drill cuttings from MLC, structural cased and conductor cased sections	Mostly cuttings; drilling fluids for the structural and conductor cased sections will included minor amounts of additives	40,576 bbl; 384 bbl/hr while drilling[1]	Discharged at the seafloor - NPDES Discharge 013
WBM drilling fluids & cuttings with adhered WBM	water based drilling fluids and cuttings	6950 bbl; average 77 bbl/hr discharge while drilling[2]; 1500 bbl reserve drilling fluids discharged at 1000 bbl/hr at the end of the well	Discharged to sea through disposal caisson – NPDES Discharge 001
Blowout preventer fluid	Water, glycol, water soluble lubricant	Projected at 108 bbl (6 tests at 18 bbl/test – this volume includes a retest after each test)	Discharged at the seafloor at the BOP – NPDES Discharge 006

[1] total drilling time is estimated at 106 hr for this top hole section.
[2] total drilling time is estimated at 90 hr for this section (hole sections drilled after the riser is established).

Table 6.a-5 Projected Generated Wastes, Disposal, and Ocean Discharges from Burger S

Type of Waste	Composition	Projected Generated Amount / Discharge Rate	Treatment / Storage/ Disposed
Drill cuttings from MLC, structural cased and conductor cased sections	Mostly cuttings; drilling fluids for the structural and conductor cased sections will included minor amounts of additives	40,583 bbl; 384 bbl/hr while drilling[1]	Discharged at the seafloor - NPDES Discharge 013
WBM drilling fluids & cuttings with adhered WBM	water based drilling fluids and cuttings	6933 bbl; average 90 bbl/hr discharge while drilling[2]; 1500 bbl reserve drilling fluids discharged at 1000 bbl/hr at the end of the well	Discharged to sea through disposal caisson – NPDES Discharge 001
Blowout preventer fluid	Water, glycol, water soluble lubricant	Projected at 108 bbl (6 tests at 18 bbl/test – this volume includes a retest after each test)	Discharged at the seafloor at the BOP – NPDES Discharge 006

[1] total drilling time is estimated at 106 hr for this top hole section.
[2] total drilling time is estimated at 90 hr for this section (hole sections drilled after the riser is established).

Table 6.a-6 Projected Generated Wastes, Disposal, and Ocean Discharges from Burger V

Type of Waste	Composition	Projected Generated Amount / Discharge Rate	Treatment / Storage/ Disposed
Drill cuttings from MLC, structural cased and conductor cased sections	Mostly cuttings; drilling fluids for the structural and conductor cased sections will included minor amounts of additives	40,587 bbl; 384 bbl/hr while drilling[1]	Discharged at the seafloor - NPDES Discharge 013
WBM drilling fluids & cuttings with adhered WBM	water based drilling fluids and cuttings	7444 bbl; average 83 bbl/hr discharge while drilling[2]; 1500 bbl reserve drilling fluids discharged at 1000 bbl/hr at the end of the well	Discharged to sea through disposal caisson – NPDES Discharge 001
Blowout preventer fluid	Water, glycol, water soluble lubricant	Projected at 108 bbl (6 tests at 18 bbl/test – this volume includes a retest after each test)	Discharged at the seafloor at the BOP – NPDES Discharge 006

[1] total drilling time is estimated at 106 hr for this top hole section.
[2] total drilling time is estimated at 90 hr for this section (hole sections drilled after the riser is established).

c) NPDES Permit

Regulated discharges in EP Revision 1 were granted authorization under NPDES GP AKG-28-0000. This GP has been replaced by NPDES GP AKG-28-8100. Regulated discharges from the *Discoverer* during the next exploration drilling program will be made in accordance with NPDES GP AKG-28-8100. Shell will submit notices of intent (NOIs) to the EPA for authorization to discharge under the new NPDES GP. Waste stream flow diagrams for the *Discoverer* will be provided with the NOIs.

Drilling Fluid Components

In order to accommodate contingencies during the drilling process, an updated list of the components that may be added to the drilling fluids through the various drilling stages are provided in Tables 6.c-1 and 6.c -2 on a per well basis. Base, additive and contingency products are listed for the top sections of the well (MLC, structural and conductor cased sections – Table 6.c-1) and the well sections below the conductor cased section (Table 6.c-2).

Table 6.c-1 New Drilling Fluid Components Added to Seawater/Salt Water Gel and Polymer Sweeps for the Upper Sections of the Well

Generic Description	Product Name	Max Concentration
Base Mud		
Bentonite extender	GELEX	0.05 lb/bbl
Contingency Products		
Dye	Sodium Fluoresceine Green Dye	.5 gal/bbl in seawater

Table 6.c-2 Drilling Fluid Components (Kla-Shield Mud) Per Well (all sections below the conductor casing)

Generic Description	Product Name(s)	Maximum Concentration
Base Mud		
Shale/Clay Inhibitor	EMI-2009	20 lbs/bbl
Biopolymer	Flowzan	2 lb/bbl
Additives		
Copolymeric shale stabilizer	POROSEAL	19 lb/bbl
Citric Acid	stock product	4 lb/bbl
Biocide	Busan 1060	0.4 lb/bbl
Liquid defoamer	DF-9065	0.3 lb/bbl
Vegetable, polymer fiber blend	MI SEAL	40 lb/bbl
Graphite	G-SEAL	10 lb/bbl
Calcium carbonate	SAFECARB-20	200 lb/bbl
Calcium carbonate	SAFECARB-40	200 lb/bbl
Calcium carbonate	SAFECARB-250	200 lb/bbl
Sodium Chloride	stock product	100 lb/bbl
Resinated Lignite	RESINEX	10 lb/bbl
Sulfonated Asphalt	ASPHASOL SUPREME	8 lb/bbl
Contingencies		
Mixture	FORM-A-BLOK	40 lb/bbl
Cellulose	FORM-A-SET AK	Formulation pill
Zinc oxide	Sulf-X	2.5 lb/bbl
Mixture	Pipelax ENV WH	4% v/v
Mixture	LUBE 945	3% v/v
Mixture	CLEAN SPOT	4% v/v
Surfactant	SCREENKLEEN	2% v/v
Mixture	SAFE-SCAV HS	0.1 lb/bbl

Section 7.0 AIR EMISSIONS INFORMATION

This section describes the sources of air emissions and maximum projected actual air emissions from Shell's EP Revision 2. For purposes of demonstrating exemption from the BOEM Air Quality Regulatory Program (AQRP) (30 CFR Part 550, Subpart C), facility-wide maximum projected emissions generated from the proposed exploration activities are calculated and compared to the BOEM exemption formulas established in 30 CFR 550.303(d). Consistent with the BOEM's current interpretation of facility[2], Shell includes in this assessment emissions from the *Discoverer* drillship and all associated vessels operating within 25 nautical miles of the *Discoverer* while it is anchored at a drill site. The following is a list of the vessels that are included for the air emissions evaluation under 30 CFR 550.303(d):

- (1) drillship - M/V *Noble Discoverer*
- (2) ice management vessels
- (2) anchor handlers
- (2) offshore supply vessels
- (1) oceanographic research vessel
- (1) OSR vessel
- (1) OSR barge and tug
- Arctic oil storage tanker

As required under 30 CFR 550.224, information on support vessels and aircraft anticipated to be used in the exploration drilling program described in EP Revision 2 is detailed in Section 13. Under Section 14, information on the onshore support facilities as required under 30 CFR 550.225 is included.

[1] Item 6-Tips to Avoid Common Emissions Spreadsheet Errors (dated December 2011) available on BOEM website:http://www.boem.gov/About-BOEM/Procurement-Business-Opportunities/BOEM-OCS-Operation-Forms/BOEM-OCS-Operation-Forms.aspx

a) Projected Emissions (30 CFR 550.218(a))

Appendix O of EP Revision 2 provides detailed documentation of projected emissions including the basis for all calculations (30 CFR 550.218(a)(2)) attributable to operation of the *Discoverer* and associated vessels operating within 25 mi. Table 8 of Appendix O includes peak hourly emissions as required under 30 CFR 550.218(a)(1)(i). Table 7 of Appendix O provides the annual emissions, emissions over the duration of the proposed exploration activities, a discussion of the frequency and duration of emissions, and the total of all emissions listed as required under 30 CFR 550.218(a)(1)(ii) through (v).

Shell presents a conservative depiction of emissions for the purpose of demonstrating its exemption from the AQRP (i.e., the emissions presented overstate what is expected). This conservative approach is required by 30 CFR 550.218(a)(3), which requires Shell to base the projected emissions on the maximum rated capacity of the equipment on the proposed drilling unit under its physical and operational design.

As further discussed in Appendix O, diesel-fueled engines are the primary source of emissions associated with the exploration drilling activity. Analogous to how we drive our automobiles, diesel engines are not expected to continuously operate at maximum rated power during the proposed exploration activity. In calculating emissions for this exemption analysis, Shell has included an 80 percent power operating assumption that reflects the physical and operational design for a diesel-fueled engine. Consistent operation at higher rates compromises the life and reliability of the engines, so vessels and drill rigs are virtually always designed to operate at a fraction of the rated capacity of the engines.

As discussed further in Appendix O, while the emissions inventory assumes *Discoverer* emissions units operate 100 percent of the season (except for the propulsion engine), emissions units on the support vessels are assumed to operate less than 100 percent of the time, as neither the supply vessels nor the ice management vessels will be within 25 mi of the *Discoverer* 100 percent of the time, nor will either of these types of vessels actually operate under dynamic positioning (DP) for the significant lengths of time estimated under the conservative assumptions used to demonstrate exemption from the AQRP. Shell adopted this approach to ensure a conservative representation of associated vessel operations.

Maximum projected uncontrolled emissions are provided to demonstrate exemption from the AQRP in Table 7-1 of EP Revision 2.

b) Emission Reduction Measures (30 CFR 550.218(b))

Shell intends to employ emission controls on the main generators on the *Discoverer* and on some of the support vessels that are candidates for use with the *Discoverer* in the Chukchi Sea. Shell has proposed and implemented several emission reduction measures including procuring only ultra-low sulfur diesel (ULSD) fuel for vessels operating as part of the exploration drilling program, and installing catalytic diesel particulate filters (CDPF) and selective catalytic reduction (SCR) controls on the *Discoverer's* primary generation units. However, Shell has elected to present maximum projected emissions for the 30 CFR 550.303(d) exemption threshold analysis without consideration of these emission controls. Shell will in fact operate these controls and purchase only ULSD throughout the exploration season, but the 30 CFR 550.303(d) exemption analysis in Section 7(e) conservatively assumes the controls are not employed.

Under Appendix O, there are some operating restrictions that are included in the emissions calculations because they reflect the physical and operational design of the proposed activities in EP Revision 2. These operating restrictions can be readily monitored by measuring annual fuel consumption. Shell proposes to monitor total fuel consumption.

c) Processes, Equipment, Fuels, and Combustibles (30 CFR 550.218(c))

The processes of the *Discoverer* are focused on the generation of electrical, compressed air, and hydraulic energy for drilling operation. All other processes are secondary and related to general purpose heating (using boilers), transfer of materials about the deck (using cranes), pumping of cement, and incineration (primarily domestic waste). All engines on the *Discoverer* and associated vessels will be fueled by diesel purchased with sulfur content at or below 0.0015 weight percent. Detailed descriptions of these processes and emissions units are provided in Appendix O.

d) Distance to Shore (30 CFR 550.218(d))

The minimum distance from a drill site to the shoreline is 64 mi (103 km).

e) Impact Evaluation for Non-Exempt Drilling Units (30 CFR 550.218(e))

As required by 30 CFR 550.218(e), Table 7-1 compares aggregate projected annual emissions with the exemption criteria at 30 CFR 550.303(d). The comparison confirms the exploration program is exempt and no further air quality review is necessary pursuant 30 CFR 550.303(d).

Table 7-1 Application of BOEM Exemption Formula to the EP Revision 2

Parameter	BOEM formula at 30 CFR 250.303(d) [1]	BOEM Exemption Threshold (E in tons/yr)	Total Projected Annual Emissions (tons/yr) [2]	Exempt?
CO	$E=3400D^{2/3}$	54,400	1,357	Yes
TSP ($PM_{2.5}$ & PM_{10})	E=33.3D	2,131	63	Yes
SO_2	E=33.3D	2,131	104	Yes
NOx	E=33.3D	2,131	2,019	Yes
VOC	E=33.3D	2,131	415	Yes

[1] D=distance from the edge of the Burger Prospect to the nearest onshore area in statute miles (64 mi, 103 km)
[2] As provided in Table 7 of Appendix O.

f) Modeling Report (30 CFR 550.218(f))

According to 30 CFR 550.218(f), results of the modeling and impact analysis are required to be included only if 30 CFR 550.303 requires the use of an approved air quality model to model projected air emissions in developing EP Revision 2. As discussed in the previous section, the exploration drilling program is exempt from further air quality review using the exemption formula found at 30 CFR 550.303(d); therefore, an impact analysis and use of an approved air quality model is not required under the AQRP.

Emission calculations as presented in the Original EP and EP Revision 1 demonstrates Shell is exempt from a modeling requirement and modeling is not required. In this revision, Shell has not included a dispersion modeling analysis based on the emissions in Table 7-1. The modeling analysis is not required, and would significantly overstate concentrations attributable to the exploration drilling program described in EP Revision 2. A more accurate presentation of expected emissions attributable to Shell's revised exploration program is presented in Appendix O.

Section 8.0 OIL AND HAZARDOUS SUBSTANCES SPILL INFORMATION

d) Calculated Volume of Worst Case Discharge Scenario

Shell has changed the relief well drilling unit and its location in EP Revision 2. Shell plans to have the *Polar Pioneer* and its support vessels based in Dutch Harbor when drilling into hydrocarbon bearing zones. Although the *Polar Pioneer* will be staged in Dutch Harbor, the potential total duration of the time it will take to mobilize and complete a relief well at the Burger Prospect is still 38 days, as in EP Revision 1.

Section 9.0 ALASKA OUTER CONTINENTAL SHELF PLANNING INFORMATION

c) Well Control Plan

The Well Control Plan Outline has been re-worded to use language more familiar to Shell's well engineers and responders to a potential well control event. In this rewording, Shell has not changed the quality or substance of its well control response effort. (See Appendix L).

Section 10.0 ENVIRONMENTAL MONITORING

a) Monitoring Systems

Environmental Monitoring at Drill Sites While Exploration Drilling

As part of the requirements under the NPDES permit, Shell will conduct an Environmental Monitoring Program (EMP) as outlined in the permit AKG-28-8100. The specific details around this monitoring program will be submitted with the NPDES NOI; however, the EMP will generally consist of a 4 phase monitoring program.

- Phase I establishes the baseline conditions of the drill site prior to exploration drilling activities and will either be supported with historical data or supplemental data collected prior to exploration drilling activities. The baseline data generally consist of benthic samples, receiving water chemistry, sediment characteristics, and a visual assessment of the sea floor.
- Phase II requires monitoring to be conducted while exploration drilling activities are occurring and consists of discharge plume monitoring, metals analysis of the drilling fluid, and effluent toxicity screening for specified discharge streams.
- Phases III and IV are similar in nature and are conducted once exploration drilling activities are completed. Phase III monitoring will occur shortly after exploration drilling operations cease at a drill site. Phase IV is conducted no later than 15 months after exploration drilling operations cease. Benthic samples, sediment characteristics, and a sea bottom survey will be completed during these phases.

The results from this monitoring program will be submitted to EPA as required in permit AKG-28-8100.

b) Incidental Takes

Given updated modeling techniques and marine mammal densities, the calculated marine mammal exposures have been revised. The following Table 10.b-1 lists the changes in exposure number for the three sound producing activities that were listed and described in detail in EP Revision 1, i.e. sounds generated during exploration drilling, sounds due to icebreaking and sounds generated by zero-offset vertical seismic profiling (ZVSP) activities. In addition, new sound categories have been added: sound generated while drilling the MLC, sounds due to anchor handling, and sounds made by support vessels while on DP when tending to the drilling unit.

Table 10.b-1 Number of Potential Exposures of Marine Mammals to Received Sound Levels in the Water of >120 dB rms Generated by Drilling Activities and >160 dB rms Generated by ZVSPs during each Exploration Drilling Season

Species	Number of Exposures to Sound Levels > 120 dB and >160 dB [2]																			
	120 dB During Drilling (EP Revision 1)		120 dB During Drilling (EP Revision 2)		120 dB During Icebreaking (EP Revision 1)		120 dB During Icebreaking (EP Revision 2)		160 dB During ZVSP (EP Revision 1)		160 dB During ZVSP (EP Revision 2)		120 dB During MLC Drilling (EP Revision 2)		120 dB During Support Vessel DP (EP Revision 2)		120 dB During Anchor Handling (EP Revision 2)		Totals Exposures (EP Revision 2)	
	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max	Avg	[1]Max
Beluga	0	5	0	5	4	5	51	96	1	5	6	11	16	30	11	21	138	261	221	423
Narwhal	0	5	0	1	0	5	0	1	0	5	0	1	0	1	0	1	0	1	0	5
Killer whale	0	5	0	1	0	5	1	4	0	5	0	1	0	2	0	1	3	10	4	19
Harbor porpoise	0	5	0	5	1	5	20	34	0	5	2	4	6	11	4	7	54	92	86	153
Bowhead whale	1	5	1	5	19	38	316	765	5	11	36	88	98	238	69	166	856	2076	1376	3338
Fin whale	0	5	0	1	0	5	1	4	0	5	0	1	0	2	0	1	3	10	4	19
Gray whale	1	5	1	5	14	28	172	239	6	13	20	27	54	74	37	52	466	648	750	1045
Humpback whale	0	5	0	1	0	5	1	4	0	5	0	1	0	2	0	1	3	10	4	19
Minke whale	0	5	0	1	0	5	1	4	0	5	0	1	0	2	0	1	3	10	4	19
Bearded seal	1	5	0	5	12	23	110	209	5	9	13	24	34	65	24	45	299	568	480	916
Ribbon seal	0	5	0	1	0	5	6	26	0	5	1	3	2	8	1	6	18	70	28	114
Ringed seal	17	28	10	16	343	568	3196	5293	132	218	366	607	996	1649	694	1149	8672	14362	13934	23076
Spotted seal	0	5	0	5	7	11	64	106	3	5	7	12	20	33	14	23	173	287	278	466

[1] Arbitrary estimates have been included in the maximum columns to account for chance encounters or where greater numbers may be encountered than calculations suggested. Not all marine mammals will change their behavior when exposed to these sound levels

[2] Assumes two wells and a partial well per season

Section 11.0 LEASE STIPULATIONS INFORMATION

In EP Revision 2, Shell proposes to change some of its compliance measures under the existing lease stipulations from what was proposed and approved in EP Revision 1. These changes are discussed below. The source for the italicized text below is the OCS Chukchi Sea Planning Area Oil and Gas Lease Sale 193. The full text of each stipulation was provided in EP Revision 1, but only relevant excerpts are repeated here.

Stipulation No. 4 - Industry Site-Specific Bowhead Whale Monitoring Program

A lessee proposing to conduct exploration operations, including ancillary seismic surveys, on a lease within the blocks identified below during the periods of subsistence use related to bowhead whales, beluga whales, ice seals, walrus, 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 (USFWS) 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 Nanuq 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.

Shell Proposed Actions:

<u>Sound Source Verification</u>

In the future, field measurement sound propagation profiles of vessels not previously sound sourced and the drillship will be conducted during different drilling operational modes, so as to determine those activities that produce the greatest opportunities for mitigation. Shell plans to conduct initial sound source verification of the drillship and support vessels (if necessary) as soon as practicable upon arrival at the prospect.

Stipulation No. 5 - Lease Sale 193 Conflict Avoidance Mechanisms to Protect Subsistence Whaling and Other 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.

Shell Proposed Actions:

Plan of Cooperation

The following table (Table 11.0-1) outlines POC meetings held in several villages during October and November 2012. In 2012, Shell met with villagers and discussed the next exploration drilling program in the Chukchi Sea. Early in 2013, Shell decided to defer the drilling program for that year. In July 2013, Shell personnel travelled to Kotzebue and met with representatives of the borough, city, village corporation (KIC) and the native village government (IRA). Other than the few minor revisions that are outlined in EP Revision 2, the exploration drilling program remains materially the same.

Table 11.0-1 Dates and Locations of Meetings Held in 2012-2013 Regarding Shell's Chukchi Sea Exploration Drilling Program for the Development of the POC

2012	Meeting Location	Meeting Attendees
23 October	Point Lay	Plan of Cooperation Community Meeting
24 October	Wainwright	Plan of Cooperation Community Meeting
26 October	Kaktovik	Plan of Cooperation Community Meeting
29 October	Barrow	Plan of Cooperation Community Meeting
30 October	Nuiqsut	Plan of Cooperation Community Meeting
6 November	Barrow	NSB Assembly Workshop Meeting
2013	**Meeting Location**	**Meeting Attendees**
29 July	Kotzebue	NWAB, City of Kotzebue, KIC and IRA representatives
5 November	Barrow	NSB Assembly
5 November	Wainwright	Plan of Cooperation Community Meeting
Upcoming Scheduled Meetings in 2013 -See Following Presentation		
6 November	Point Lay	Plan of Cooperation Community Meeting
7 November	Point Hope	Plan of Cooperation Community Meeting
8 November	Barrow	Plan of Cooperation Community Meeting
13 November	Kotzebue	Plan of Cooperation Community Meeting
14 November	Deering	Plan of Cooperation Community Meeting

[1] NSB = North Slope Borough; NWAB = Northwest Arctic Borough; KIC = Kikiktagruk Iñupiat Corporation; IRA = Kotzebue tribal government

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Stipulation No. 7 - Lighting of Lease Structures to Minimize Effects to Spectacled and Steller's Eider

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.

Shell Proposed Actions:

Shell will not continue with the use of the ClearSky lighting technology. These lights were experimental and the manufacturer discontinued these lights. They are no longer available. A revised Bird Strike Avoidance and Lighting Plan, reflecting this change, can be found in Appendix I.

SHELL ALASKA VENTURE

Program Update

Community Meeting Updates

November 2013

EXPLORATION PROGRAM

- Committed to developing Alaska's Outer Continental Shelf in a measured and responsible pace
- 2014
  - Planning for a potential Chukchi drilling season

PLANNING FOR 2014 EXPLORATION

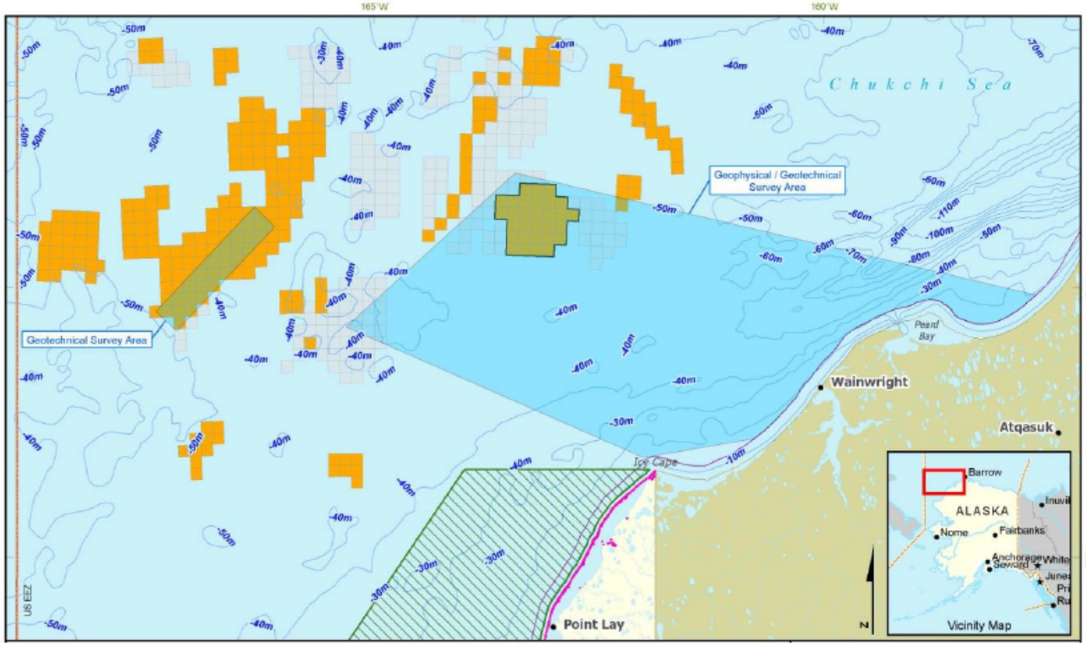
- Focused on the potential of a Chukchi-only drilling season
  - Primary drilling rig: Noble Discoverer
    - Support vessels similar to 2012
      - Anchor handlers
      - Ice management
      - Oil spill response
      - Supply
      - Towing
  - Back-up relief rig
    - Stationed at Dutch Harbor
- Drilling focused on Burger Prospect

OIL SPILL RESPONSE

- Same offshore, nearshore and onshore recovery capabilities that we brought in 2012 drilling season
  - Capping stack and subsea containment system
  - Oil spill response vessel Nanuq with skimming vessels
  - Arctic tanker
  - Oil spill response barge
  - Booms, skimmers, and pumps
  - Pre-staged equipment, personnel

GEOTECH

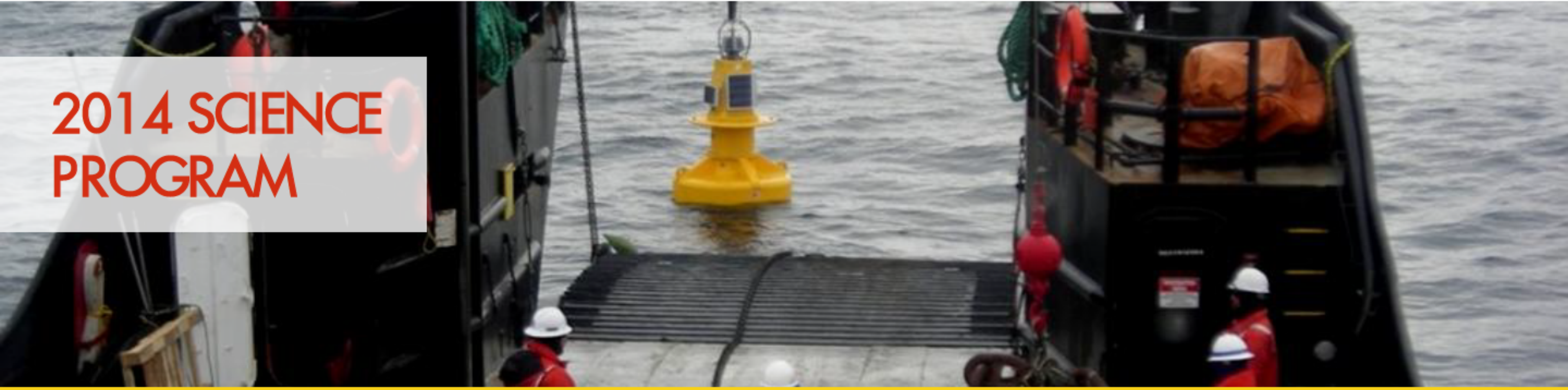
- Geotechnical coring
  - Shallow cores to characterize subsurface geology for exploration rig mooring and success-case pipeline studies
  - Season: July – October, mainly 40-ft borings with a few up to 400 ft
  - Discharges regulated by EPA, State of Alaska



Shell Exploration & Production Company, Alaska Venture

ARCTIC CONTAINMENT SYSTEM

- Arctic Containment System (ACS)
  - Not a regulatory/statutory requirement
- ACS is a fourth line of defense for stopping a worst case discharge
- 2013 Progress
  - Successful sea trials conducted for Bureau of Safety and Environmental Enforcement
  - Certified by U.S. Coast Guard
- Planning to stage ACS and support vessels in Kotzebue Sound



2014 SCIENCE PROGRAM

- Continue Offshore/Nearshore Ecological Studies (August – October)
  - Jointly funded by Shell, ConocoPhillips and Statoil
  - Eco-system wide baseline studies
  - Ice and Metocean buoys
  - North Slope Science Agreement

MITIGATION MEASURES

- Collaboration and communication with whaling associations, walrus, Nanuq, Seal Commissions and hunters
- Full oil spill response capabilities
- Relief well capability
- Crew change by helicopter and collaboration on routes to and from operations
- Real-time ice and weather forecasting
- Protected Species Observers on all vessels
- Four Communication Centers in 2013, possible five additional Centers in 2014

COMMUNICATION CENTERS

- 2013 and 2014
  - Point Hope
  - Point Lay
  - Wainwright
  - Barrow
- 2014
  - Kivalina
  - Kotzebue
  - Savoonga
  - Wales
  - Nome

COMMUNITY LIAISON OFFICERS

SUBSISTENCE ADVISORS

- Community Liaison Officers
  - Advise on culturally appropriate communications, local concerns and issues
  - Keep community apprised of Shell's plans

Barrow
Community Liaison Officer
Ronald Fischer

- Subsistence Advisors
  - Communication link between Shell and subsistence hunters
  - Minimize potential impacts from onshore and offshore activities
  - Avoid potential conflicts during traditional subsistence hunting and gathering activities
  - Develop and implement Traditional Knowledge data

Barrow Subsistence Advisor
Mary Sage

Barrow Subsistence Advisor
Ransom Rentenaar

SOCIAL IMPACTS

- What are social impacts?
  - Impact on individuals, communities and/or society
    - Positive impacts such as jobs, economic development or social investment
    - Negative impacts such as noise, traffic, flaring or emissions
  - Real and perceived

- Social Impact Review on Shell's 2012 operations
  - Looks at community perceptions of 2012 impacts and mitigation strategy
  - Sets stage for thinking long-term about social context and effective mitigations
  - Independent 3rd party contractor (ERM) will be contacting villages about interviews/surveys in early November
  - Atqasuk, Barrow, Kaktovik, Nuiqsut, Pt Lay, Pt Hope, Wainwright

PROTECTED SPECIES OBSERVERS

- Training ⇨ Deployment:
  - Deployment to vessel/airplane for 3-week shift
  - Monitor for marine mammals
  - Mitigate to minimize potential impacts to marine mammals and subsistence activities
  - Share Traditional Knowledge
  - Communicate with Comm Centers
  - Report sightings data each day

SEASONAL EMPLOYMENT OPPORTUNITIES

- SA Program:
  - UIC Umiaq , Contact: Arlene Thomas, 907-677-8251, www.ukpik.com
- PSO Program:
  - ASRC Energy Services, Contact: Meghan Larson, 907-339-5492, www.asrcenergy.com
- Com Center Operator Program (Chukchi Villages):
  - Tikigaq Corp. www.tikigaq.com
  - Cully Corp. www.cullycorp.com
  - Olgoonik Corp. www.olgoonik.com
  - UIC www.ukpik.com
  - Bering Straits Native Corp. www.beringstraits.com
  - Kikiktagruk Inupiat Corp. www.kikiktagruk.com

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The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this presentation "Shell", "Shell group" and "Royal Dutch Shell" are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words "we", "us" and "our" are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. ''Subsidiaries'', "Shell subsidiaries" and "Shell companies" as used in this presentation refer to companies over which Royal Dutch Shell plc either directly or indirectly has control. Companies over which Shell has joint control are generally referred to "joint ventures" and companies over which Shell has significant influence but neither control nor joint control are referred to as "associates". In this presentation, joint ventures and associates may also be referred to as "equity-accounted investments". The term "Shell interest" is used for convenience to indicate the direct and/or indirect (for example, through our 23% shareholding in Woodside Petroleum Ltd.) ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest.

This presentation contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as ''anticipate'', ''believe'', ''could'', ''estimate'', ''expect'', ''goals'', ''intend'', ''may'', ''objectives'', ''outlook'', ''plan'', ''probably'', ''project'', ''risks'', "schedule", ''seek'', ''should'', ''target'', ''will'' and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional risk factors that may affect future results are contained in Royal Dutch Shell's 20-F for the year ended December 31, 2012 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward looking statements contained in this presentation and should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation, May 20-30, 2013. Neither Royal Dutch Shell plc nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation.

We may have used certain terms, such as resources, in this presentation that United States Securities and Exchange Commission (SEC) strictly prohibits us from including in our filings with the SEC. U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain these forms from the SEC by calling 1-800-SEC-0330.

Section 12.0 ENVIRONMENTAL MITIGATION MEASURE INFORMATION

Following summarizes the changes in existing mitigation measures, or new mitigation measures, adopted by Shell for future drilling operations at the Burger prospect for EP Revision 2:

Vessel and Aircraft Travel

- Shell will not be able to continue with the use of the ClearSky lighting technology as a mitigation measure. They are no longer available. In compliance with the Chukchi Sea 193 Lease Sale Stipulation No. 7, (see Section 11) lighting on the drillship will be shaded to minimize the disorientation and attraction of birds to the lighted drillship in order to reduce the possibility of a bird collision.
- Vessels will not operate within 1 mi (1.6 km) of walrus when observed on land.
- Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land.
- If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid flying within 0.5 mi (805 m) of known walrus or polar bear concentrations.
- Shell developed an Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses, in April 2012. This document depicts a process and procedures for mutual engagement with USFWS biologists during ice management where the potential exists for the presence of Pacific walruses. The process and procedures were implemented during the Chukchi Exploration Drilling Program in 2012 and will be adopted for EP Revision 2 (see Appendix P). This document was submitted to the USFWS following promulgation of the current Chukchi Sea incidental take regulations for Polar bears and Pacific walrus.

Exploration Drilling Operations

- Shell will not recycle used drilling fluids from one drill site to the next.
- Shell's blowout prevention program will involve changing the BOP systems test frequency from once every 7 days to once every 14 days. 30 CFR 250.447(b) requires a BOP system test before 14 days have elapsed since the last pressure test.
- Drilling fluids will not be cooled. No permafrost has been observed in shallow hazards surveys or during drilling in 2012.
- The second relief well drilling vessel will be the *Polar Pioneer* if the primary drilling vessel is disabled and not capable of drilling its own relief well. The *Kulluk* is not available as a relief well drilling unit.

Oil Spill Response

- The Arctic Containment System (ACS) and the nearshore response tug and barge will be located in or near Goodhope Bay, Kotzebue Sound. Positioning the ACS in or near Goodhope Bay, Kotzebue Sound yields a response time to a well control incident at the Burger Prospect that is consistent with the time for the previously stated location for the ACS.

Air Emissions

- Certain engines on *Discoverer* will be Tier-rated to reduce CO, VOCs, and hazardous air pollutants (HAPs).

Section 13.0 SUPPORT VESSELS AND AIRCRAFT INFORMATION

a) Planned Chukchi Sea Revised Marine Vessel and Aircraft List

The following vessels and aircraft are planned to be added to the list of vessels described in EP Revision 1. Specification and additional information for the types of vessels to be added can be found in Tables 13.a-1 and 13.a-3. Marine vessel routes are plotted on Figure 13.e-1.

- Ice Management vessel
- Anchor Handler vessel
- Resupply tug and barge
- Additional tug
- Additional OSV
- Science (Oceanographic Research) vessel for discharge monitoring
- Tug and barge – used for nearshore OSR
- S-92/EC225 (or similar) helicopter (1) for crew rotations

Also, the current two OSVs listed in EP Revision 1 (M/V *Harvey Spirit* and *Harvey Explorer*) may be replaced by similar but slightly larger OSVs similar to the M/V *Harvey Sisuaq*. One or more of the OSVs may be a Vessel of Opportunity Skimming System in the unlikely event of an oil spill.

Vessels

The *Discoverer* will have the following additional support.

Ice Management Vessel

The M/V *Nordica* (or similar vessel) will be used on an occasional or as needed basis to help with ice management or other duties (see Table 13.a-1). The *Nordica* is the ice management vessel listed in the approved Camden Bay EP; it will be available for use in the Chukchi Sea when needed.

Anchor Handling Vessel

The M/V *Aiviq* (or similar vessel) will be used on an occasional or as needed basis to help with anchor handling duties with either the drilling vessel and/or the ACS (see Table 13.a-1). The *Aiviq* (or similar) will be the third anchor handler in addition to the two anchor handlers listed in EP Revision 1. The *Aiviq* is an anchor handler listed in the approved Camden Bay EP but will be available for work in the Chukchi Sea when needed.

Resupply Tug and Barge

The planned exploration drilling operations will also require an offshore resupply tug and barge to provide general resupply support for the exploration drilling operations. It will remain in the Chukchi Sea Planning Area most of the time, but may make trips to Dutch Harbor. The vessels will be a large ocean-going tug and barge such as the tug M/V *Lauren Foss* and *Tuuq* barge, or similar vessels (see Table 13.a-1).

Additional Tug

A tug similar to the M/V *Ocean Wave* will also be included and will be used as needed for general usage (see Table 13.a-1).

Science (Oceanographic Research) Vessel

Shell will also use a vessel for gathering scientific baseline data as well as monitoring discharges from the drillship as required under the NPDES GP AKG-28-8100 (see Table 13.a-1). Additionally, the vessel will provide crew change support and resupply activities as operationally required.

Additional Offshore Supply Vessel

A third OSV will be added to the explorating drilling program (see Table 13.a-1).

Nearshore Tug and Barge for Oil Spill Response

The barge and tug will be staged in or near Goodhope Bay, Kotzebue Sound for nearshore oil spill response in the unlikely event of a spill (see Table 13.a-1).

It is anticipated that the shallow water landing craft already listed in EP Revision 1 may be needed to tend to the vessels staged in or near Goodhope Bay, Kotzebue Sound.

In addition to the changes in support vessels, the ACS staging location has changed. The ACS will now be staged in or near Goodhope Bay, Kotzebue Sound.

Crew changes between Barrow and the drill site are typically completed using helicopters. On occasion, if helicopter crew changes are prevented by weather or other reasons, the crew may be transferred to smaller vessels or the landing craft, which could make landfall on a beach near Barrow.

Oil Storage Tanker

The oil storage tanker (OST) *Affinity* (or similar) may likely be positioned closer to the *Discoverer* during drilling activities. In EP Revision 1, the OST was located between the Chukchi Sea and the Beaufort Sea.

Aircraft

Offshore operations will be serviced by an additional helicopter operated out of onshore support base locations. The helicopter will either be a Sikorsky S-92 or Euro copter EC225 capable of transporting 10-12 persons; it will be used to transport crews between the onshore support base and the drillship or support vessels with helidecks. Flight route alternatives are plotted on Figure 13.e-2. The route chosen will depend on weather conditions and whether subsistence users are active on land or at sea. These routes may be modified depending on weather and subsistence uses. The helicopter will also be used to haul small amounts of food, materials, equipment, and waste between vessels and the shorebase. The primary helicopter support base is located at the Barrow airport, however there will be aircraft support in Wainwright. With the addition of the crew change helicopter, Shell will also increase the number of round trips to the drillship or other vessels with helidecks, likely located very near the drilling operations from 12 trips/week to up to 40 trips/week. The added trips are needed to accommodate the extra personnel due to the added vessels and to minimize delays due to weather and operational constraints. Shell may need to use hangar space at the Deadhorse airport if space is not available in Barrow. In this case, one of the crew change helicopters may make a once daily round trip from Deadhorse to Barrow then back to Deadhorse. The routes along which the helicopter would transit between Barrow and Deadhorse are indicated in Figure 13.e-2; however, any one of these routes may be altered as needed to avoid any potential impacts to subsistence. Any such route alterations would be effected through consultation with the villages' Subsistence Advisors.

Table 13.a-1 Vessels Added to Support the Exploration Drilling Program

	Science (Oceanographic Research/ Berthing Vessel[1,2,8]	Tug[1,3]	Tug and Barge[1,4]		Ice Management Vessel[1,5]	Anchor Handler[1,6,8]	Nearshore OSR Tug and Barge[1,7,8]		OSV[1,2]
			Barge	**Tug**			**Barge**	**Tug**	
Length	300 ft (91.4 m)	146 ft (44.4m)	400 ft (122m)	150 ft (45.7m)	380 ft (116m)	360.6 ft (110m)	205 ft (62.5m)	90 ft (27.4m)	300 ft (91.4m)
Width	64 ft (19.5m)	46 ft (14m)	99.5 ft (30.3m)	40 ft (12.2m)	85 ft (26m)	80 ft (24.4m)	90 ft (27.4m)	32 ft (9.8m)	64 ft (19.5m)
Draft	20 ft (6.1m)	25 ft (7.6m)	19.3 ft (5.9m)	18.5ft (5.6m)	27 ft (8.4m)	24 ft (7.3m)	na	8.5 ft (2.6m)	20 ft (6.1m)
Accommodations	50	13	--	11	82	64	--	8	50
Maximum Speed	14 knots (26 kph)	16 knots (30 kph)	--	12 knots (22 kph)	16 knots (30 kph)	15 knots (27.8 kph)	--	7 knots (13 kph)	14 knots (26 kph)
Fuel Storage	6,428 bbl (1,022 m^3)	5,585 bbl (888 m^3)	390 bbl (62 m^3)	1,786 bbl (284 m^3)	11,070 bbl (1,760 m^3)	12,575 bbl (2,000 m^3)	--	1,428 bbl (227m^3)	6,428 bbl (1,022 m^3)
Liquid Storage	--	--	76,900 bbl (12,226m^3)	--	--	--	18,636 bbl (2,963 m^3)	--	--

[1] Or similar vessel
[2] Specifications listed for M/V *Harvey Sisuaq*
[3] Specifications listed for the M/V *Ocean Wave*
[4] Specifications listed for the barge *Tuuq* and the tug M/V *Lauren Foss*
[5] Specifications listed for the *Nordica*
[6] Specifications listed for the *Aiviq*
[7] Specifications listed for the *Point Oliktok* tug and *Endeavor* barge (available for nearshore response in the unlikely event of a spill)
[8] these vessels are re-positioned from the approved Camden Bay EP

Table 13.a-3 Fuel Storage Capacity and Trip Information for Additional Support Vessels and Aircraft

Vessel Type	Maximum Fuel Tank Storage Capacity	Trip Frequency or Duration
Marine Support Vessels (or similar)		
Ice management vessel[1,2]	11,070 bbl (1,760 m3)	Limited usage
Anchor Handler vessel[1,3]	12,575 bbl (2,000 m^3)	Limited usage
OSV[1,4]	6,428 bbl (1022 m^3)	Approximately 30 round trips (combined for both OSVs) for resupply between drillship and Dutch Harbor during the exploration drilling season, and 4-6 refuel trips (combined for both OSVs) between OST and drillship
Resupply tug and barge[1,5]	1,786 bbl (284 m^3)	Remains in or near Goodhope Bay, Kotzebue Sound most of the time, but may make $\leq$2 trips to Dutch Harbor or to Shell exploration drilling operations in the Chukchi Sea
Tug[1,6]	5,585 bbl (888 m^3)	Remain in the Arctic but outside the Lease sale area much of the time for general usage, with occasional trips to the prospect / drilling unit
Science (Oceanographic Research) Vessel[1,4]	6,428 bbl (1022 m^3)	Will spend most time near the drillship to monitor NPDES discharges
Nearshore OSR Tug and Barge[1,7]	1,428 bbl (227 m^3)	No trips - To be used for nearshore OSR in the event of a spill
Aircraft (or similar)		
Helicopter – S-92 or EC225 (or similar) – for crew rotation & groceries/supply	18 bbl (2.9 m^3)	Approximately 40 trips/eek between the shorebase and the prospect (approximately 3.0 hr/trip) Helicopter may transit to and from Deadhorse on a daily basis
Fixed wing aircraft DA42 (or similar)	1.9 bbl (0.3 m^3)	Used for marine mammal overflights

[1] or similar vessel
[2] Specifications listed for the *Nordica*
[3] Specifications listed for the *Aiviq*
[4] Specifications listed for the *M/V Harvey Sisuaq*
[5] Specifications listed for the barge *Tuuq* and the tug *Lauren Foss*
[6] Specifications listed for the *M/V Ocean Wave*
[7] Specifications listed for the *Point Oliktok* tug and *Endeavor* barge (if needed for nearshore response in the unlikely event of a spill)

b) Air Emissions

Table 9 from Appendix O lists the source, composition, frequency and duration of air emissions associated with support vessels that will be within 25 mi of the drilling unit.

Figure 13.e-1 Marine Vessel Routes

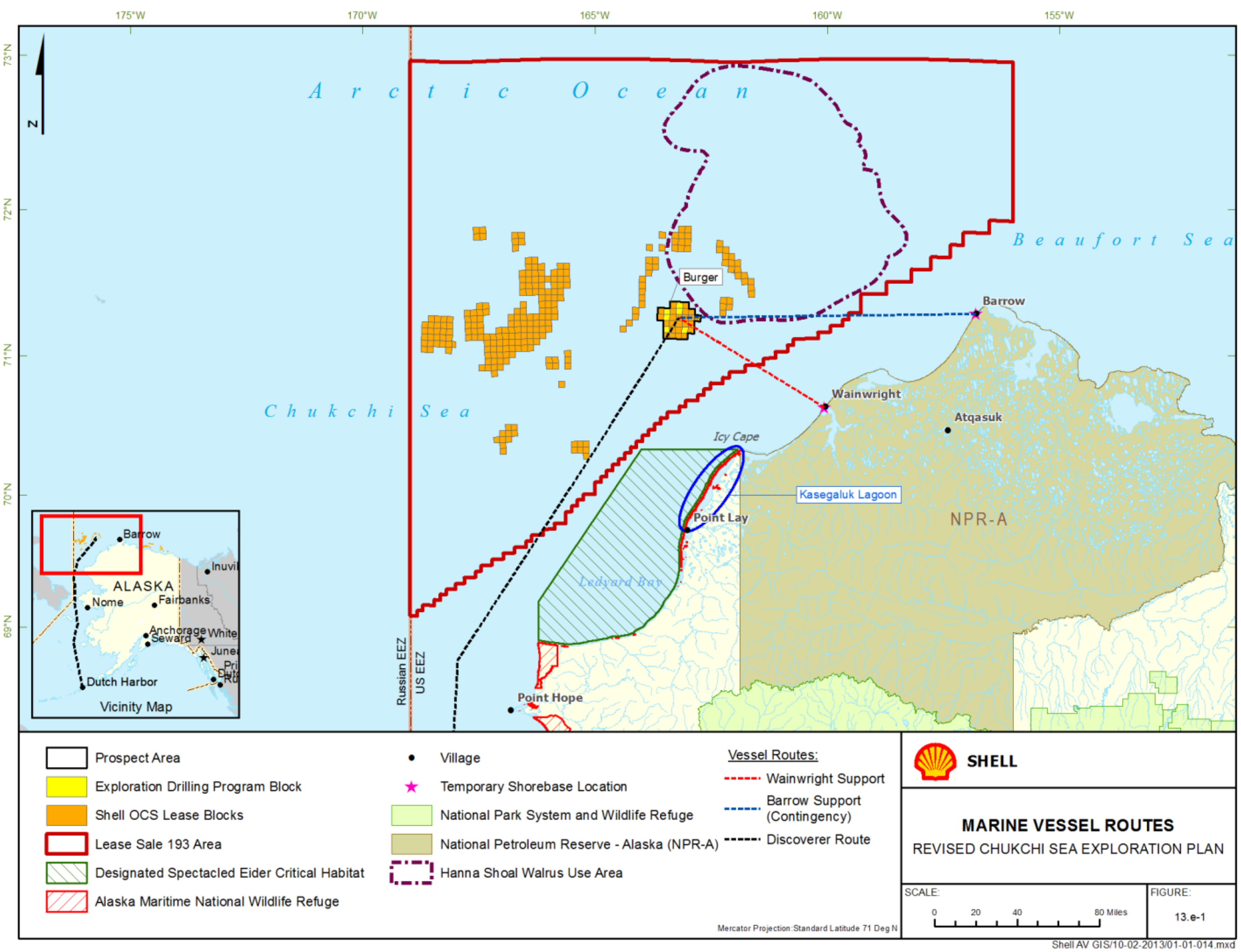
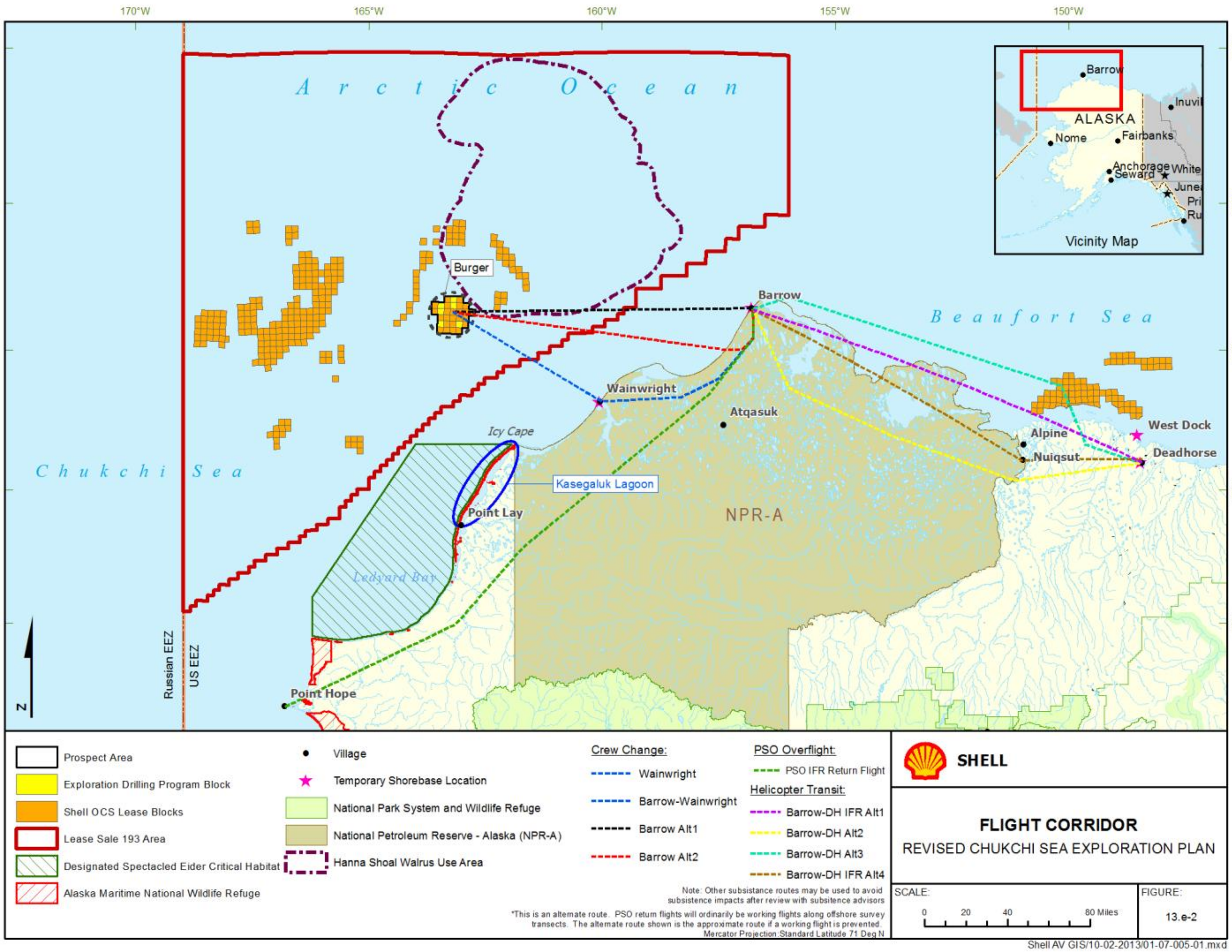


Figure 13.e-2 Flight Corridor



Section 14.0 ONSHORE SUPPORT FACILITIES INFORMATION

a) General

Shell plans to increase its man camp capacity in Barrow from 75 beds to approximately 200 beds. The camp will be used primarily to house workers going to and coming from the drilling vessel and support vessels.

Shell may occasionally conduct crew changes using a marine vessel (landing craft or similar) from Barrow to the drillship / support vessels or from the drillship / support vessels to Barrow.

Shorebase facilities for marine support will be at already established facilities in Wainwright. Shell will have contingency space for up to 55 persons in Wainwright.

b) Air Emissions

Air emissions will increase due to the planned increase in the size of the man camp. The following Table 14.b-1 provides the anticipated air emissions associated with the onshore facilities.

Table 14.b-1 Air Emissions Associated with Onshore Facilities

Emission Unit	NO_X lb/hr	PM lb/hr	CO lb/hr	VOC lb/hr	SO_2 lb/hr
Man Camp Generator	7.73	0.36	6.303	2.34	0.62
Hangar/Storage Building Boiler	0.49	0.04	0.41	0.02	0.41
Vehicles	7.9E-3	7.9E-4	0.29	7.7E-3	1.2E-2
Emission Unit	**NO_X ton/season**	**PM ton/season**	**CO ton/season**	**VOC ton/season**	**SO_2 ton/season**
Man Camp Generator	12.76	0.64	11.16	4.15	1.10
Hangar/Storage Building Boiler	0.35	0.0	4.88	1.1E-2	0.29
Vehicles	1.2E-2	1.2E-3	0.42	1.1E-2	0.02

Section 15.0 COASTAL ZONE MANAGEMENT ACT

NOT APPLICABLE

Section 16.0 ENVIRONMENTAL IMPACT ANALYSIS

The Environmental Impact Analysis revisions are provided in Appendix F.

Section 17.0 ADMINISTRATIVE

b) Bibliography

The following documents are additional reports mentioned in this revision:

Bisson, L.N., H.J. Reider, H.M. Patterson, M. Austin, J.R. Brandon, T. Thomas, and M.L. Bourdon. 2013. Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort Seas, July–November 2012: Draft 90-Day Report. D.W. Funk, C.M. Reiser, and W.R. Koski, editors. LGL Rep. P1272D–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, USA, and JASCO Applied Sciences, Victoria, BC, Canada, for Shell Offshore Inc, Houston, TX, USA, Nat. Mar. Fish. Serv., Silver Spring, MD, USA, and U.S. Fish and Wild. Serv., Anchorage, AK, USA. 266 p. + app.

UMIAQ 2012. 2011 Subsistence Advisor Program, North Slope Alaska. Report prepared by UMIAQ, Anchorage, AK for Shell Exploration and Production, Anchorage AK.

UMIAQ 2013. 2012 Subsistence Advisor Program, North Slope Alaska. DRAFT Report prepared by UMIAQ, Anchorage, AK for Shell Exploration and Production, Anchorage AK.

LIST OF REVISED APPENDICES

Appendix B

National Pollutant Discharge Elimination System Notice of Intent

(To be revised and submitted to BOEM at a later date)

Appendix C

Application for National Marine Fisheries Service Incidental Harassment Authorization

(To be revised and submitted to BOEM at a later date)

Appendix D

Marine Mammal Monitoring and Mitigation Plan

Marine Mammal Monitoring and Mitigation Plan

Exploration Drilling of Selected Lease Areas in The Alaskan Chukchi Sea in 2014

Shell Gulf of Mexico Inc.

November 2013

TABLE OF CONTENTS

ACRONYMS

°C	degrees Celsius
°T	degrees True North
μPa	microPascals(s)
4MP	Marine Mammal Monitoring and Mitigation Plan
AEWC	Alaska Eskimo Whaling Commission
AMAR	Advanced Multi-channel Acoustic Recorder
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
DASAR	Directional Autonomous Seafloor Acoustic Recorder
dB	decibel
CD	Compact Disc
cm^3	cubic centimeter
ESW	effective strip width
ft	feet
GPS	Global Positioning System
Hz	Hertz
IHA	Incidental Harassment Authorization
JASCO	JASCO Applied Sciences
kHz	kilohertz
km	kilometer
LBCHU	Ledyard Bay Critical Habitat Unit
Leq	sound energy equivalent level
LOA	Letter of Authorization
m	meter(s)
mi	mile(s)
psi	pounds per square inch
PSO	Protected Species Observer
MMS	Minerals Management Service
NMFS	National Marine Fisheries Service
NSB	North Slope Borough
NVD	Night-vision Device
rms	Root Mean Square
Shell	Shell Gulf of Mexico Inc.
SAR	Search and Rescue
UAS	Unmanned Aerial System
USFWS	U.S. Fish and Wildlife Service
VSI	vertical seismic imager
ZVSP	Zero-offset Vertical Seismic Profile

INTRODUCTION

Shell Gulf of Mexico Inc. (Shell) will conduct a Marine Mammal Monitoring and Mitigation Plan (4MP) for exploration drilling activities in the Chukchi Sea during the 2014 drilling season. The 4MP developed for Shell's exploration drilling program supports protection of the marine mammal resources in the area, fulfills reporting obligations to the Bureau of Ocean Energy Management (BOEM), Bureau of Safety and Environmental Enforcement (BSEE), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS), and establishes a means for gathering additional data on marine mammals for future operations planning.

Shell plans to conduct exploration drilling within existing lease holdings in the Chukchi Sea. Exploration drilling will be conducted from the Motor/Vessel (M/V) *Noble Discoverer* drillship owned and operated by Noble Corporation. The drillship is an ice-class drilling vessel designed, engineered and constructed to safely operate in arctic waters like the Chukchi Sea. In addition to the drillship, several support vessels will be required. The support vessels are detailed in Section 13 of EP Revision 2 and in Section 2 of the Environmental Impact Analysis (EIA) for EP Revision 2, and include tugs and barges, an icebreaker, anchor handler/ice management vessel, and oil spill response vessels.

At, or near the end of each well a zero offset vertical seismic profile (ZVSP) will be conducted. During ZVSP surveys, an airgun array is deployed adjacent to the drillship, while receivers are placed in the wellbore. The sound source (airgun array) is fired repeatedly, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The survey will last 10-14 hours as the receivers are moved through the length of the wellbore and the airguns are fired 5-7 times after each movement. The purpose of the ZVSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell's 4MP is a combination of active monitoring of the area of operations and the implementation of mitigation measures designed to minimize project impacts to marine resources. Monitoring will provide information on the numbers of marine mammals potentially affected by the exploration operations and facilitate real time mitigation to prevent injury of marine mammals by industrial sounds or activities. These goals will be accomplished by conducting vessel-based visual monitoring, aerial photographic surveys, and acoustic monitoring programs to document the potential reactions of marine mammals in the area to the various sounds and activities and to characterize the sounds produced by the exploration drilling activities, support vessels, and a ZVSP.

A minimally-manned aerial photographic survey around the offshore drilling operations, opportunistic aerial photographic surveys to monitor marine mammals in coastal and nearshore areas of the Chukchi Sea, and recordings of ambient sound levels and vocalizations of marine mammals along the Chukchi Sea coast will be used to interpret potential impacts to marine mammals around the offshore exploration drilling operations and in subsistence use areas closer to shore. Acoustic measurements will be made to establish safety radii for real time mitigation around ZVSP operations, and to verify pre-season estimates of the sound footprints and disturbance radii for exploration drilling activities. Preliminary sound source analyses will be supplied to NMFS within 120 hours of completion of the measurements, if possible. A detailed report will be issued to NMFS as part of the 90-day report following the end of the exploration drilling season. Shell will continue to measure the sound propagation of the drillship at various times or throughout the exploration drilling program. Sound energy from support vessels will also be measured. Bottom-founded hydrophones will also be placed in a large array across the

Chukchi Sea to collect information on the use of the region by marine mammals and additional information on the propagation of sounds from human activities.

VESSEL-BASED MARINE MAMMAL MONITORING PROGRAM

Introduction

The vessel-based operations of Shell’s 4MP are designed to meet the requirements of the Incidental Harassment Authorization (IHA) and the Letter of Authorization (LOA) which Shell requests from the NMFS and the USFWS, respectively, and to meet any other stipulated agreements between Shell and other agencies or groups. The objectives of the program will be to ensure that disturbance to marine mammals and subsistence hunts is minimized, that effects on marine mammals are documented, and to collect data on the occurrence and distribution of marine mammals in the project area.

The 4MP will be implemented by a team of experienced protected species observers (PSOs). These PSOs will be trained, experienced field observers, including both biologists and Inupiat personnel. The PSOs will be stationed aboard, at a minimum, the drillship, the ice management and anchor handling vessels throughout the exploration drilling period. The duties of the PSOs will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the exploration drilling operations; initiating mitigation measures when appropriate; and reporting the results. Reporting of the results of the vessel-based monitoring program will include the estimation of the number of marine mammal “exposures” as defined by the NMFS and stipulated in the IHA.

The vessel-based operations of Shell’s 4MP will be required to support the vessel-based exploration drilling activities in the Chukchi Sea. The dates and operating areas will depend upon ice and weather conditions, along with Shell’s arrangements with agencies and stakeholders. The *Discoverer* and associated support vessels will transit through the Bering Strait into the Chukchi Sea on or about July 1, arriving on location at the Burger Prospect as soon as ice and weather conditions allow. Exploration drilling activities will then commence on or about July 4, as ice, weather and other conditions allow for safe exploration drilling operations, and may last until October 31. Priority is placed on finishing the Burger A well that was begun in 2012. If Burger A is begun first and finished then operations will move to another Burger drill site. Should ice conditions at Burger A preclude drilling early in the season, operations could begin at another Burger drill site. At the end of the drilling season, the drillship and support vessels plan to travel out of the Chukchi Sea. Transit entirely out of the Chukchi Sea by all vessels associated with exploration drilling may continue into the month of November due to ice, weather, and sea states. Vessel-based monitoring for marine mammals will be done throughout the period of operations to comply with provisions in the anticipated IHA and LOA from NMFS and USFWS, respectively.

The vessel-based work will provide:

- the basis for real-time mitigation, if necessary, as required by the various permits that Shell receives;
- information needed to estimate the number of “exposures” of marine mammals to sound levels that may result in harassment, which must be reported to NMFS and USFWS;
- data on the occurrence, distribution, and activities of marine mammals in the areas where the exploration drilling program is conducted;
- information to compare the distances, distributions, behavior, and movements of marine mammals relative to the drillship at times with and without exploration drilling activity;

Chukchi Sea, Alaska Marine Mammal Monitoring and Mitigation Plan

- a communication channel to coastal communities including Inupiat whalers; and
- employment and capacity building for local residents, with one objective being to develop a larger pool of experienced Inupiat PSOs

The 4MP will be operated and administered consistent with monitoring programs conducted during exploration drilling, seismic, and shallow hazards surveys in 2006–2013 or such alternative requirements as may be specified in the IHA and LOA received from NMFS and USFWS, respectively for this project. Any other agreements between Shell and agencies or groups such as BOEM, BSEE, USFWS, the North Slope Borough (NSB), and the Alaska Eskimo Whaling Commission (AEWC) will also be fully incorporated. All PSOs will be provided training through a program approved by NMFS and Shell, as described in the PSO section of this 4MP. At least one observer on each vessel will be an Inupiat who will have the additional responsibility of communicating with the Inupiat community and (during the various subsistence harvests) directly with Inupiat subsistence advisors and/or hunters and whalers. Details of the vessel-based marine mammal monitoring program are described below.

Mitigation Measures during Exploration Drilling Activities

Shell's planned exploration drilling program incorporates both design features and operational procedures for minimizing potential impacts on marine mammals and on subsistence hunts. The design features and operational procedures of the mitigation measures are described in the IHA (Section 12 of the IHA application to which the 4MP is appended) and LOA applications submitted to NMFS and USFWS, respectively and are not repeated in entirety here. Survey design features include:

- timing and locating exploration drilling and support activities to avoid interference with the annual subsistence hunting by the people of the Chukchi villages;
- conducting pre-season acoustic modeling to establish the appropriate safety zones and behavioral or disturbance radii;
- vessel-based monitoring to implement appropriate mitigation if necessary, and to determine the effects of project activities on marine mammals,
- acoustic monitoring of drillship and vessel sounds and marine mammal vocalizations;
- aerial surveys with photographic equipment over operations and in coastal and nearshore waters with photographic equipment and PSOs to help determine the effects of project activities on marine mammals; and
- seismic activity mitigation measures during performance of ZVSP surveys

The potential disturbance of marine mammals during exploration drilling operations will be minimized further through the implementation of several vessel-based mitigation measures (see Section 12 of the IHA application to which the 4MP is appended) if mitigation becomes necessary.

Safety and Disturbance Zones

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around industrial sound sources are customarily defined as the distances within which received pulse levels are ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. These safety criteria are based on an assumption that sound energy received at lower levels will not injure these animals or impair their hearing abilities, but that higher received levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the safety radii (Richardson et al.

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1995). NMFS assumes that marine mammals exposed to underwater impulsive sounds at received levels ≥160 dB (rms) have the potential to exhibit behavioral reactions great enough to meet the definition of "harassment" in the MMPA. For continuous sounds NMFS has established a similar disturbance threshold at ≥120 dB (rms).

Exploration Drilling Activities

Expected safety and disturbance radii based on sound produced by the drillship *Discoverer* were modeled by JASCO Applied Sciences (JASCO) at the three potential drill sites (JASCO 2009). Actual sound levels produced by drilling of the top hole section of the Burger-A well by *Discoverer* in 2012 were accurately measured in a dedicated sound source verification program through most of the drilling activities. The modeling and measurement results together provide a good characterization of the expected noise levels and their variability over the various activities of the proposed drilling program and between drill sites. Changes in the water column of the Chukchi Sea through the course of the exploration drilling season will likely affect the propagation of sounds produced by drilling activities, so models were run for expected oceanographic conditions in July and October to bracket the seasonal variability. The water profiles considered for modeling drilling sound for both times did not include the stratified profiles of warm saline water overlying cold brackish water that occasionally occur in this area. The non-stratified profiles that were used lead to more conservative (greater) sound threshold radii because the stratified profiles produce downward acoustic refraction and more bottom interactions that reduce radii. The modeled radii will be used for mitigation purposes, should they be necessary, until direct measurements are available early during the exploration drilling activities. Shell will measure the received levels of underwater sound versus distance and direction from the sound sources using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable in the field and used to verify (and if necessary adjust) the safety and disturbance radii.

Prior to 2012, sounds from the *Discoverer* had not previously been measured in the Arctic. However, measurements of sounds produced by the *Discoverer* were made in the South China Sea in 2009 (Austin and Warner 2010). The results of those measurements were used to model the sound propagation from the *Discoverer* (including a nearby support vessel) at planned drilling locations in the Chukchi and Beaufort Seas (Warner and Hannay 2011). Broadband source levels of sounds produced by the *Discoverer* varied by activity and direction from the ship, but were generally between 177 and 185 dB re 1 µPa @ 1 m rms (Austin and Warner 2010). Propagation modeling at the Burger Prospect resulted in an estimated distance of 0.814 miles (mi) (1.31 kilometers [km]) to the point at which drilling sounds would likely fall below 120 dB. In the 2012 IHA application, the modeled 0.814 mi (1.31 km) distance was multiplied by 1.5 (= 1.22 mi [1.97 km]) as a precautionary measure before calculating the total area that may be exposed to continuous sounds ≥120 dB re 1 µPa rms by the *Discoverer* at each drill site on the Burger Prospect.

During 2012 exploration drilling activities, measurements of sounds produced by the *Discoverer* were made on the Burger Prospect. The recordings were made using four JASCO AMAR-G3 acoustic recorders deployed on the seafloor 0.62 mi (1 km) to 5.0 mi (8 km) from the *Discoverer*. The recorded data show a number of tonal components likely produced by vibrations from rotating machinery. Most of the acoustic energy was contained in the 100-1000 Hz and 1-10 kHz frequency bands, both of which typically had levels just below 120 dB re 1 µPa. Preliminary analysis showed that broadband sound levels from the *Discoverer* alone were 116-123 dB re 1 µPa at 0.62 mi (1 km) during normal drilling activities when support vessels were not in vicinity of the drillship. There were also intermittent periods of time when vessel activities near the *Discoverer*, and during anchoring and mudline cellar (MLC) excavation activities, when

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broadband sound levels increased up to 140 dB re 1 µPa at 0.62 mi (1 km). The 2012 measurement of the distance to 120 dB re 1 µPa threshold for normal drilling activity was 0.93 mi (1.5 km) which is 24% less than the modeled distance with safety margin. The distance to 120 dB re 1 µPa threshold during MLC construction was 8.1 km.

The source levels noted above for exploration drilling activities are not high enough to cause a temporary reduction in hearing sensitivity or permanent hearing damage to marine mammals. Consequently, mitigation as described for seismic activities including ramp ups, power downs, and shut downs should not be necessary for exploration drilling activities. However, Shell plans to use PSOs onboard, at a minimum, the drillship and the ice management and anchor handling vessels to monitor marine mammals and their responses to industry activities and to initiate mitigation measures should in-field measurements of the operations indicate conditions represent a threat to the health and well-being of marine mammals.

ZVSP Surveys

The sound source likely to be used by Shell for the ZVSP survey is the BHI H-RACK four-airgun array, which consists of two 150 in3 (2,458 cu cm^3) airguns and two 100 in^3 (1,639 cu cm^3). JASCO Applied Sciences modeled the broadband sound output from the airgun array and calculated threshold distances to the 190 through 120 dB re 1 µPa (in 10 dB increments) for the 500 in3 full array operating at 2000 psi and for the 100 in^3 airgun operating at 1000 psi at the Burger A well site (Tables 1 and 2).

Table 1. Threshold distances for the 500 in^3 airgun array operating at 2000 psi.

RMS SPL (dB re 1 µPa)	R95% (km)
	Burger A
190	0.076
180	0.502
170	1.479
160	4.313
150	10.109
140	21.551
130	42.051
120	78.25

Table 2. Threshold distances for the 100 in^3 airgun operating at 1000 psi.

RMS SPL (dB re 1 µPa)	R95% (km)
	Burger A
190	<0.050
180	<0.050
170	0.119
160	0.744
150	2.095
140	5.837
130	13.245
120	26.718

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PSOs on the drillship will initially use 1.5X these modeled safety radii for monitoring and mitigation purposes. An acoustics contractor will perform direct measurements of the received levels of underwater sound versus distance and direction from the ZVSP array using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable in the field and used to verify (and if necessary adjust) the safety distances during later ZVSP activities. The mitigation measures to be implemented will include pre-ramp up watches, ramp ups, power downs and shut downs as described below.

Ramp Ups

A ramp up of an airgun array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of airguns firing until the full volume is achieved. The purpose of a ramp up (or “soft start”) is to “warn” cetaceans and pinnipeds in the vicinity of the airguns and to provide the time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

During the proposed ZVSP surveys, the operator will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start when no airguns have been firing) will begin by firing a single airgun in the array. A full ramp up will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs to assure that no marine mammals are present. The entire safety zone must be visible during the 30-minute lead-in to a full ramp up. If the entire safety zone is not visible, then ramp up from a cold start cannot begin. If a marine mammal(s) is sighted within the safety zone during the 30-minute 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 minutes: 15 minutes for small odontocetes and pinnipeds, or 30 minutes for baleen whales and large odontocetes.

Power Downs and Shut Downs

A power down is the immediate reduction in the number of operating energy sources to some smaller number. A shut down is the immediate cessation of firing of all energy sources. The arrays will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable safety zone of the full arrays, but is outside the applicable safety zone of the single source. If a marine mammal is sighted within the applicable safety zone of the single energy source, the entire array will be shut down (i.e., no sources firing).

Protected Species Observers

Vessel-based monitoring for marine mammals will be done by trained PSOs aboard, at a minimum, the drillship, ice management and anchor handler vessels throughout the period of exploration drilling operations to comply with expected provisions in the IHA and LOA that Shell receives. The observers will monitor the occurrence and behavior of marine mammals near the drillship, ice management and anchor handling vessels, during all daylight periods during the exploration drilling operation, and during most periods when exploration drilling is not being conducted. PSO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the exploration drilling operations; and documenting exposures of animals to sound levels that may constitute harassment as defined by NMFS.

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Number of observers

A sufficient number of PSOs will be onboard to meet the following criteria

- 100 percent monitoring coverage during all periods of exploration drilling operations in daylight;
- Maximum of four consecutive hours on watch per PSO; and
- Maximum of approximately 12 hours on watch per day per PSO

PSO teams will consist of trained Inupiat and field biologist observers. An experienced field crew leader will be a member of every PSO team aboard, at a minimum, the drillship, the ice management and anchor handling vessels during the exploration drilling program. The total number of PSOs aboard may decrease later in the season as the duration of daylight decreases assuming NMFS does not require continuous nighttime monitoring. Inupiat PSOs will also function as Native language communicators with hunters and whaling crews and with the Communications and Call Centers (Com Centers) in Native villages along the Chukchi Sea coast.

Crew Rotation

Shell anticipates that there will be provision for crew rotation at least every three to six weeks to avoid observer fatigue. During crew rotations, detailed hand-over notes will be provided to the incoming crew leader by the outgoing leader. Other communications such as email, fax, and/or phone communication between the current and oncoming crew leaders during each rotation will also occur when possible. In the event of an unexpected crew change Shell will facilitate such communications to insure monitoring consistency among shifts.

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers will be individuals with experience as observers during one or more of the 2006–2013 monitoring projects for Shell or recent experience with other operators in Alaska or the Canadian Beaufort, or Chukchi Seas.

Biologist-observers will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring projects. Résumés for those individuals will be provided to NMFS for approval. All observers will be trained and familiar with the marine mammals of the area. A marine mammal observers' handbook, adapted for the specifics of the planned Shell exploration drilling program will be prepared and distributed beforehand to all PSOs (see below).

Most observers will also complete a two-day training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the exploration drilling season. Any exceptions will have or receive equivalent experience or training. The training session(s) will be conducted by marine mammalogists with extensive crew-leader experience during previous vessel-based seismic monitoring programs, in the Arctic.

Primary objectives of the training include:

- Review of the marine mammal monitoring plan for this project, including any amendments adopted, or specified by NMFS or USFWS in the IHA or LOA, by BOEM, BSEE, or other agreements in which Shell may elect to participate;
- Review of marine mammal sighting, identification, (photographs and videos) and distance estimation methods, including any amendments specified by NMFS or USFWS in the IHA or LOA;
- Review of operation of specialized equipment (reticle binoculars, Big eye binoculars, night vision devices, and GPS system);

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- Review of, and classroom practice with, data recording and data entry systems, including procedures for recording data on mammal sightings, exploration drilling and monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers; and
- Review of specific tasks of the Inupiat communicator

PSO Handbook

A Protected Species Observers' Handbook will be prepared for Shell's monitoring program. The Handbook will contain maps, illustrations, and photographs as well as copies of important documents and descriptive text and are intended to provide guidance and reference information to trained individuals who will participate as PSOs. The following topics will be covered in the PSO Handbook:

- summary overview descriptions of the project, marine mammals and underwater sound energy, the marine mammal monitoring program (vessel-based, aerial, acoustic measurements, special studies), the NMFS IHA and USFWS LOA and other regulations/permits/agencies, the Marine Mammal Protection Act;
- monitoring and mitigation objectives and procedures, including initial safety radii;
- responsibilities of staff and crew regarding the marine mammal monitoring plan;
- instructions for ship crew regarding the marine mammal monitoring plan;
- data recording procedures: codes and coding instructions, common coding mistakes, electronic database; navigational, marine physical, and drilling data recording, field data sheet;
- use of specialized field equipment (reticle binoculars, Big-eye binoculars, NVDs, laser rangefinders);
- reticle binocular distance scale;
- table of wind speed, Beaufort wind force, and sea state codes;
- data storage and backup procedures;
- list of species that might be encountered: identification, natural history;
- safety precautions while onboard;
- crew and/or personnel discord; conflict resolution among PSOs and crew;
- drug and alcohol policy and testing;
- scheduling of cruises and watches;
- communications;
- list of field gear provided;
- suggested list of personal items to pack;
- suggested literature, or literature cited;
- field reporting requirements and procedures;
- copies of the NMFS IHA and USFWS LOA will be made available; and
- coordinates delineating areas where ships cannot operate such as the Ledyard Bay Critical Habitat Unit (LBCHU)

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Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the drillship and support vessels. Ideally this vantage point is an elevated stable platform from which the PSO has an unobstructed 360^o view of the water. The observer(s) will scan systematically with the naked eye and 7×50 reticle binoculars, supplemented with Big-eye binoculars and night-vision equipment when needed (see below). Personnel on the bridge will assist the marine mammal observer(s) in watching for pinnipeds and whales. New or less-experienced PSOs will be paired with an experienced PSO or experienced field biologist so that the quality of marine mammal observations and data recording is kept consistent.

Information to be recorded by marine mammal observers will include the same types of information that were recorded during previous monitoring projects (e.g., Bisson et al. 2013, Moulton and Lawson 2002, Reiser et al. 2010, Reiser et al. 2011). When a mammal sighting is made, the following information about the sighting will be carefully and accurately recorded:

- species, group size, age/size/sex categories (if determinable), physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals;
- behavior when first sighted and after initial sighting;
- heading (if consistent), bearing and distance from observer;
- apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace;
- time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare, on support vessels the distance and bearing to the drillship will also be recorded; and
- positions of other vessel(s) in the vicinity of the observer location

The ship's position, speed, water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

Distances to nearby marine mammals will be estimated with binoculars (Fujinon 7×50 binoculars) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon.

Observers may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. However, previous experience showed that a Class 1 eye-safe device was not able to measure distances to seals more than about 230 feet (ft) [70 meters (m)] away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 1,968 ft (600 m) the maximum range at which the device could measure distances to highly reflective objects such as other vessels. Humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about ±20 percent when given immediate feedback about actual distances during training.

Maximizing time with eyes on the water is strongly promoted during training and is a goal of the PSO program. Each ship with PSOs will have voice recorders available to them. This will allow PSOs to remain focused on the water in situations where a number of sightings occur together. Additionally, Shell has moved entirely to real-time electronic data recording (described below) and automated as much of the process as possible to minimize time spent recording data as opposed to focusing eyes on the water.

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PSO's are instructed to identify animals as unknown when appropriate rather than strive to identify an animal when there is significant uncertainty. Shell also asks PSOs to provide any sightings cues they used and any distinguishable features of the animal even if they are not able to identify the animal and record it as unidentified. Emphasis is also placed on recording what was not seen, such as dorsal features.

Monitoring At Night and In Poor Visibility

Night-vision equipment "Generation 3" binocular image intensifiers or equivalent units will be available for use when needed. However, past experience with night-vision devices (NVDs) in the Beaufort Sea and elsewhere indicates that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Harris et al. 1997, 1998; Moulton and Lawson 2002, Hartin et al, 2011). Data will be collected to further evaluate night-vision equipment.

Specialized Field Equipment

Shell will provide or arrange for the following specialized field equipment for use by the onboard PSOs: reticle binoculars, Big-eye binoculars, GPS unit, laptop computers with custom designed software for recording the data, night vision binoculars, and possibly digital still and digital video cameras. Big-eye binoculars will be mounted and used on key monitoring vessels including the drillship, ice management vessels and the anchor handler.

Field Data-Recording, Verification, Handling, and Security

The observers on the drillship and support vessels will record their observations directly into computers using a custom software package. The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered, and by subsequent manual checking. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, and will facilitate transfer of the data to statistical, graphical or other programs for further processing. Quality control of the data will be facilitated by (1) the start-of-season training session, (2) subsequent supervision by the onboard field crew leader, and (3) ongoing data checks during the field season.

The data will be sent off of the ship to Anchorage on a daily basis and backed up regularly onto CDs and/or USB disks on the ship, and stored at separate locations on the vessel. If possible, any hand-written data sheets will be photocopied daily during the field season. Data will be secured further by having data sheets and backup data CDs carried back to the Anchorage office during crew rotations.

In addition to routine PSO duties, observers will be encouraged to record comments about their observations into the "comment" field in the database. Copies of these records will be available to the observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

PSOs will be able to plot sightings in near real-time for their vessel. Significant sightings from key vessels (drillship, ice management, anchor handlers and aircraft will be relayed between platforms to keep observers aware of animals that may be in or near the area but may not be visible to the observer at any one time. Emphasis will be placed on relaying sightings with the greatest potential to involve mitigation or reconsideration of a vessel's course (e.g., large group of bowheads, walruses on ice).

Observer training will emphasize the use of "comments" for sightings that may be considered unique or not fully captured by standard data codes. In addition to the standard marine mammal sightings forms, a specialized form was developed for recording traditional knowledge and

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natural history observations. PSOs will be encouraged to use this form to capture observations related to any aspect of the arctic environment and the marine mammals found within it. Examples might include relationships between ice and marine mammal sightings, marine mammal behaviors, comparisons of observations among different years/seasons, etc. Voice recorders will also be available for observers to use during periods when large numbers of animals may be present and it is difficult to capture all of the sightings on written or digital forms. These recorders can also be used to capture traditional knowledge and natural history observations should individuals feel more comfortable using the recorders rather than writing down their comments. Copies of these records will be available to all observers for reference if they wish to prepare a statement about their observations for reporting purposes. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

Field Reports

Throughout the exploration drilling program, the biologists will prepare a report each day or at such other interval as required summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to NMFS and USFWS as required.

Reporting

The results of the vessel-based monitoring, including estimates of exposure to key sound levels, will be presented in the 90-day and final technical report(s). Reporting will address the requirements established by NMFS in the IHA, and USFWS in the LOA (if so stipulated).

The technical report(s) will include:

- summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through study period for sea state, and other factors affecting visibility and detectability of marine mammals;
- analyses of the effects of various factors influencing detectability of marine mammals: sea state, number of observers, and fog/glare;
- species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories (when discernible), group sizes, and ice cover; and
- analyses of the effects of exploration drilling operations:
    - sighting rates of marine mammals during periods with and without exploration drilling activities (and other variables that could affect detectability),
    - initial sighting distances versus drilling state,
    - closest point of approach versus drilling state,
    - observed behaviors and types of movements versus drilling state,
    - numbers of sightings/individuals seen versus drilling state,
    - distribution around the drillship and support vessels versus drilling state,
    - estimates of “take by harassment”

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Data will be visualized by plotting sightings relative to the position of the drillship. Shell will also overlay the sightings data with acoustic data that indicates the sound levels associated with the exploration drilling activity and with maps of call locations determined by the seafloor recorders. Additionally, sightings data will be incorporated into animations of the call locations around the exploration drilling activity. Seafloor recorders used in the Chukchi Sea do not have the ability to localize calls. Larger groups of recorders, however, can localize calls using arrival times of the calls captured on several nearby recorders.

Shell will consider requests for data collected during the marine mammal monitoring only after the data have been put through a quality control/quality assurance program. Such requests may include incorporating the data with other companies' data and/or integrating the raw data with data from other marine mammal studies.

ACOUSTIC MONITORING PLAN

Exploration Drilling, ZVSP and Vessel Sound Measurements

Objectives

Exploration drilling sounds are expected to vary significantly with time due to variations in the level of operations and the different types of equipment used at different times onboard the drillship. The goals of these measurements are:

- to quantify the absolute sound levels produced by exploration drilling and to monitor their variations with time, distance and direction from the drillship;
- to measure the sound levels produced by vessels operating in support of exploration drilling operations. These vessels will include crew change vessels, tugs, ice-management vessels, and spill response vessels not measured in 2012; and
- to measure the sound levels produced by an end-of-hole vertical seismic profiling (ZVSP) survey using a stationary sound source

Exploration Drilling Sound Characterization

Sound characterization and measurements of all exploration drilling activities will be performed using three AMAR autonomous acoustic recording stations (Figures 1 and 2) deployed on the seabed along the same radial at distances of 0.62, 1.2, 2.5 and 5 mi (1, 2, 4 and 8 km) from the drillship. All three recording stations will sample at least at 32 kHz, providing calibrated acoustic measurements in the 5 Hz to 16 kHz frequency band. The logarithmic spacing of the recorders is designed to sample the attenuation of drillship sounds with distance. The autonomous recorders will sample through completion of the first well, to provide a detailed record of sounds emitted from all activities. These recorders will be retrieved and their data analyzed and reported in the project's 90-day report.

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FIGURE 1. Geometry of the three autonomous acoustic recorders that will sample sound produced by exploration drilling operations of drillship *Discoverer*

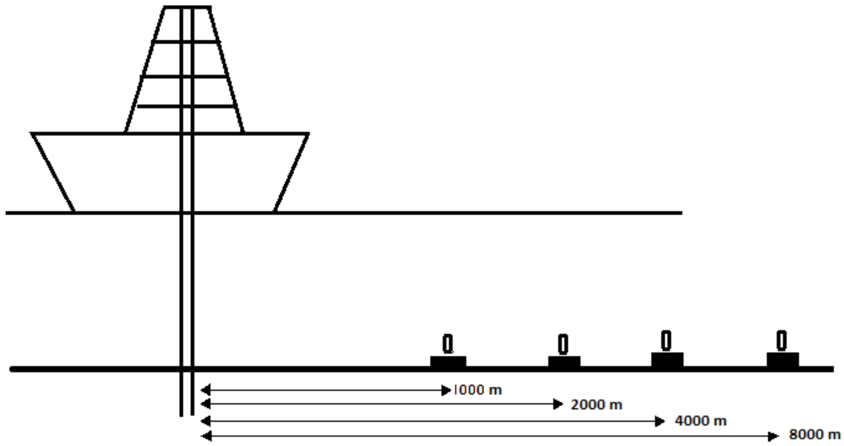

FIGURE 2. AMAR autonomous acoustic recorder for acoustic monitoring of drilling activities

The deployment of drilling sound monitoring equipment will occur before, or as soon as possible after the *Discoverer* is on site. Activity logs of exploration drilling operations and nearby vessel activities will be maintained to correlate with these acoustic measurements. All results, including back-propagated source levels for each operation, will be reported in the 90-day report.

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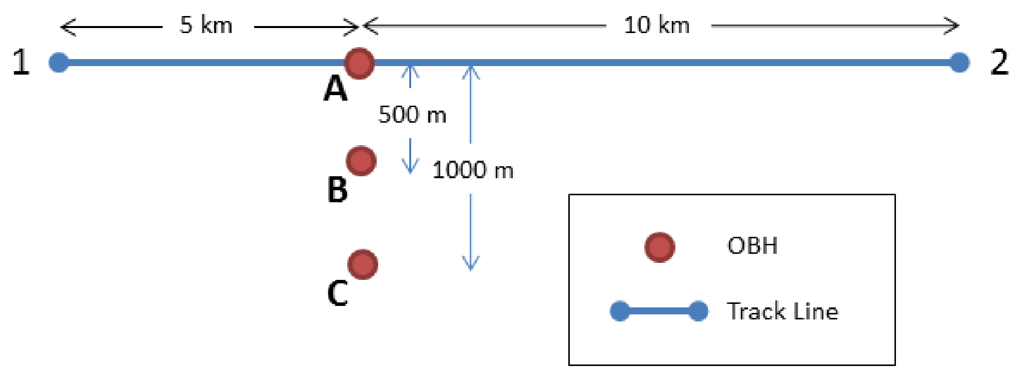
Vessel Sound Characterization

Vessel sound characterizations will be performed using dedicated recorders deployed at sufficient distances from exploration drilling operations so that sound produced by those activities does not interfere. Three AMAR acoustic recorders will be deployed on and perpendicular to a sail track on which all Shell vessels will transit. The deployment geometry will be as shown in Figure 3. This geometry is designed to obtain sound level measurements as a function of distance and direction. The fore and aft directions are sampled continuously over longer distances to 3 and 6 miles (5 and 10 km) respectively, while broadside and other directions are sampled as the vessels pass closer to the recorders.

FIGURE 3. AMAR recorder deployment geometry relative to vessel sail track for support vessel sound characterization measurements.



Vessel sound measurements will be processed and reported in a manner similar to that used by Shell and other operators in the Beaufort and Chukchi Seas during seismic survey operations. The measurements will be further analyzed to calculate source levels. Source directivity effects will be examined and reported. Preliminary vessel characterization measurements will be included in a field report to be delivered 120 hours after the recorders are retrieved and data downloaded. Those results will include sound level data but not source level calculations. All vessel characterization results, including source levels, will be reported in 1/3-octave bands in the project 90-day report.

Zero Offset Vertical Seismic Profiling Sounds Monitoring

Sounds produced by the ZVSP survey at, or near the end of each well will be recorded using the drilling sounds monitoring equipment. During ZVSP surveys, an airgun array, which is typically much smaller than those used for routine seismic surveys, is deployed at a location near or adjacent to the drillship, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired repeatedly, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically a string of them, are then raised up to the next interval in the wellbore and the process is repeated until the entire wellbore has been surveyed. The purpose of the ZVSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

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During the ZVSP the sound source is maintained at a constant location near the wellbore. A typical sound source likely to be used by Shell is the BHI H-RACK four-airgun array, which consists of two 150 in^3 (2,458 cm^3) airguns and two 100 in^3 (1,639 cm^3) airguns. These airguns can be activated in any combination and Shell would utilize the minimum airgun volume required to obtain a suitable signal. Current specifications of the array are provided in Table 1-3. The airgun array is depicted within its frame or sled (Figure 4), which is approximately 9.5ft (2.9 m) x 7 ft (2.1 m) x 2.5 ft (0.8 m) (see photograph below). Typical receivers would consist of a Baker Hughes Incorporated four level seismic string, which has four receivers 50 ft (15 m) apart.

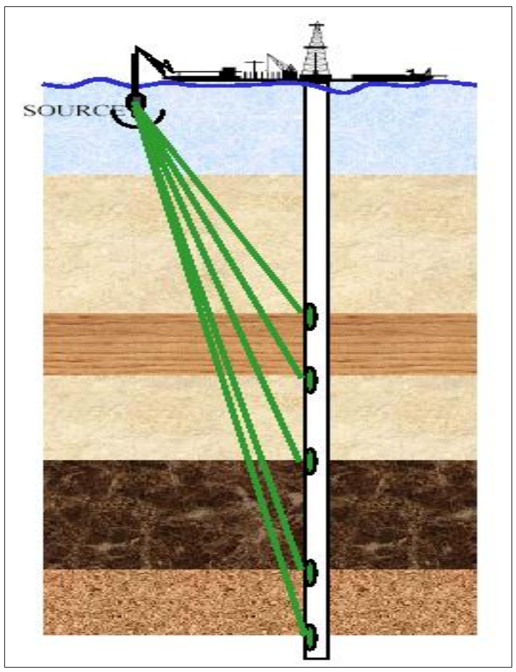
FIGURE 4. Photograph of BHI H-RACK 4-airgun array in sled.

Table 3 Sound Source (Airgun Array) Specifications for ZVSP Surveys in the Chukchi Sea

Source Type	No. Sources	Maximum Total Chamber Size	Pressure	Source Depth	Calibrated Peak-Peak Vertical Amplitude	Zero-Peak Sound Pressure Level
BHI, H-RACK Sleeve Array	4 airguns 2 X 150 in.^{3}	500 in.^{3}	2000 psi	9.8 ft / 3.0 m	15.4 bar @1m	237.7 dB re1μPa @1m

A ZVSP survey will be conducted at each well after total depth is reached. For each survey, Shell will deploy the sound source (airgun array) over the side of the drillship *Discoverer* with a crane (sound source will be 50-200 ft / 15-60 m from the drillship depending on crane location), to a depth of approximately 10-23 ft (3-7 m) below the water surface. The VSI with its four receivers will be temporarily anchored in the wellbore at depth (Figure 5). The sound source will be pressured up to 2,000 pounds per square inch (psi), and activated 5-7 times at approximately 20-second intervals. The VSI will then be moved to the next interval of the wellbore and re-anchored, after which the airgun array will again be activated 5-7 times. This process will be repeated until the entire well bore is surveyed in this manner. The interval between anchor points for the VSI will be approximately 200 ft (60 m) along the wellbore up to a depth of 1,440 ft, and 150 ft in the shallow portion of the wellbore. This would result in a total of about 216 activations of the airgun array. Each survey is expected to be conducted over a period of about 10-14 hours.

FIGURE 5. SCHEMATIC OF ZVSP

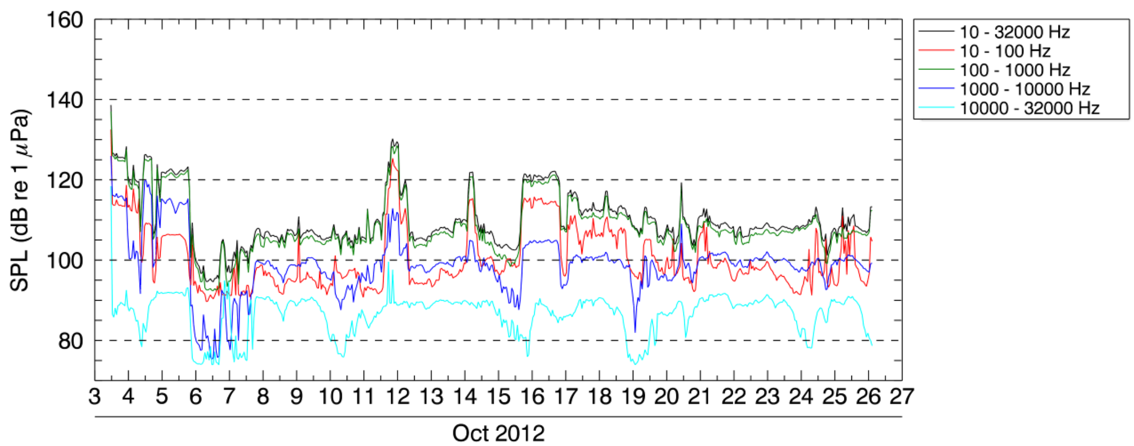


ZVSP sound verification measurements will be performed using either the AMARs, which are deployed for drillship sound characterizations, or by JASCO Ocean Bottom Hydrophone (OBH) recorders. The use of AMARs or OBHs depends on the specific timing these measurements will be required by NMFS; the AMARs will not be retrieved until several days after the ZVSP as they are intended to monitor during retrievals of drillship anchors. If the ZVSP acoustic measurements are required sooner, four OBH recorders would be deployed at the same locations and those could be retrieved immediately following the ZVSP measurement. Shell proposes that these measurements be performed using the AMARs as their data and measurement results will be available before any subsequent ZVSP operations. The ZVSP measurements can be delivered within 120 hours of retrieval and download of the data from either instrument type.

Acoustic Data Analyses

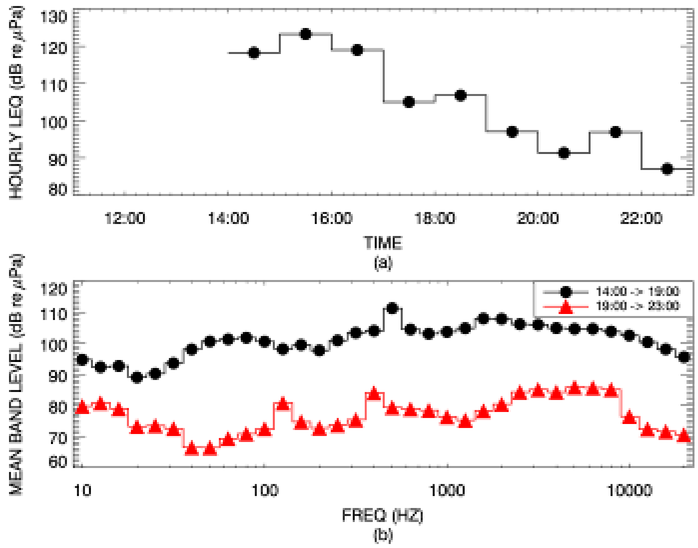
Exploration drilling sound data will be analyzed to extract a record of the frequency-dependent sound levels as a function of time. Figure 6 shows the results of this type of analysis. These results are useful also for correlating measured sound energy events with specific survey operations. The analysis provides absolute sound levels in finite frequency bands that can be tailored to match the highest-sensitivity hearing ranges for species of interest. For example, bowhead hearing is thought to be most acute in the 100 Hertz (Hz) – 1,000 Hz frequency range that corresponds with the green line in the upper plot of Figure 6.

FIGURE 6. EXAMPLE RESULT DISPLAY SHOWING SOUND LEVEL SPECTRAL ENERGY DISTRIBUTION BETWEEN SEVERAL DIFFERENT FREQUENCY BANDS



The analyses will also consider sound level integrated through 1-hour durations (referred to as sound energy equivalent level Leq (1-hour)). Figure 7 (upper) shows an example of a Leq analysis of hydrophone data. Similar graphs for long time periods will be generated as part of the data analysis performed for indicating exploration drilling sound variation with time in selected frequency bands.

FIGURE 7. UPPER: 1-HOUR LEQ LEVELS THAT WILL BE CALCULATED FROM ACOUSTIC MEASUREMENTS FOR USE IN CORRELATING WITH POSSIBLE BOWHEAD WHALE DEFLECTION DATA. LOWER: FREQUENCY BAND DISTRIBUTION OF SOUND ENERGY IN TWO DIFFERENT TIME PERIODS



Reporting of Results

Acoustic sound level results will be reported in the 90-day and comprehensive reports for this program. The results reported will include:

- sound source levels for the drillship and all exploration drilling support vessels;
- spectrogram and band level versus time plots computed from the continuous recordings obtained from the hydrophone systems;
- hourly Leq levels at the hydrophone locations; and
- correlation of exploration drilling source levels with the type of exploration drilling operation being performed. These results will be obtained by observing differences in exploration drilling sound associated with differences in the drill rig activity as indicated in detailed drillship logs

Acoustic "Net" Array in Chukchi Sea

Background and Objectives

This section describes acoustic studies that were undertaken from 2006 through 2013 in the Chukchi Sea as part of the Joint Monitoring Program and that will be continued by Shell during exploration drilling operations. The acoustic "net" array used during the 2006–2013 field seasons in the Chukchi Sea was designed to accomplish two main objectives. The first was to collect information on the occurrence and distribution of marine mammals (including beluga whale, bowhead whale, walrus and other species) that may be available to subsistence hunters near villages along the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns. The second objective was to measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sounds from industry and other activities further offshore in the Chukchi Sea.

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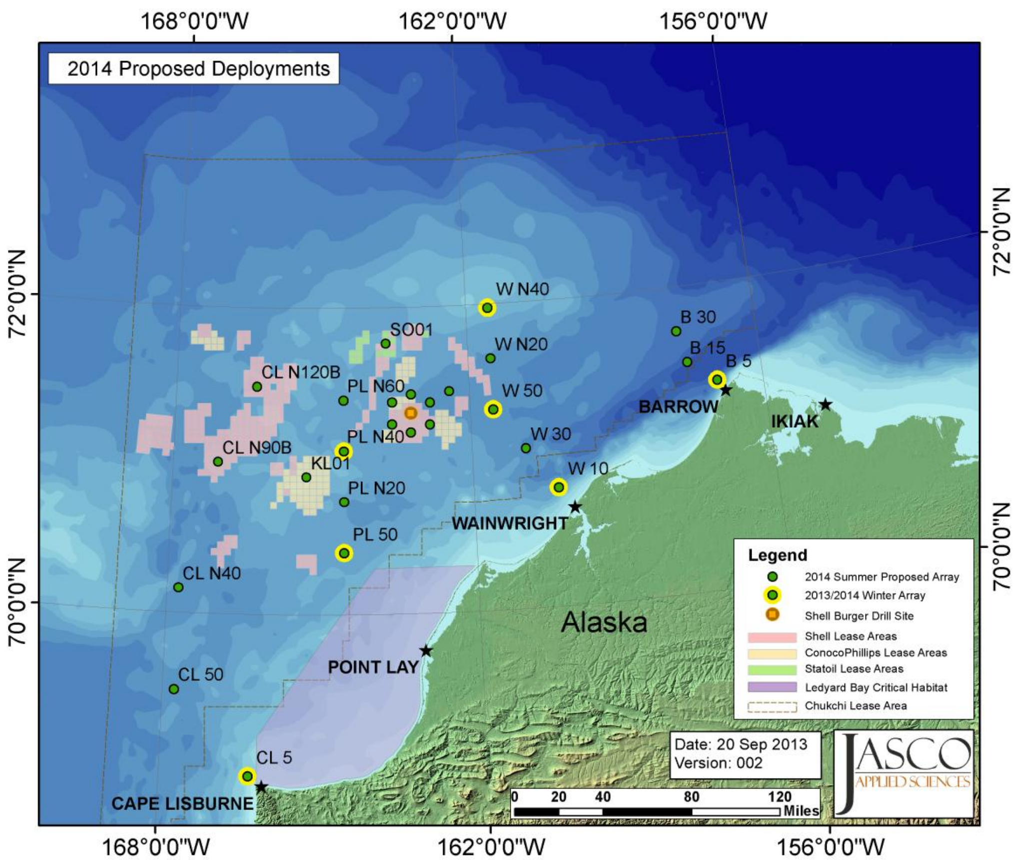
Technical Approach

A net array configuration similar to that deployed in 2007–2013 is again proposed. The basic components of this effort consist of autonomous acoustic recorders deployed widely across the US Chukchi Sea through the open water season and then winter season. These precisely calibrated systems will sample at 16 kHz with 24-bit resolution, and are capable of recording marine mammal sounds and making anthropogenic noise measurements. The net array configuration will include a regional array of 18 AMAR recorders deployed July-October off the four main transect locations: Cape Lisburne, Point Hope, Wainwright and Barrow as shown in Figure 8. Six additional summer AMAR recorders will be deployed in a hexagonal geometry at 16 km from the nominal drillship location at Burger-A to monitor directional variations of drilling-related sounds and to examine marine mammal vocalization patterns in vicinity of exploration drilling activities. One recorder will be placed 32 km northwest of Burger-A to monitor for drilling sound propagation toward the south side of Hanna Shoal, which acoustic and satellite tag monitoring has identified as frequented by walrus in August. Acoustic monitoring will continue through the winter with 7 AMAR recorders deployed October 2013 – August 2014 at the locations indicated in Figure 8. All of these offshore systems will capture exploration drilling sounds, where present, over large distances to help characterize the sound transmission properties in the Chukchi Sea. They will continue to provide a large amount of information related to marine mammal distributions in the Chukchi Sea.

FIGURE 8. PROPOSED OPEN WATER DEPLOYMENT LOCATIONS OF ACOUSTIC RECORDERS IN THE EASTERN CHUKCHI SEA, ALASKA



In early October, all of the regional recorders will be retrieved and the winter recorders will be deployed. The winter recorders will sample at 16 kHz on a 17% duty cycle (40 minutes every 4 hours). The winter recorders deployed in previous years have provided important information about bowhead, beluga, walrus and several seal species migrations in fall and spring.

Analysis and Reporting

The Chukchi acoustic net arrays will produce an extremely large dataset comprising several Terabytes of acoustic data. The analyses of these data require identification of marine mammal vocalizations. Because of the very large amount of data to be processed, the analysis methods will incorporate automated vocalization detection algorithms that have been developed over several years. While the hydrophones used in the net array are not directional, and therefore not capable of accurate localization of detections, the number of vocalizations detected on each of the sensors provides a measure of the relative spatial distribution of some marine mammal species, assuming that vocalization patterns are consistent within a species across the spatial and geographic distribution of the hydrophone array. These results therefore provide information such as timing of migrations and routes of migration for belugas and bowheads.

A second purpose of the Chukchi net array is to monitor the amplitude of exploration drilling sound propagation over a very large area. It is expected that sounds from drilling activities will be detectable on hydrophone systems within approximately 30 km of the drillship when ambient sound energy conditions are low. The drilling sound levels at recorder locations will be quantified and reported.

Analysis of all acoustic data will be prioritized to address the primary questions. The primary data analysis questions are to (a) determine when, where, and what species of animals are acoustically detected on each recorder (b) analyze data as a whole to determine offshore distributions as a function of time, (c) quantify spatial and temporal variability in the ambient sound energy, and (d) measure received levels of exploration drilling survey events and drillship activities. The detection data will be used to develop spatial and temporal animal detection distributions. Statistical analyses will be used to test for changes in animal detections and distributions as a function of different variables (e.g., time of day, season, environmental conditions, ambient sound energy, and drilling or vessel sound levels).

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CHUKCHI OFFSHORE AERIAL PHOTOGRAPHIC MONITORING PROGRAM

Shell has been reticent to conduct manned surveys in the offshore Chukchi Sea because conducting those surveys on a regular basis puts people at risk. There is a strong desire; however, to obtain data on marine mammal distribution in the offshore Chukchi Sea and Shell will conduct a photographic aerial survey that would put fewer people at risk as an alternative to the fully-manned aerial survey. The photographic survey would reduce the number of people on board the aircraft from six persons to two persons (the pilot and copilot) and would serve as a pilot study for future surveys that would use an Unmanned Aerial System (UAS) to capture the imagery. Successful surveys with only pilots and camera systems were conducted in 2012.

Aerial photographic surveys have been used to monitor distribution and estimate densities of marine mammals in offshore areas since the mid-1980s, and before that, were used to estimate numbers of animals in large concentration areas. For example, Koski and Davis (1980), Koski et al. (2002) and Richard et al. (1990) used aerial photography to provide more precise estimates of numbers of belugas in concentration areas during aerial surveys of Lancaster Sound and Hudson Bay, respectively. Later Richard et al. (1994), Witting et al. (2005) and Heide-Jørgensen et al. (2010) used aerial photography to estimate numbers and densities of narwhals and minke whales in their survey areas.

Digital photographs provide many advantages over observations made by people if the imagery has sufficient resolution (Koski et al. 2013). With photographs there is constant detectability across the imagery, whereas observations by people decline with distance from the center line of the survey area. Observations at the outer limits of the transect can decline to 5-10% of the animals present. The distance from the trackline of sightings is more accurately determined from photographs; group size can be more accurately determined; and sizes of animals can be measured, and hence much more accurately determined, in photographs. As a result of the latter capability, the presence or absence of a calf can be more accurately determined from a photograph than by in-the-moment visual observations. Another benefit of photographs over visual observations is that photographs can be reviewed by more than one independent observer allowing quantification of detection, identification and group size biases.

During the 2012 field season Shell successfully conducted photographic surveys using two Nikon D800 cameras mounted in a Twin Otter to record marine mammals around their drill sites in the Chukchi Sea. In addition, a HD video camera was tested and compared to the still camera for evaluation as a tool for real-time monitoring during future studies. Shell plans to use a DA42 or similar aircraft, made by Diamond Aircraft, with similar Nikon cameras mounted in the airplane. If there is enough room Shell may also mount a third DSLR camera with a longer lens. The longer lens will help Shell understand if it is missing seals that could be detected with the longer lens.

The photographic survey provides imagery that can be used to evaluate the ability of future studies to use the same image capturing systems in an UAS where people would not be put at risk. Although the two platforms are not the same, the slower airspeed and potentially lower flight altitude of the UAS would mean that the data quality would be better from the UAS. Comparisons are currently being made between data collected by human observers on board both the Chukchi and Beaufort aerial survey aircraft and the digital imagery collected in 2012.

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Camera Specifications

The cameras that Shell will use are Nikon D800s, which are 36.3 megapixel cameras that store imagery in 7,360×4,912 pixel arrays. The aircraft will be flown at 1,000 or 1,500 ft above sea level and the cameras will be triggered to provide 50% overlap with adjacent photos and 100% overlap among all imagery. Actual trigger timing will depend on the survey speed and altitude of the aircraft but would be about every three (when at 1000 ft) or five seconds (when at 1500 ft), The cameras will have 20 mm lenses, which will each cover a swath ~720 or ~1000 m on the water surface with one pixel representing a 6-9 cm square at the water surface on the trackline and about 31 or 46 cm at the outer edge of the frame. The cameras will be mounted such that one DSLR points 25° to the right and one 25° to the left side of the trackline, with the inner edge of both cameras' field of view overlapping about 67 or 100 m on either side of the centerline. These pixel sizes on the trackline are one seventeenth or one eighth of the pixel size (25 cm square) tested by Koski et al. (2009) during their tests with a video camera for detection of kayaks and is a smaller pixel size (better resolution) on the trackline than was tested by Amanda Hodgson (16.8 cm) during her surveys of humpback whales off Australia and which proved adequate for counting humpback whales in their imagery.

This camera configuration was used successfully in 2012 during surveys at both 1,000 and 1,500 ft and the resolution permitted detection and identification of all medium and large cetaceans seen by PSOs on the manned aircraft. Further, it also permitted counting of walrus/bearded seals (Koski et al 2013). The resolution does not always permit differentiation of bearded seals from walrus, especially when they are in the water. This imagery resolution provides slightly better ability for determining species and detecting animals than people would have in an aircraft flying at 1,000 feet above sea level and more pinnipeds were sighted during the review of the imagery than PSOs saw in the same swath during the survey.

Route planning and data storage software are off-the-shelf products. The set up includes a harness to connect the camera and GPS to the Photo Coupler Controller which is connected to a GPS for triggering capture of images and recording of metadata for each image (Figure 9). The system can be powered by 10-32 volt DC or a custom power source and has a back-up battery power source to prevent interruption to data capture. Acquisition of imagery can be controlled from a laptop and/or preprogrammed route plan and there is live view of what the sensors are viewing on the water surface.

The system is "plug-and-play" and does not require input from persons on board the aircraft during the flight. The system can be pre-programmed to take photographs starting and stopping at predetermined locations or times. A laptop computer in the cockpit can be used to override the preprogrammed instructions and take additional images whenever desired.

Survey Timing and Frequency

Photographic surveys would start as soon as the ice management, anchor handler and drillship are at or near the first drill site and operable Shell Search and Rescue (SAR) assets are in-place. Surveys would continue throughout the drilling period and until the drilling related vessels have left the exploration drilling area. Since the current plans are for vessels to enter the Chukchi Sea about 1 July, surveys would be initiated on about 3 July. This start date differs from past practices of beginning five days prior to initiation of an activity and continuing until five days after cessation of the activity because the presence of vessels with helidecks in the area where overflights will occur, plus operable Shell SAR assets are the main mitigations that will allow for safe operation of the overflight program this far offshore. The surveys will be based out of Barrow and the same aircraft will conduct the offshore surveys around the drillship and the coastal saw-tooth pattern. Surveys of the offshore area around the drillship will take precedence

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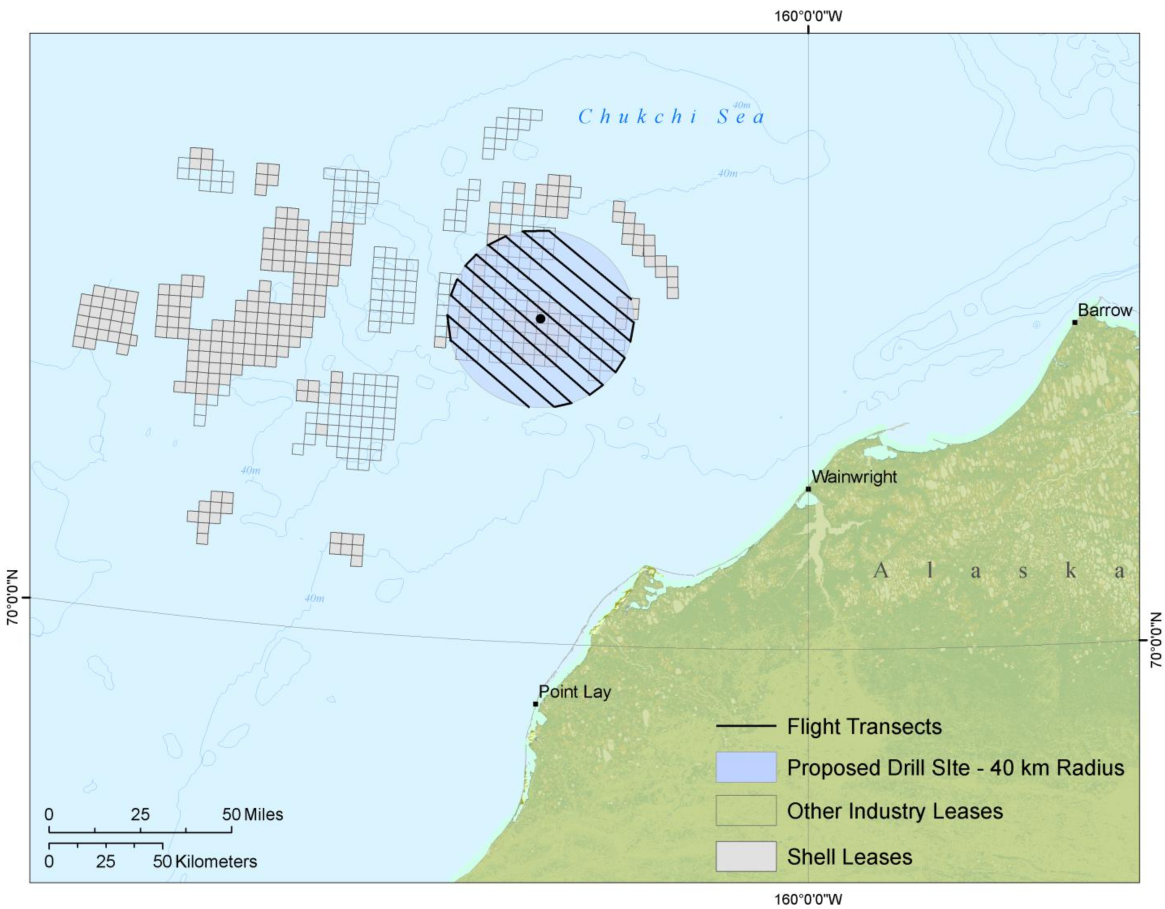
over the sawtooth survey, but if weather does not permit surveying offshore, the nearshore survey will be conducted if weather permits.

Survey Pattern

The survey grid covers a circular area with a radius 40 km around the drillship as shown in Figure 9. Transects will be spaced 7.2 km apart which will allow even coverage of the survey area during a single flight if weather conditions permit completion of a survey. A random starting point will be selected for each survey and the evenly spaced lines will be shifted NE or SW along the perimeter of the circular survey area based on the start point. The total length of survey lines will be about 1,200 km and the exact length will depend on the location of the randomly selected start point.

FIGURE 9. AERIAL PHOTOGRAPHIC SURVEY DESIGN FOR THE CHUKCHI SEA DRILL SITES. THIS DESIGN MAXIMIZES THE AREA COVERED IN A SINGLE FLIGHT AND ASSUMES 7.2 KM BETWEEN TRANSECT LINES



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Data Analyses

Following each survey, the imagery will be backed up on a second hard drive and stored at accommodations in Barrow until it can be transferred to Anchorage. In Anchorage a team of trained photo analysts will review the photographs from the surveys and collect appropriate data. Programs to assist in the finding and identification of marine mammals in the imagery may not be available for the field season, but imagery obtained will be used to help develop those programs for future studies.

Other Imagery and Sensors

In addition to the imagery indicated above, Shell is examining systems that are in development that would allow collection of additional imagery. They include collection of multi-spectral/hyper-spectral imagery and a multi-camera system that would allow collection of imagery over a wider area. If these systems are ready for testing, Shell will consider incorporating these systems into the Chukchi Sea program.

CHUKCHI SEA COASTAL AERIAL SURVEY

Nearshore aerial surveys of marine mammals in the Chukchi Sea were conducted over coastal areas to approximately 23 mi (37 km) offshore in 2006–2008 and in 2010 in support of Shell's summer seismic exploration activities. In 2012 these surveys were flown when it was not possible to fly the photographic transects out over the Burger well site due to weather or rescue craft availability. These surveys provided data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. Shell plans to conduct these nearshore aerial surveys in the Chukchi Sea as opportunities unfold and those surveys will be similar to the previous programs but utilizing image recorders in lieu of PSOs for collection of data. . As noted above, the first priority will be to conduct photographic surveys around the offshore exploration drilling activities, but nearshore surveys will be conducted whenever weather does not permit flying offshore. As in past years, surveys in the southern part of the nearshore survey area will depend on the end of the beluga hunt near Point Lay. In past years, Point Lay has requested that aerial surveys not be conducted until after the beluga hunt has ended and so the start of surveys has been delayed until mid-July.

Alaskan Natives from villages along the east coast of the Chukchi Sea hunt marine mammals during the summer and Native communities are concerned that offshore oil and gas exploration activities may negatively impact their ability to harvest marine mammals. Of particular concern are potential impacts on the beluga harvest at Point Lay and on future bowhead harvests at Point Hope, Point Lay, Wainwright and Barrow. Other species of concern in the Chukchi Sea include the gray whale, bearded, ringed, and spotted seals, and walrus. Gray whale and harbor porpoise are expected to be the most numerous cetacean species encountered during the proposed aerial surveys, although harbor porpoise are difficult to detect from aircraft. Beluga whales may occur in high numbers early in the season. The ringed seal is likely to be the most abundant pinniped species. The current aerial survey program will be designed to collect distribution data on cetaceans but will be limited in its ability to collect similar data on pinnipeds and harbor porpoises because they are not reliably detectable during review of the collected images.

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Objectives

The aerial survey program objectives will be:

- to collect data on the distribution and abundance of marine mammals in coastal areas of the eastern Chukchi Sea;
- 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; and
- to collect marine mammal sighting data using digital media

Survey Procedures

Transects will be flown in a saw-toothed pattern between the shore and 23 mi (37 km) offshore as well as along the coast from Point Barrow to Point Hope (Figure 10). This design will permit completion of the survey in one to two days and will provide representative coverage of the nearshore region. Sawtooth 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. As with past surveys of the Chukchi Sea coast, coordination with coastal villages to avoid disturbance of the beluga whale subsistence hunt will be extremely important. "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.

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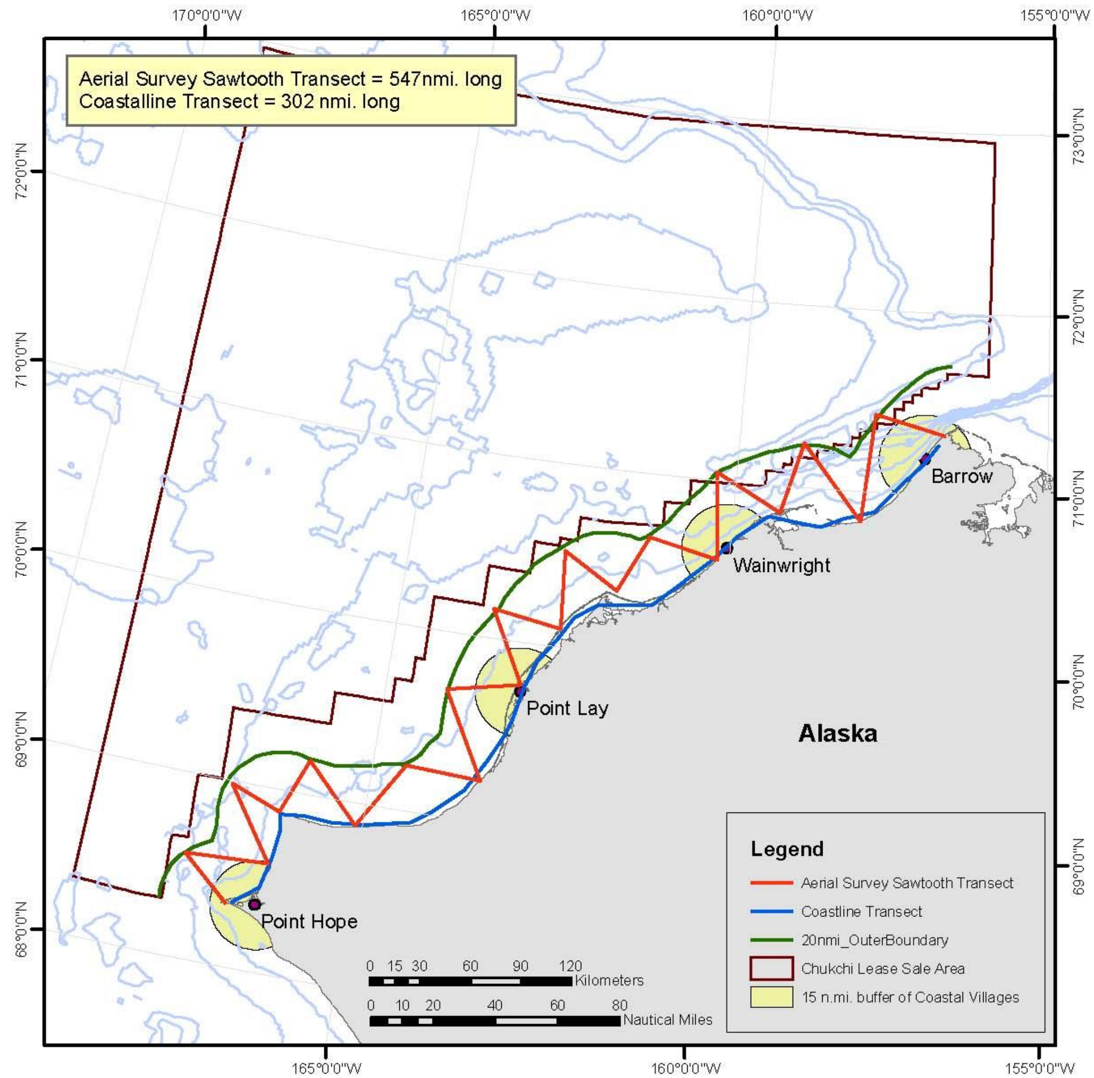
FIGURE 10. AERIAL SURVEY TRANSECTS LOCATION AND GENERAL PATTERN FOR THE EASTERN CHUKCHI SEA. SPECIFIC TRANSECT START-/END-POINTS WILL BE ALTERED RANDOMLY FROM SURVEY TO SURVEY, AND HUNTING AREAS WILL BE AVOIDED WHEN HUNTING IS OCCURRING.



Standard aerial survey procedures used in previous marine mammal projects (by Shell as well as by others) will be followed. This will facilitate comparisons and (as appropriate) pooling with other data, and will minimize controversy about the chosen survey procedures. The aircraft will be flown at 110–120 knots ground speed and usually at an altitude of 1,000 ft (305 m). In accordance with anticipated stipulations in the LOA, survey aircraft will be flown at 1,500 ft (457 m) over the LBCHU. Aerial surveys at an altitude of 1,000 ft (305 m) do not provide much information about seals but are suitable for bowhead, beluga, and gray whales. The need for a 1,000+ ft (305+ m) or 1,500+ ft (454+ m) cloud ceiling will limit the dates and times when surveys can be flown. Selection of a higher altitude for surveys would result in a significant reduction in the number of days during which surveys would be possible, impairing the ability of the aerial program to meet its objectives.

The surveyed area will include waters where belugas are normally available to subsistence hunters. If large concentrations of belugas are encountered during the survey, the aircraft will climb to ~10,000 ft (3,050 m) altitude to avoid disturbing the whales and cause them to leave the area. If whales are in offshore areas, the aircraft will climb high enough to include all whales within a single photograph; typically about 3,000 ft (914 m) altitude. When in shallow water, belugas and other marine mammals are more sensitive to aircraft over flights and other forms of disturbance than when they are offshore (see Richardson et al. 1995 for a review). They frequently leave shallow estuaries when over flown at altitudes of 2,000–3,000 ft (610-904 m), whereas they rarely react to aircraft at 1,500 ft (457 m) when offshore in deeper water. Additionally, if large groups of other marine mammals are encountered on the surveys, such as the large aggregations of walruses seen in 2007 and 2010, Shell will attempt to photograph the animals and provide location information to interested stakeholders.

Coordination with Other Aerial Surveys

The BOEM, the NMFS, the USFWS, the NSB, or other organizations may also conduct aerial surveys in the Chukchi Sea during the exploration drilling season. Shell will consult with any groups or organizations conducting aerial surveys along the eastern Chukchi Sea coast regarding coordination during the exploration drilling season. The objectives will be:

- to ensure aircraft separation when both crews conduct surveys in the same general region;
- to coordinate the aerial survey projects in order to maximize consistency and minimize duplication; and
- to maximize consistency with previous years' efforts insofar as feasible

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Chukchi Sea, Alaska Marine Mammal Monitoring and Mitigation Plan

Appendix E

Application for U.S. Fish & Wildlife Service Letter of Authorization

(To be revised and submitted to BOEM at a later date)

Appendix F

Environmental Impact Analysis (EIA)

Environmental Impact Assessment
Revision 2

Exploration Plan, Chukchi Sea, Alaska

Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915

Chukchi Sea Lease Sale 193

Revision 1 (May 2011)
Revision 2 (November 2013)

Submitted to:

U.S. Department of the Interior
Bureau of Ocean Energy Management
Alaska OCS Region

Submitted by:

Shell Gulf of Mexico Inc.
3601 C Street, Suite 1000
Anchorage, AK 99503

Appendix F (Environmental Impact Analysis [EIA]) of Chukchi Sea EP Revision 2 (EP Revision 2) is structured differently than the EIA of approved EP Revision 1. In accordance with 30 CFR § 550.285(b), Shell limited EP Revision 2 to only the changes or information affected by the changes. As a result, Shell organized the EIA of EP Revision 2 toward only those changes, or information affected by those changes to the Chukchi Sea exploration drilling program.

Table of Contents (Updates Only)

<u>List of Attachments</u>

List of Tables (Updates Only)

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ACRONYMS & ABBREVIATIONS

4MP	Marine Mammal Monitoring and Mitigation Plan
AAAQS	Alaska Ambient Air Quality Standards
ACMP	Alaska Coastal Management Program
ACS	Arctic Containment System
ADF&G	Alaska Department of Fish & Game
AEWC	Alaska Eskimo Whaling Commission
AIS	Automatic Identification System
APDES	Alaska Pollutant Discharge Elimination System
Approved EP	Shell's Approved Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2009a)
AQCR	Air Quality Control Region
AQRP	Air Quality Regulatory Program
ASAMM	Aerial Surveys of Arctic Marine Mammals
ATV	all terrain vehicle
BACT	best available control technology
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
BO	Biological Opinion
BOD	biological oxygen demand
BOP	blowout preventer
BSEE	Bureau of Safety and Environmental Enforcement
BWASP	Bowhead Whale Aerial Survey Project
CAA	Clean Air Act
CDPF	catalytic diesel particulate filter
CFR	Code of Federal Regulations
CO	carbon monoxide
CO2	carbon dioxide
COD	chemical oxygen demand
Com Center	Communications Center
COMIDA CAB	Chukchi Sea Offshore Monitoring in Drilling Area: Chemical and Benthos
COTPZ	Captain of the Port Zone
CSESP	Chukchi Sea Environmental Studies Program
CWA	Clean Water Act
DP	dynamic positioning
DPS	distinct population segment
EA	Environmental Assessment
EFH	Essential Fish Habitat
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Analysis for Shell's Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2011b)
EIS	Environmental Impact Statement
EMP	Environmental Monitoring Program

EP Revision 1	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2011a)
EP Revision 2	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (Shell 2013a)
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FONSI	Findings of No Significant Impact
GHGs	greenhouse gas emissions
HAPs	hazardous air pollutants
HSWUA	Hanna Shoal Walrus Use Area
IHA	Incidental Harassment Authorization
ITRs	incidental take regulations
LBCHU	Ledyard Bay Critical Habitat Unit
LC_{50}	lethal concentration 50
LOA	Letter of Authorization
MARPOL	International Convention for the Prevention of Pollution from Ships
MAWP	maximum allowable working pressure
MLC	mudline cellar
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MSA	Magnuson-Stevens Fishery Conservation Act
MSD	Marine Sanitation Device
NAAQS	National Ambient Air Quality Standards
NAD 83	North American Datum 1983
NWR	National Wildlife Refuge
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxide
NPFMC	North Pacific Fishery Management Council
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NSB	North Slope Borough
OCS	Outer Continental Shelf
OOC	Offshore Operators Committee
OSR	Oil Spill Response
OSRP	Oil Spill Response Plan
OST	oil storage tanker
OSV	offshore supply vessel
OxyCat	oxidation catalysts
Pb	lead
$PM_{2.5}$	particulate matter < 2.5 micrometers
PM_{10}	particulate matter < 10 micrometers

POC	Plan of Cooperation
PSD	Prevention of Significant Deterioration
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
RIPS	Rotor Ice Prevention System
RKB	Rotor Kelly Bushing
ROV	Remotely Operated Vehicle
RS/FO	Regional Supervisor/Field Operations
SA	Subsistence Advisor
SAR	Search And Rescue
SCR	Selective Catalytic Reduction
SEIS	Supplemental Environmental Impact Statement
Shell	Shell Gulf of Mexico Inc
SIWAC	Shell Ice and Weather Advisory Center
TCP	Traditional Cultural Property
TD	Total Depth
TK	Traditional Knowledge
TTS	Temporary Threshold Shift
TSS	Total Suspended Solids
USCG	U.S. Coast Guard
UD	Utilization Distribution
USFWS	U.S. Fish and Wildlife Service
ULSD	Ultra Low Sulfur Diesel
VGP	Vessel General Permit (EPA NPDES)
VOC	Volatile Organic Compound
WBM	Water Based Mud
WCD	Worst Case Discharge
WRF	Weather Research and Forecasting
ZVSP	Zero-offset Vertical Seismic Profile

UNITS OF MEASURE

µ	micrometer
µPa	micro-Pascal
ac	acre
bbl	barrel (petroleum)
cm	centimeter
dB	decibel
ft	foot
ft^2	square foot
ft^3	cubic foot
g	gram(s)
ha	hectare
hr	hour
Hz	hertz
in	inch
kHz	kilohertz
km	kilometer
km^2	square kilometer
kW-hr	kilowatt per hour
m	meter
m^2	square meter
m^3	cubic meter
mg	milligram(s)
mi	statute mile
mi^2	square mile (statute)
min	minute
ml	milliliter
mm	millimeter
nmi	nautical mile
ppb	parts per billion
ppm	parts per million
sec	second

PREFACE

This Environmental Impact Analysis (EIA) accompanies Shell Gulf of Mexico Inc.'s (Shell) November 2013 *Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska* for Burger Prospect: Posey Area Blocks 6714, 6762, 6764, 6812, 6912, 6915 (EP Revision 2).[1] This EIA is prepared pursuant to the requirements of the Outer Continental Shelf Lands Act (OCSLA), 43 U.S.C. §§ 1331-1356, and the regulations of BOEM, including 30 C.F.R. §§ 550.212(o) and 550.227. This EIA is a project- and site-specific analysis focusing specifically on the differences between Shell's activities as described in EP Revision 1 and approved by BOEM on December 15, 2011, and the proposed revisions to operations set forth in EP Revision 2.

This EIA provides a description of the changes to Shell's activities as set forth in EP Revision 2. It identifies and describes the resources and conditions of the project area and assesses the potential environmental impacts on those resources and conditions of the revised activities, focusing on the differences between the approved EP Revision 1 and this EP Revision 2 and the environmental impacts associated with those differences. It further identifies and describes the existing and revised mitigation measures that Shell will implement in connection with the planned activities. The EIA presents data, analysis, and conclusions to assist BOEM in complying with the National Environmental Policy Act (NEPA), and other relevant federal laws, including the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), and the Clean Air Act (CAA) as the agency considers EP Revision 2 for approval.

Shell's plan, as detailed in EP Revision 2, is to use the same single drillship, the Motor Vessel (M/V) *Frontier Discoverer* (*Discoverer*), to complete exploration drilling activities offshore in the Chukchi Sea, Alaska at the same six well locations on the same six leases (one well per lease) identified in EP Revision 1. The drill sites are over 64 miles (mi) offshore in Arctic waters that are inaccessible for eight months or more of the year due to pack ice. They are remote from any infrastructure, and Shell's proposed exploration is the only offshore exploration drilling program anticipated to take place on federal outer continental shelf (OCS) lands. Shell plans to continue to conduct exploration drilling operations during successive open water seasons, beginning on or about July 4 until approximately October 31 in each drilling season.

<u>Shell's Arctic Experience</u>

Shell, through its parent and affiliate corporations, has substantial experience exploring for oil and gas in Arctic environments, including the Beaufort and Chukchi Seas. Beginning almost 50 years ago, various Shell Oil Company (Shell) subsidiaries operated continuously in Alaska until 1998. Shell was one of the most prominent explorers in all of the frontier offshore basins of Alaska, as well as being an operator and major producer in Cook Inlet. During the 1980s, Shell either operated or was a partner in nine exploration wells drilled offshore in the Beaufort Sea. During the late-1980s through the early-1990s, Shell also drilled four exploration wells in the Chukchi Sea and participated in a fifth exploration well.

In 2012, under Shell's approved EPs in the Beaufort and Chukchi Seas, Shell drilled a top hole with the *Discoverer* at the Burger A Prospect in the Chukchi Sea and another top hole with the *Kulluk* at the Sivulliq Prospect in the Beaufort Sea. Shell's Burger A well was drilled to a measured depth of 1505 ft

[1] Shell's initial Chukchi Sea Exploration Plan was submitted in 2009 and approved by the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) in 2010 ("Approved EP"). In May 2011, Shell submitted a revised Chukchi Sea Exploration Plan, which was approved by the Bureau of Ocean Energy Management (BOEM) in December 2011. For purposes of this submittal, Shell refers to the 2011 approved EP as "EP Revision 1." Shell's November 2013 Revised Chukchi Sea Exploration Plan ("EP Revision 2") proposes limited changes to EP Revision 1. This EIA provides an analysis of Shell's exploration drilling program as described in EP Revision 2.

rotary kelly bushing (RKB) and was temporarily abandoned according to the Bureau of Safety and Environmental Enforcement (BSEE) regulations at 30 C.F.R. §§ 250.1721-1723. In support of its 2012 drilling, Shell deployed numerous assets, rotated thousands of employees to the Arctic, and demonstrated its ability to respond quickly and effectively to changing ice conditions in the Arctic. This activity marked industry's return to offshore drilling in the Alaskan Arctic after more than a decade. Shell's 2012 exploration drilling operations in the Arctic were conducted safely, and with no serious injuries or environmental impact.

Project Description and Changes from Approved EP Revision 1

Shell's EP Revision 2 proposes exploration drilling activities over several seasons, on the same six lease blocks and same locations within the Burger Prospect (i.e., Burger A, F, J, R, S, and V) included in Shell's EP Revision 1. There is a long history of safe, environmentally sound exploration drilling activity in the Chukchi Sea. Five wells were drilled in the Chukchi Sea between 1989 and 1991 (Figure 1.2-1 in EP Revision 1), and Shell safely drilled a top hole in Burger A in 2012. These historic wells include the Burger #1 well drilled within the same prospect as Shell's planned wells.

Shell will complete all six exploration wells using the *Discoverer.* The *Discoverer* is ice-strengthened for operating in Arctic OCS waters. The *Discoverer* includes state-of-the-art drilling and well control equipment, as well as accommodations for a crew of up to 140 persons. The *Discoverer* will be supported by additional vessels for ice management, anchor handling, and crew transport and supplies, as well as oil spill response vessels and barges staged near the drilling vessel, with a full complement of crew and oil spill response equipment. Additional vessels will implement Shell's marine mammal monitoring and mitigation plan and support scientific research efforts. All support vessels will be equipped for operating in Arctic waters.

Changes to Vessels and Travel Routes and Aircraft and Flights

One change between EP Revision 1 and EP Revision 2 is the use of additional support vessels and oil spill response equipment for Shell's exploration drilling program in the Chukchi Sea. These adjustments have been made in direct response to Shell's experiences in the 2012 season. Additional vessels will be used occasionally to support exploration drilling activities in the Chukchi Sea (e.g., ice management, anchor handling, offshore supply, and oil spill response augmentation) and are therefore included in EP Revision 2 and analyzed in this EIA.

EP Revision 2 also allows for adding another helicopter for crew change operations, shuttling helicopters between Barrow and Deadhorse shorebases, and increasing the number of helicopter round trip flights between shorebases and the prospect. These changes respond to the weather conditions experienced by Shell in the 2012 operations, which restricted the periods during which helicopter flights for crew changes could be carried out. Similar conditions are expected in future years; therefore Shell plans to increase helicopter flight frequency to accommodate crew changes associated with all vessels. Table P-1 provides a summary of the changes in the vessels and aircraft support.

Table P-1 Comparison of the Exploration Drilling Program Under Approved EP Revision 1 and EP Revision 2

Parameter	Approved EP Revision 1 (Exploration Drilling Started 2012)	EP Revision 2 (November 2013) (Drilling In Subsequent Seasons)
Support Vessels	• Ice Management vessel • Anchor handler • 2 Offshore Supply Vessels (OSV) • Shallow water landing craft • Oil spill response vessel • Oil spill response tug and barge • Oil spill tanker for recovered liquids • Oil spill containment tug/barge • Oil spill containment Anchor handler	***Added vessels:*** • Resupply tug and barge • Resupply OSV • Support tug • Science vessel for discharge monitoring • Ice Management vessel • Anchor Handler vessel • OSR tug and barge for nearshore response ***Changes in current vessels:*** • Increase the size of the current 2 OSVs
Aircraft	• S-92 or EC225 for crew change • S-61, S92 or EC225 for search and rescue	• Additional S-92 Helicopter (or similar) for crew change

There have also been some changes in the designated location of the some of the vessels and the frequency of their use. Further information regarding the location and specifications of these vessels and aircraft is provided in Sections 2.1 and 2.2 of this EIA and in Section 13 (Support Vessels and Aircraft Information) of EP Revision 2.

Changes to Drilling Protocols

Each drill site has been surveyed by Shell and determined not to contain any shallow hazards or archeological and historical resources that would be impacted by Shell's proposed drilling. Shell plans to pre-set anchors at one or more drill site(s) in advance of the drillship arriving. Once the drilling vessel is mobilized to a drill site and securely anchored to the seafloor, exploration drilling operations will commence. Each of the planned Burger wells will take approximately 32 days to construct a mudline cellar (MLC) and drill to total depth (TD). EP Revision 2 includes re-entering Burger A, which was started during the 2012 drilling season and temporarily abandoned per 30 C.F.R. §§ 250.1721-1723, and drilling it to total permitted depth.

It is anticipated that the work included in EP Revision 2 will take place over multiple drilling seasons. Depending on a variety of factors in a given drilling season, including ice, weather conditions, the length of the open water season, and operational conditions, Shell may drill an approved well to TD or limit operations on such well to constructing MLCs and/or upper hole segments (*i.e.*, "partial well" or "top hole"). Any well where drilling is suspended would be secured in compliance with BSEE regulations and with the approval of the Regional Supervisor/Field Operations (RS/FO), whether permanently abandoned (30 CFR 250.1710 through 1717) or temporarily abandoned (30 CFR 250.1721-1723). All wells will be permanently plugged and abandoned in accordance with BSEE requirements upon completion of drilling. No oil or gas will be produced from the wells, and no pipelines or other permanent facilities will be built.

EP Revision 2 also includes changes to drilling fluids and wastes. Specifically, Shell adds a number of drilling fluid components to the drilling fluids plan; increases its estimates of drilling waste volumes; and alters the discharge method for drilling wastes from the MLC and upper well sections (top hole). These changes are a direct result of lessons learned from Shell's 2012 operations. The details on drilling fluids and wastes are discussed below in Section 2.4.

Changes to Support Facilities

Shell will expand its existing man-camp in Barrow by adding up to 125 beds and a kitchen car, and utilize a larger (55-person) man camp in Wainwright through contractor Olgoonik. The camp in Barrow may also be moved to a new location. These changes are being implemented to accommodate crews from the additional support vessels, and lessen any real or perceived impact that persons in crew-change status may impact Barrow. Crew change personnel may require shelter on occasions when flights in and out of Barrow are restricted by weather and flying conditions. Additional information on the construction of these facilities and their maintenance (*e.g.*, electricity, water, sewage) is provided in Section 2.3 below.

Permits and Authorizations

All operations will comply with applicable federal, state and local laws, regulations, and lease and permit requirements. Shell will have trained personnel and monitoring programs in place to ensure such compliance. In addition, BOEM and other federal regulatory agencies will maintain continuing oversight of all of Shell's exploration activities, and BOEM and BSEE retain the specific authority to require additional mitigation, as appropriate to respond to actual conditions encountered.

The following are among the permits and authorizations governing Shell's activities, which collectively impose mandatory requirements to ensure safety, protect the environment, avoid interference with subsistence resources and activities, and mitigate any potential adverse impacts. The current status of each permit is also noted.

- Applications for Permit to Drill (APD) from BSEE for each proposed well. *Burger drill sites A, J, and V received authorizations in 2012 to drill to the base of the 20 inch casing. APDs for these prospects require revision following EP Revision 2 approval to allow for drilling to total depth; APDs for the Burger drill sites F, R and S are still pending.*
- National Pollutant Discharge Elimination System Permit (NPDES) under the Clean Water Act (CWA) from the U.S. Environmental Protection Agency (EPA), imposing strict limits on the permissible discharges to the Chukchi Sea. *Shell will submit notices of intent (NOIs) for discharge at Burger drill sites to EPA after EP Revision 2 is "deemed submitted" by BOEM; authorizations will be secured prior to the start of exploration drilling.*
- Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS), prohibiting the intentional taking of marine mammals (all species of whales and seals) and regulating the incidental non-lethal harassment of protected species. *Shell will request authorization after EP Revision 2 is "deemed submitted" by BOEM; authorizations will be secured prior to the start of exploration drilling.*
- Letter of Authorization (LOA) from the U.S. Fish and Wildlife Service (USFWS), prohibiting the intentional taking of marine mammals (polar bear and Pacific walrus) and regulating the incidental non-lethal harassment of protected species. *Shell will request authorization after EP Revision 2 is "deemed submitted" by BOEM; authorizations will be secured prior to the start of exploration drilling.*
- Nationwide Permit No. 8 under the Rivers and Harbors Act from the U.S. Army Corps of Engineers (USACE), regulating the location and installation of the *Discoverer* on the seafloor. *Requests for these permits for Burger A, F, J, R., S, and V drill sites were submitted on December 13, 2012 and approved on January 28, 2013. The approvals are valid through January 28, 2015.*

Mandatory and Voluntary Mitigation Measures

Shell must also implement mandatory mitigation measures and safety programs. The mitigation measures Shell will continue to employ were developed over several years of Arctic exploration activities, in consultation with Alaska Native stakeholders, and have been proven effective in minimizing impacts to the environment, subsistence resources, and Alaska Native subsistence activities. Shell's measures were effective in the 2012 season to protect this important resource, and therefore remain fundamentally the same as they were in the 2012 season.

Shell successfully implemented mandatory mitigation measures in the 2012 open water season, and plans to continue them in EP Revision 2, with some adjustments based on new legal requirements and feasibility. Changes in Shell's mandatory mitigation measures for EP Revision 2 include:

- Bird Strike Avoidance and Lighting Plan. *The process and procedures in this Plan were successfully implemented during the Chukchi exploration drilling program in 2012 and will be continued for EP Revision 2, with one minor change. Shell will not be able to continue with the use of the ClearSky lighting technology as a mitigation measure. These lights are no longer available. In compliance with the Chukchi Sea 193 Lease Sale Stipulation No. 7, (see EP Revision 2 Section 11) lighting on the drillship will be shaded to minimize the disorientation and attraction of birds to the lighted drillship in order to reduce the possibility of a bird collision. Due to this minor change, a revised Bird Strike Avoidance and Lighting Plan can be found in Appendix I to the EP Revision 2.*

Polar Bear and Pacific Walrus Authorizations for Incidental and Intentional Harassment

Shell will apply for LOAs for incidental and intentional harassment of polar bears and Pacific walrus which will detail mitigation measures required for avoidance of impacts to species or subsistence activities. Shell will adopt mitigation measures from prior LOAs plus the renewed Chukchi Sea incidental take regulations (ITRs – 2013-2018) directly into the mitigation measures for exploration drilling (EP Revision 2 Section 12):

- Vessels will not operate within 1 mi (1.6 km) of walrus when observed on land.
- Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land.
- If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid flying within 0.5 mi (805 m) of known walrus or polar bear concentrations.

Shell's EP Revision 1 also adopted a number of voluntary mitigation measures, such as a Communications Plan to coordinate activities with subsistence users, employment of local Subsistence Advisors, and voluntary limitations on aircraft and vessel routes and travel. Shell plans minor changes to the voluntary mitigation measures it undertook in the 2012 open water season; however, Shell plans to continue the vast majority in EP Revision 1. The proposed changes are the result of lessons learned in the 2012 open water season and feasibility. The planned changes are indicated below, along with the reasons for the change.

- Shell will not recycle drilling fluids from one drill site to the next. *Spent drilling fluids will be discharged after each well is drilled to TD because of space restrictions on the drillship and the need for multiple drilling fluid types.*
- Drilling mud (fluid) will not be cooled. *This measure was removed as no permafrost has been observed in shallow hazards surveys or during drilling in 2012.*
- Shell's blowout prevention program will involve changing the BOP systems test frequency from once every 7 days to once every 14 days. *This change is consistent with 30 CFR 250.447(b), which requires a BOP system test before 14 days have elapsed since the last pressure test.*

- The Arctic Containment System (ACS) and the nearshore response tug and barge will be located in or near Goodhope Bay, Kotzebue Sound. *Positioning the ACS in or near Goodhope Bay, Kotzebue Sound yields a response time to a well control incident at the Burger Prospect that is consistent with the time for the previously stated location for the ACS in EP Revision 1.*
- Certain engines on *Discoverer* will be Tier-rated. *This change will reduce CO, VOCs, and hazardous air pollutants (HAPs).*
- Shell developed an *Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses,* in April 2012 which depicts a process and procedures for engagement with USFWS biologists during ice management where the potential exists for the presence of Pacific walruses. The process and procedures were implemented during Shell's Chukchi exploration drilling in 2012 and will be adopted for EP Revision 2 (Appendix P). This document was submitted to the USFWS following promulgation of the current Chukchi Sea ITRs for polar bears and Pacific walrus. *This adaptive approach will further mitigate the effects of ice management on Pacific walrus through well defined ice management procedures when in the presence of Pacific walrus in conjunction with regular contact with USFWS personnel.*

Environmental Analyses

BOEM (and its predecessors, BOEMRE and the Minerals Management Service, or "MMS") has performed numerous environmental studies of the Arctic OCS over the last 40 years. In recent years, these environmental studies have included the following:

- Final Environmental Assessment for incidental take regulations walruses and polar bears in the Chukchi Sea (USFWS 2013) (new)
- Environmental Assessment – Shell 2013 Ancillary Activities Survey, Chukchi Sea, Alaska. (BOEM 2013) (new)
- Draft Environmental Impact Statement on the effects of oil and gas activities in the Arctic Ocean (NMFS 2011) (new)
- Environmental Assessment for ancillary activities (Statoil shallow hazards surveys) in the Chukchi Sea (BOEMRE 2011a) (new)
- Final Environmental Assessment – Shell 2012 Exploration Drilling Program in the Chukchi Sea (BOEM 2011c) (new)
- Final Supplemental Environmental Impact Statement (SEIS) – Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 (BOEMRE 2011) (new)
- Final Environmental Assessment - Shell 2010 Exploration Drilling Program in the Chukchi Sea (MMS 2009)
- Environmental Impact Statement - Beaufort and Chukchi Sea Planning Areas - Oil and Gas Lease Sales 209, 212, 217, and 221 (OCS EIS/EA MMS 2008a)
- Final Environmental Impact Statement - Oil and Gas Lease Sale 193 and Seismic Surveying Activities in the Chukchi Sea (OCS EIS/EA MMS 2007a)
- Environmental Assessment - Shell Offshore, Beaufort Sea Exploration Plan, 2007-2009 (+MMS 2007-009)
- Draft Programmatic Environmental Impact Statement - Seismic Surveys in the Beaufort and Chukchi Seas, Alaska (MMS 2007c)
- Environmental Assessment - Proposed Oil & Gas Lease Sale 202, Beaufort Sea Planning Area and Finding of No New Significant Impacts (MMS 2006a)
- Environmental Assessment - Proposed Oil & Gas Lease Sale 195, Beaufort Sea Planning Area and Finding of No Significant Impacts (MMS 2004)

- Final Environmental Impact Statement - Beaufort Sea Planning Area Oil and Gas - Lease Sales 186, 195, and 202, (MMS 2003)
- Final Environmental Impact Statement - Lease Sale 126 in the Chukchi Sea (MMS 1990)
- Final Environmental Impact Statement - Lease Sale 109 in the Chukchi Sea (MMS 1987)

In addition, BOEM and its predecessor MMS have conducted or funded numerous baseline studies of the Arctic OCS and is planning even more. Among recent publications, these baseline studies include:

- Sedimentation rate analyses in Chukchi Sea Offshore Monitoring in the Drilling Area (COMIDA): chemical and benthos (CAB) final report. (Dunton 2013,OCS Study BOEM 2012-012) (new)
- Satellite Tracking of Bowhead Whales Movements and Analysis from 2006 to 2012 Final Report. (Quakenbush, et al 2013, OCS Study BOEM 2013-01110) (new)
- Bowhead Whale Abundance Through Photographic Analysis (Rugh 2008)
- Empirical Weathering Properties of Oil in Ice and Snow (MAR Inc. 2008, OCS Study MMS 2008-033)
- Alternative Oil Spill Occurrence Estimators and Their Variability for the Alaskan OCS - Fault Tree Method: Update of GOM OCS Statistics to 2006 (Bercha Group 2008, OCS Study MMS Study 2008-025)

The BOEM website lists dozens of studies completed to date, as well as planned studies for the future (http://www.alaska.BOEM.gov/ess/index.htm). In addition, Shell has performed its own studies in preparation for this project, including coastal environmental sensitivity surveys, water and sediment quality surveys, acoustical monitoring and air quality monitoring. A multi-faceted baseline study within a 30 x 30 nautical mile study area encompassing all the blocks in Shell's Burger Prospect was conducted in 2008, 2009, and 2010 and the resulting reports used to prepare Shell's prior EIA in EP Revision 1 are listed in the EP Revision 1 Preface. The baseline studies program has continued annually and the newer reports have been used to support the revised EIA for EP Revision 2. Those reports are listed below:

- Marine mammal distribution and abundance in the northeast Chukchi Sea, July-October 2008-2011. Draft Report (Aerts et al. 2012)
- Chukchi Sea Environmental Studies Program 2008-2011: Benthic ecology of the northeastern Chukchi Sea (Blanchard and Knowlton, 2013)
- Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2012 (Gall and Day 2013)
- Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2011 (Gall and Day 2012)
- Distribution and abundance of seabirds in the northeastern Chukchi Sea, 2008 - 2010 (Gall and Day 2011)
- Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2010 (Hopcroft et al. 2011)
- Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea: report for survey year 2011 (Hopcroft et al. 2012)
- 2011 Fish and invertebrate trawl surveys in the Chukchi Sea Environmental Studies Program (NRC 2012)
- Fish community observation for three locations in the Chukchi Sea, 2010 (Priest et al. 2011)

- Species composition and assemblage structure of demersal fishes in the northeastern Chukchi Sea in A synthesis of diversity, distribution, abundance, age, size and diet of fishes in the Lease Sale 193 area of the northeastern Chukchi Sea (Priest and Raborn 2011)

These studies provide many volumes of data on the Arctic OCS. The studies, collectively, analyze everything from potential impacts on the natural environment to the socioeconomic effects of exploration activities on humans. The studies also include numerous technical studies ranging from the likely trajectory of spilled oil in the ocean to the effects of drilling sound energy on threatened and endangered species. The studies provide information for agency decision making on whether to lease, where to and where not to lease, lease stipulations and mitigation measures, operational requirements, and permit restrictions. This comprehensive body of work, which in part forms the basis for the evaluation presented herein, will allow BOEM and other regulatory agencies to evaluate EP Revision 2 and ensure that all oil and gas exploration activities are performed in an environmentally sound manner, with minimal impacts to the environment.

Among other important findings, detailed studies by BOEM, and its predecessors BOEMRE and MMS, have repeatedly confirmed that exploration drilling activities (such as those addressed in Shell’s approved EP Revision 1 and this EP Revision 2):

- Have only negligible to minor and fleeting impacts on the environment, including wildlife;
- Do not threaten the continued existence of any endangered or threatened species;
- Do not cause significant or unreasonable interference with any subsistence species, particularly bowhead whales, or Alaska Native subsistence activities when appropriate mitigation measures are followed; and
- Pose a statistically insignificant risk of a large, catastrophic oil spill (blowout)

This EIA, which supports EP Revision 2, comes to essentially the same findings as BOEM, namely, the exploration drilling activities proposed at the Burger Prospect in the Chukchi Sea:

- Have negligible to minor direct or indirect environmental impacts, and impacts which do occur are expected to be ameliorated soon after drilling ceases and would be expected to be un-measurable the following year;
- Have negligible or minor and short term effects on biological resources, as most effects on marine mammals, marine birds, and marine fish are limited to temporary disturbance or displacement;
- Do not threaten the continued existence of any endangered or threatened species;
- Will not cause significant or unreasonable interference with any subsistence species, particularly bowhead whales, or Alaska Native subsistence activities;
- Will have brief minor impacts on water quality; and
- Pose a statistically insignificant risk of a large, catastrophic oil spill (blowout)

In this EIA, Shell considers the cumulative impacts from other reasonably foreseeable future activities over the next three years. Section 4.6 on cumulative impacts discusses Shell’s determination, grounded in government guidance and NEPA case law, as to which future activities are reasonably foreseeable and which are speculative and appropriately excluded from the cumulative impacts analysis. Activities defined as reasonably foreseeable and considered *for the first time* in this cumulative impacts analysis (and not considered in the prior EIA) included: National Oceanic and Atmospheric Administration’s (NOAA) anticipated hydrographic surveys in coastal waters of the Chukchi Sea in 2013-2018 (based upon an IHA application) and potential shallow hazards, ice gouge and strudel scour surveys, geotechnical surveys, and environmental surveys of various types in the Chukchi Sea during the open water season over the next three years. EPA anticipates issuance of an Arctic NPDES general permit for geotechnical boring activities in the Beaufort and Chukchi Seas in fall 2013. This permit would authorize discharges from geotechnical facilities operating during one, or more seasons within OCS and State of Alaska waters. Activities which were defined as “speculative” and not reasonably foreseeable, and therefore not considered in the cumulative impacts analysis included: large-scale three-dimensional (3D) or two-dimensional (2D) seismic surveys in the Chukchi Sea by Shell or other operators during the same time frame, shallow hazards surveys in the Chukchi Sea by other operators during the same time frame, and exploration drilling by other oil and gas leaseholders in the Chukchi Sea.

1.0 INTRODUCTION

Shell received approval from the BOEM for its *Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska Burger Prospect, Posey Area blocks 6714, 6762, 6764, 6812, 6912, 6915, Chukchi Sea Lease Sale 193* (EP Revision 1, Shell 2011a) on 15 December 2011. Per BOEM's requirements at 30 CFR 550.212(o), Shell's EP Revision 1 was accompanied by an *Environmental Impact Analysis*: *Revised Chukchi Sea Exploration Plan* (EIA, Shell 2011b). Shell conducted one season of exploration drilling under EP Revision 1 during the 2012 open water season. Shell is now preparing for continued operations, and proposes to modify its approved EP Revision 1 to facilitate the efficient completion of the program. In EP Revision 2, Shell seeks approval to make these revisions to EP Revision 1 that would, on approval, be implemented beginning in Shell's next open water season.

The following impact analysis addresses the potential environmental impacts associated with EP Revision 2. As directed by BOEM regulations at 30 CFR 550.285(b), only changes in expected environmental impacts related to EP Revision 2 are addressed in this document, which revises and supplements the EIA for EP Revision 1 (Shell 2011b). The impact analyses address EP Revision 2 specifically, but also provide conclusions as to whether or not the impacts of the entire exploration drilling program, with the revisions, differ from the impacts identified in the prior EIA.

This document is organized as follows

- Section 2.0 briefly summarizes EP Revision 2 including the mitigation measures
- Section 3.0 summarizes important changes in environmental conditions and resources
- Section 4.0 provides an analysis of the direct, indirect, and cumulative impacts

Analysis of Impacts and Comparison with Shell's Approved EP, EP Revision 1, and EP Revision 2

Shell seeks to revise its approved EP Revision 1. This EP and EIA have been prepared consistent with the requirements under 30 CFR 250.211-228. In the Approved EP, Shell identified seven blocks (Posey Area Blocks 6713, 6714, 6763, 6764, 6912 and Karo Area Blocks 6864 and 7007) of interest in three prospects (Burger, Southwest Shoebill, and Crackerjack), that contained five potential drill sites (Burger C, F, J, Southwest Shoebill C, and Crackerjack C). The Approved EP consisted of an exploration drilling program, which was to be conducted during the 2010 exploration drilling season, and included plans to drill three of the above-referenced five proposed drill sites using the drillship *Discoverer*.

The Approved EP contained an extensive EIA. BOEMRE subsequently prepared an Environmental Assessment (EA) of the proposed exploration drilling program and distributed the EA for public comment. After rigorous agency review, which included evaluation and verification of information provided in the EIA, BOEMRE concluded the exploration drilling program would have no significant environmental impacts, and issued a Finding of No Significant Impact (FONSI) and approved the Approved EP on 7 December 2009. The Approved EP was also found to be consistent with the Alaska Coastal Management Program (ACMP) and the enforceable policies of the affected coastal districts on 2 March 2010. Shell was not able to conduct the exploration drilling program in 2010 or 2011, and submitted EP Revision 1 in May 2011. That exploration drilling program was limited to a single prospect (Burger Prospect) with six identified EP Blocks (Posey Area Blocks 6714, 6762, 6764, 6812, 6912, and 6915). Six drill sites were identified (Burger A, F, J, R, S, and V) in EP Revision 1. EP Revision 1 was approved by BOEM on 15 December 2011. Shell subsequently submitted minor revisions to Section 7 of the EP, which adjusted the estimated volumes of air pollutant emissions that would be emitted by the exploration drilling program; these revisions were approved by BOEM on August 30, 2012.

Shell conducted exploration drilling activities in the Chukchi Sea in the 2012 drilling season, during which Shell drilled a partial well at the Burger A drill site. Based on that experience, Shell now seeks approval for a limited number of revisions. EP Revision 2 is still limited to the Burger Prospect, with the same six EP Blocks and the same six approved drill sites. EP Revision 2 includes changes in the number of support vessels and vessel travel corridors, changes in the aircraft supporting the program and aircraft travel routes, and changes to the drilling fluids plan and estimates of the volume of drilling waste discharges. Other changes include revised estimates of the area of ensonification by vessel and drilling sound based on sound measurements recorded in 2012, changes to air permitting and emissions, changes in the relief well drilling unit, revisions to shorebases, and changes in mitigation measures. There are very few salient differences between EP Revision 1 and EP Revision 2 as indicated in Table 1.0-1. Additional minor differences are described in the following sections.

Table 1.0-1 Exploration Drilling Program Under Approved EP, EP Revision 1, and EP Revision 2

Parameter	Approved EP	EP Revision 1	EP Revision 2
Wells	≤ Three wells	Six	Six
Drilling unit	Drillship *Discoverer*	Drillship *Discoverer*	Drillship *Discoverer*
Secondary Relief Well Drilling Unit	*Kulluk*	*Kulluk*	*Polar Pioneer*
Prospects	Burger, Southwest Shoebill, Crackerjack	Burger	Burger
Potential Drill Sites	Five - Burger C, F, J, SW Shoebill C, Crackerjack C	Six - Burger A, F, J, R, S, V	Six - Burger A, F, J, R, S, V
Shorebase	Wainwright – marine, Barrow - air support	Wainwright – marine (and possible/ secondary air support), Barrow - air support	Wainwright – expanded marine (and possible/ secondary air support), Barrow - air support
Vertical Seismic Profile	None	One planned at each well	One planned at each well
Drilling Waste	Water-based fluids & cuttings discharged; recycled when practicable	Water based fluids & cuttings discharged; recycled when practicable	Water based fluids & cuttings discharged
Drilling fluids	Cooled	Cooled	Not cooled
Support vessels	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	2 anchor handlers, 2 ice management vessels, 3 larger offshore supply vessels, shallow water landing craft, science (oceanographic research) vessel, support tug, resupply tug and barge; shallow water landing craft
Oil spill response	OSR vessel, OSR barge, Oil Storage Tanker (OST)	OSR vessel, OSR barge, OST, capping stack and containment system (barge/tug/anchor handler)	OSR vessel, OSR barge, nearshore OSR barge, OST, capping stack and containment system (barge/tug/anchor handler)
Aircraft	2 helicopters (crew change and search and rescue)	2 helicopters (crew change and search and rescue)	3 helicopters (2 crew change and 1 search and rescue)
Regulatory Update	30 CFR 250 Subpart B EPA Air Jurisdiction	30 CFR 250 Subpart B NTL-2010-06 EPA Air Jurisdiction	30 CFR 550 Subpart B NTL-2010-06 BOEM Air Jurisdiction

Per 30 CFR 550.285, a revised EP, including the EIA, need only include information related to, or affected by, the proposed changes in the exploration drilling program. Shell has followed those regulations in this document, providing analyses of the portions of the exploration drilling program that would be altered by EP Revision 2.

2.0 PLANNED 2014 CHUKCHI SEA EP REVISIONS

Shell's approved EP Revision 1 allows Shell to drill exploration wells at certain approved locations over multiple seasons; these approved drill sites are not being modified (EP Revision 1 Table 2.1-1). The changes between EP Revision 1 and EP Revision 2 include: changes to the number of support vessels and vessel routes; changes to the aircraft and flights; revisions to shorebases; changes to drilling fluids and drilling wastes; changes to the relief well drilling unit; changes to air authorizations; and changes in mitigation measures. Key changes are summarized in Table 1.0-1 above and discussed in further detail below in Sections 2.1 thru 2.8.

2.1 Changes to the Support Vessel Fleet and Travel Routes

EP Revision 2 includes the following changes to the number of support vessels and routes:

- Adding an ice management vessel
- Adding an anchor handler
- Adding an offshore supply vessel (OSV)
- Adding a support tug
- Adding a re-supply tug and barge
- Adding a science (Oceanographic Research) vessel for required discharge monitoring and other activities
- Repositioned ACS and nearshore oil spill response (OSR) barge and tug
- Increasing the size of the OSVs supporting drilling operations
- Increasing OSV trips to 30 / season
- Contingency crew change by vessel from prospect or offshore vessels to Barrow beach

With these changes the operations and OSR vessels will consist of:

Drillship & Operational Support Fleet

- (1) drillship- M/V *Noble Discoverer*
- (2) ice management vessels
- (2) anchor handlers*
- (3) OSVs
- (1) support tug
- (1) resupply tug and barge
- (1) science vessel
- (1) shallow water landing craft

* One of the anchor handlers is shared between support fleet and OSR fleet, total of 2 for both fleets

OSR Fleet

- (1) OSR vessel
- (1) OSR barge and tug
- (1) nearshore OSR barge and tug
- (1) Arctic oil storage tanker (OST)
- (1) Arctic containment system (ACS) barge with tug and anchor handler for the containment system

Some of the support vessels are not yet contracted. Specifications for the vessels of the size and types that may be contracted are presented in Tables 2.1-1 and 2.1-2. Newly added or modified support vessels per EP Revision 2 are so-indicated in the footnotes. Actual vessels that are eventually contracted may differ from these specifications but they will be similar. No new vessels have been proposed for oil spill response (Table 2.1-2); however, there have been changes in designated locations. Fuel storage capacities and expected trip frequencies for these support vessels are indicated in Table 2.1-3.

Some of these vessels will not be in the Lease Sale 193 Area for extended periods but may be used in the prospect area on occasion. The additional anchor handler will be dedicated primarily to the relief well drilling unit in Dutch Harbor. The added resupply tug and barge, the nearshore OSR barge and tug, the containment barge/tug/anchor handler, and the shallow water landing craft will also be primarily located outside the Lease Sale 193 Area. Two to four mooring buoys may be established at the site. A tentative location for these vessels has been identified near Goodhope Bay in Kotzebue Sound. A shallow water landing craft may be used to effect crew changes between these vessels and the Port of Kotzebue. Other vessels may be located with these vessels on occasion. Additional information on vessel locations and activities is provided in Table 2.1-3.

Vessel transit corridors remain largely the same, with the exception that a generalized route is being identified for vessels to effect crew changes between the prospect or offshore vessels and Barrow. This is a contingency for the possibility that sufficient crew change flights cannot be accommodated by helicopters on occasion because of weather, visibility, subsistence or other operational issues. Generalized vessel transit corridors are indicated in Figure 2.1-1.

Table 2.1-1 Specifications of Support Vessels

Specs	Ice Management Vessels[1] (X2)	Anchor Handlers [2] (X2)	OSVs [3] (X3)	Science (Oceanographic Research) Vessel [4]	Landing Craft [5]	Support Tug [6]	Resupply Tug and Barge [7]	
							Tug	Barge
Length	380 ft (116 m)	380 ft (110 m)	300 ft (91.4 m)	300 ft (91.4 m)	134 ft (40.8 m)	146 ft (44 m)	150 ft (45.5 m)	400 ft (121.9 m)
Width	85 ft (26 m)	80 ft (24.4 m)	64 ft (19.5 m)	64 ft (19.5 m)	32 ft (9.7 m)	46 ft (14 m)	40 ft (12 m)	99.5 ft (30.3 m)
Draft	27 ft (8.4 m)	24 ft (7.3 m)	20 ft (6.1 m)	20 ft (6.1 m)	7 ft (2.1 m)	25 ft (7.6 m)	19 ft (5.8 m)	19.3 ft (5.9 m)
Berths	82	64	50	50	22	13	11	NA
Maximum Speed	16 knots (30 km/hr)	15 knots (28 km/hr)	14 knots (26 km/hr)	14 knots (26 km/hr)	10 knots (18 km/hr)	16 knots	12 knots (9.3 km/hr)	NA
Fuel Storage	11,070 bbl (1,760 m^3)	12,578 bbl (2,000 m^3)	6,428 bbl (1,022 m^3)	6,428 bbl (1,022 m^3)	667 bbl (106 m^3)	5,585 bbl (888 m^3)	1,786 bbl (284 m^3)	390 bbl (62 m^3)

[1] Two vessels, one new per EP Revision 2; specifications for both are based on M/V *Nordica* but may be any similar vessel
[2] Two vessels, one new per EP Revision 2 that is shared with ACS; specifications for both are based on M/V *Aiviq* but may be any similar vessel
[3] Three vessels, one new per EP Revision 2; all increased in size per EP Revision 2; specifications for all are based on the M/V *Harvey Sisuaq* but may be any similar vessel
[4] New vessel per the EP Revision 2, specifications based on the M/V *Harvey Sisuaq* but may be any similar vessel
[5] Based on the M/V *Arctic Seal* but may be any similar vessel
[6] New vessel per EP Revision 2, specifications based on the ocean class tug M/V *Ocean Wave* but may be any similar vessel
[7] New vessel per EP Revision 2, specifications based on barge *Tuuq* and tug M/V *Lauren Foss* but may be any similar vessel

Table 2.1-2 Specifications of the Major Oil Spill Response Vessels

Spec	OSR Vessel [1,2]	OSR Barge [1,3]		OST [1,4]	Nearshore OSR [1,5]		ACS [1,6]		
		Barge	Tug		Barge	Tug	Barge	Tug	Anchor Handler
Length	301 ft 91.9 m	350 ft 106.7 m	126 ft 38.4 m	748 ft 228 m	205 ft 62.5 m	90 ft 27.4 m	310 ft m	149 ft 45.7 m	380 ft (110 m)
Width	60 ft 18.3 m	76 ft 23.1 m	34 ft 10.4 m	106 ft 32.3 m	90 ft 27.4 m	32 ft 9.8 m	104 ft 30.5 m	40 ft 12.2 m	80 ft (24.4 m)
Draft	19 ft 5.9 m	22 ft 6.7 m	17 ft 5.2 m	47 ft 14.3 m	12 ft 3.8 m	8.5 ft 2.6 m	19.3 ft 5.9 m	18.5 ft 5.6 m	24 ft (7.3 m)
Fuel Storage	6,867 bbl 1,092 m^3	390 bbl 62 m^3	1,786 bbl 284 m^3	221,408 bbl 35,200 m^3	--	1,428 bbl 227 m^3	--	3,690 bbl 587 m^3	12,578 bbl (2,000 m^3)
Liquid Storage	12,690 bbl 2,017 m^3	76,900 bbl 12,226 m^3	--	553,494 bbl (86,328 m^3)	18,636 bbl 2,963 m^3	--	--	--	--
Berths	41	--	6	25	--	8	72	11	64
Max Speed	16 knots 29.6 km/hr	--	5 knots 9.3 km/hr	16 knots 29.6 km/hr	--	7 knots 13 km/hr	--	12 knots 18.5 km/hr	15 knots (28 km/hr)
Work boats	(3) work 34 ft/10 m	(1) skim 47 ft/14 m (3) work 34 ft/10 m (4) minibarges	--	--	(1) skim 47 ft/14 m) (3) work 34 ft/10 m (4) minibarges	--	--	--	--

[1] Or similar vessel
[2] Based on the M/V *Nanuq* but may be any similar vessel
[3] Based on the barge *Klamath* and the tug M/V Crowley *Sea Robin* but may be any similar vessels
[4] Based on the *Affinity*, the OST will have a minimum storage capacity of 513,000 bbl
[5] Based on the barge *Arctic Endeavor* and the tug *Point Oliktok* but may be any similar vessel
[6] Based on the barge *Arctic Challenger*, *Corbin Foss* tug, and the M/V *Aiviq* anchor handler – but may be any similar vessel – this anchor handler is shared with the other support vessels (a total of 2 anchor handlers are contemplated in EP Revision 2)

Table 2.1-3 Expected Fuel Storage Capacity and Trip Information for Support Vessels

Vessel Type	Max Fuel Tank Storage Capacity	Trip Frequency or Duration
Marine Support Vessels		
Ice management vessels (X2)[1]	11,070 bbl (1,760 m^3)	One will remain generally 3-25 mi upwind of *Discoverer* throughout the exploration drilling season One will conduct occasional ice scouting, prelay anchor protection, and other services as needed, and be staged outside the Chukchi Sea Planning Area when not being utilized
Anchor handlers (X2)[2]	12,578 bbl (2,000 m^3)	One stays in the area of *Discoverer* throughout the drilling season One primarily dedicated to relief well drilling unit but may enter Chukchi Sea planning area for anchor prelays and other duties
OSV [3] (X3)	6,428 bbl (1022 m^3)	Up to 24 round trips (total for all 3 OSVs) for resupply between drillship and Dutch Harbor and 4-6 refuel trips (combined) between OST and drillship during drilling season
Resupply tug and barge [4]	1,786 bbl (284 m^3) on tug	Remains near ACS but outside the Chukchi Sea Planning Area most of the time, may make trips to drilling unit and ≤2 trips to Dutch Harbor
Support Tug [5]	5,585 bbl (888 m^3)	Remains in Arctic but outside the Chukchi Sea Planning Area most of the time, makes occasional trips to the prospects / drilling unit
Science Vessel [3]	6,428 bbl (1022 m^3)	Conducts NPDES discharge monitoring at drillship, collects environmental baseline data in other EP Blocks, conducts other logistical duties as needed
Shallow water landing craft [6]	667 bbl (106 m^3)	Remains near ACS, makes trips as needed between offshore vessels & Kotzebue during drilling season at a frequency of about 1/week. May also access shorebases in Barrow or Wainwright, or the City of Nome.
OSR Vessels		
OSR vessel – Nanuq	6,867 bbl (1,092 m^3)	Stays in vicinity of the drillship throughout the drilling season
OSR barge [7]	1,786 bbl (284 m^3) on tug	Will be located in the vicinity of the drillship throughout the exploration drilling program
OSR work boats	7 bbl (1.1 m^3)	12 round trips/week for 2 months for OSR drills & training – between Wainwright shorebase and OSR barge or coastal sites
OST [8]	221,408 bbl (86,330 m^3)	Will be staged such that it can be on location within 24 hours
ACS containment barge and tug [9]	3,690 bbl (587 m^3)	No trips – remains in a location in Arctic but outside the Lease Sale Area from where it can respond if needed
ACS anchor handler [10]	7,484 bbl (1,190 m^3)	Generally remains with the containment barge but may enter theater for anchor prelays and other duties
Nearshore OSR barge [11]	1,428 bbl 227 m^3	Remains in Arctic near ACS but outside the Chukchi Sea Planning Area most of the time

[1] Based on specifications of the *Nordica* but may be any similar vessel
[2] Based on specifications of the *Tor Viking* but may be any similar vessel
[3] Based on specifications of the *Sisuaq* but may be any similar vessel (three vessels of this types will be used)
[4] Based on specifications of the *Lauren Foss* but may be any similar vessel
[5] Based on the ocean class tug M/V *Ocean Wave* but may be any similar vessel
[6] Based on the *Arctic Seal* but may be a similar vessel
[7] Based on the barge *Klamath* and the tug M/V Crowley *Sea Robin* but may be any similar vessels
[8] Based on the *Affinity*
[9] Based on the *Arctic Challenger* and *Crowley Invader* class ocean-going tug
[10] Based on the *Vidar Viking* or similar anchor handler
[11] Based on the barge *Arctic Endeavor* and the tug *Point Oliktok* but may be any similar vessel

2.2 Changes to the Aircraft and Flights

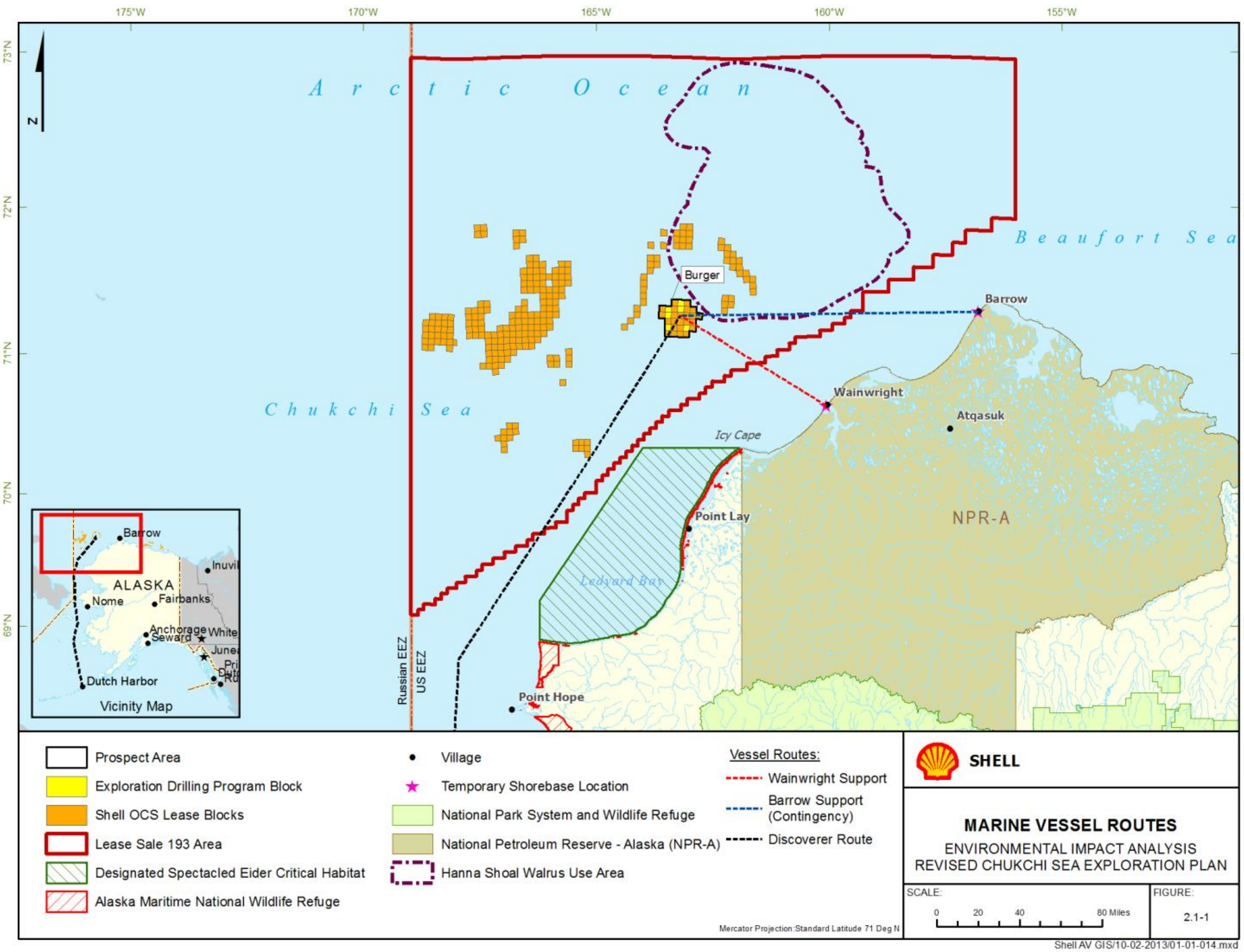
Changes to aircraft and flights in EP Revision 2 include the following:

- Adding another helicopter for crew change operations
- Shuttling helicopters between Barrow and Deadhorse shorebases
- Increasing the number of helicopter round trip flights between shorebases and the prospect to 40 / week.

With these changes the operations and search and rescue (SAR) aircraft associated with the exploration drilling program will consist of:

- (2) crew change helicopters
- (1) search and rescue (SAR) helicopter
- (1) fixed wing aircraft for crew transport
- (1) fixed wing aircraft for marine mammal monitoring flights

Figure 2.1-1 Marine Vessel Routes



Weather conditions experienced by Shell during the 2012 operations affected the ability to fly offshore for crew changes. Shell plans to improve helicopter equipment by equipping crew change and SAR helicopters with Rotor Ice Protection Systems and utilizing improved offshore instrument flight rules. This will enable the helicopters to fly at or above 1500 ft (457 m) during low-ceiling and/or icing conditions. This allows for crew change to occur on time and reduces the risk for worker fatigue offshore. Additionally, helicopter flights between the Barrow and Deadhorse shorebase may occur to assist crew change and/or resupply activities. These trips are estimated to be at a frequency of about one round trip / day. Generalized routes (Figure 2.2-1) have been selected for the helicopter shuttle flights between Barrow and Deadhorse, but these flight paths will be selected and/ or modified each day in coordination with the Subsistence Advisors (SAs).

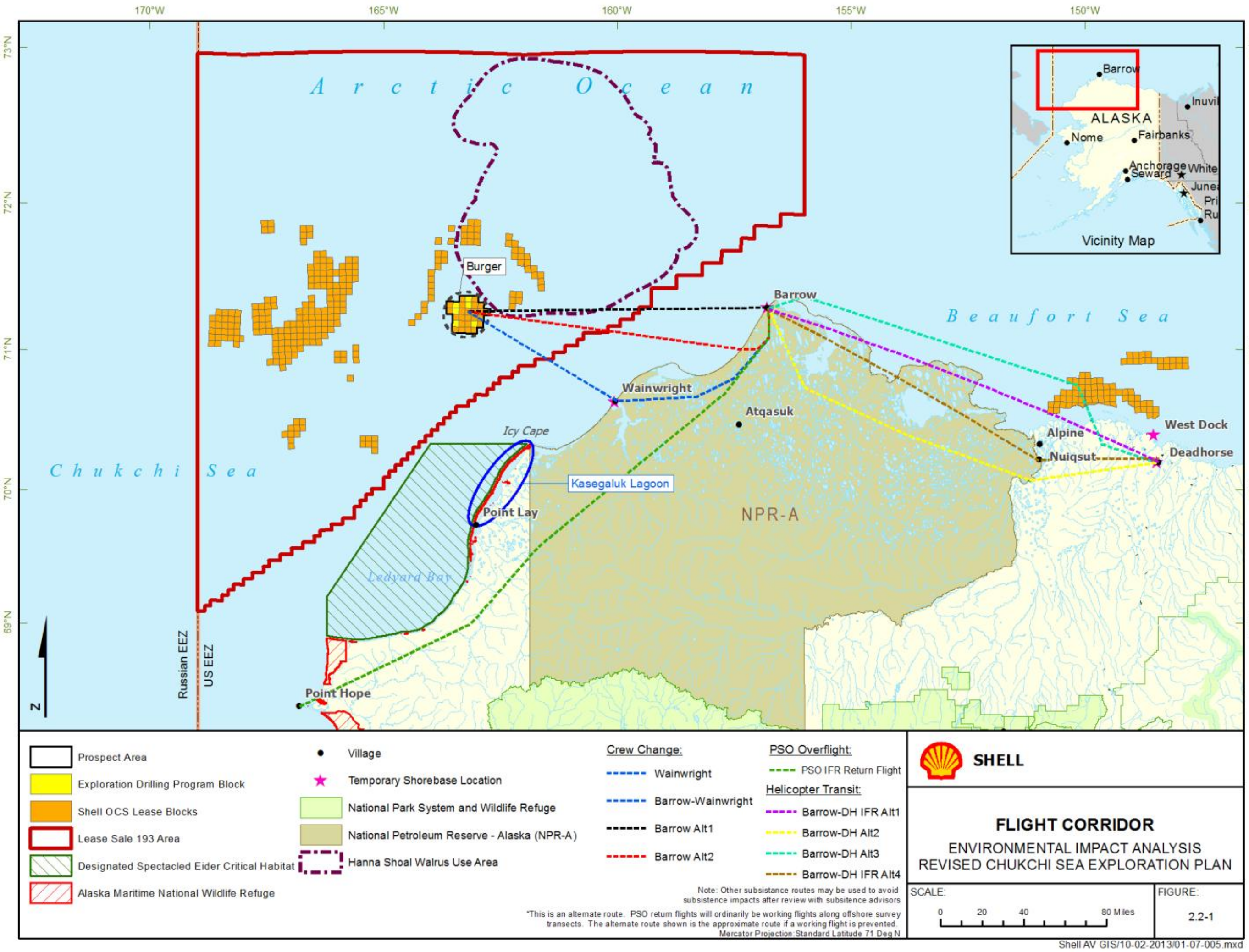
The types of aircraft that may be contracted are presented in Table 2.2-1. Some of these aircraft are not yet contracted; the aircraft that are eventually contracted may differ from these but will be similar. The expected primary uses, fuel storage capacities, and frequency of trips for these aircraft are also indicated in Table 2.2-1.

Table 2.2-1 Fuel Storage Capacity and Trip Information for Support Aircraft

Aircraft Type [1] / Purpose	Maximum Fuel Tank Storage Capacity	Trip Frequency or Duration
(1) Saab 340 B, Beechcraft 1900, Dash 8, or similar fixed-wing aircraft for transport from shorebase to regional jet service in Deadhorse or Barrow	9 bbl (1.4 m^3)	Up to 4 round trips/week between Wainwright and Barrow or Anchorage
(2) S-92, EC225, or similar helicopters for crew rotation & groceries/supply	18 bbl (2.9 m^3)	Approximately 40 round trips/week between shorebase & prospect – approx. 3.0 hr/trip Approximately 1 helicopter shuttle round trip/day between Barrow & Deadhorse
(1) S-61, S-92, EC225, or similar helicopter for search-and-rescue	18 bbl (2.9 m^3)	Stationed in Barrow – 40 hr/week for proficiency training & trips made in emergency
(1) deHavilland Twin Otter, Diamond Aircraft DA42, or similar aircraft for marine mammal monitoring	9.2 bbl (Twin Otter) 1.9 bbl (DA42)	Stationed in Barrow – sawtooth pattern 0-23 mi (37 km) offshore from Barrow to Point Hope flown twice per week

[1] Similar model of aircraft may be contracted for these purposes

Figure 2.2-1 Flight Corridors



2.3 Changes to Shorebases

The changes in EP Revision 2 include the following changes to shorebase support facilities:

- Expanding the man-camp in Barrow by adding 125 beds and a kitchen car
- Utilizing a larger (55-person) man camp in Wainwright through contractor Olgoonik

The camp in Barrow may be moved to a new location in Barrow and will be expanded to accommodate 200 persons. These changes are being implemented to accommodate crews from the additional support vessels, and a greater number of persons that may require shelter on occasions when flights in and out of Barrow are restricted by weather and flying conditions. The additional beds and kitchen will be modular construction on existing gravel pad near the Barrow Airport. Construction will take place in 2013-2014. Generators will be used to provide heat and electricity. Water and sewage will be separate and self contained. Received water and disposal of graywater and blackwater as well as other household waste will be done through North Slope Borough (NSB).

The camp in Wainwright is owned and operated by the local village native corporation, Olgoonik Development LLC. Shell will be leasing additional space at that location.

With the mooring of vessels offshore of Goodhope Bay or another location in Kotzebue Sound, Shell may achieve crew changes between the vessels and the Port of Kotzebue. In this event, Shell would likely book 15 hotel rooms for the crews in Kotzebue. There may be a total of 10 to 15 full time staff stationed in Kotzebue to assist with these operations.

2.4 Changes to the Drilling Fluids Plan and Drilling Wastes

The changes in EP Revision 2 include the following changes regarding drilling fluids and wastes:

- Adding a number of drilling fluid components to the drilling fluids plan
- Adjusting the estimates of drilling waste volumes
- Altering the discharge method for drilling wastes from the MLC and upper well sections (top hole)

Shell has revised both the volumes of drilling fluids that may be used and their components in order to drill each of the proposed wells to TD. These changes were made based on drilling operations conducted during the 2012 drilling season and revised estimates of drilling fluid to cuttings ratio. A number of drilling fluid components are being added to the plan (Table 2.4-1). Three basic drilling fluids will be used: 1) gel polymer sweeps / weighted gel / polymer fluid for the upper well sections; 2) KLA-SHIELD inhibitive water based fluid for the lower well sections; and, 3) water based abandonment fluid for the end of well. Base fluid components, additives, and contingency additives for these base fluid types are indicated in Tables 2.4-2, 2.4-3, and 2.4-4.

Table 2.4-1 Drilling Fluid Components Added to the Plan EP Revision 2

Generic Description	Product Name	Component Type	Drilling Fluid Type
Acrylic polymer	IDCAP D	Base Fluid	KLA-SHIELD WBM + abandon
Shale/clay inhibitor	EMI-2009	Base Fluid	KLA-SHIELD WBM
Shale/clay inhibitor	KLA-STOP	Base Fluid	KLA-SHIELD WBM
Biopolymer	Flowzan	Base Fluid	KLA-SHIELD WBM
Copolymeric shale stabilizer	POROSEAL	Additive	KLA-SHIELD WBM
Biocide	Busan 1060	Additive	KLA-SHIELD WBM
Liquid defoamer	DF-9065	Additive	KLA-SHIELD WBM
Vegetable, polymer fiber blend	MI SEAL	Additive	KLA-SHIELD WBM
Cellulose fiber	MIX II Fine	Additive	KLA-SHIELD WBM
Cellulose fiber	MIX II MED	Additive	KLA-SHIELD WBM
Graphite	G-SEAL	Additive	KLA-SHIELD WBM
Calcium carbonate	SAFECARB-20	Additive	KLA-SHIELD WBM
Calcium carbonate	SAFECARB-40	Additive	KLA-SHIELD WBM
Calcium carbonate	SAFECARB-250	Additive	KLA-SHIELD WBM
Sodium chloride	stock product	Additive	KLA-SHIELD WBM
Resinated lignite	RESINEX	Additive	KLA-SHIELD WBM
Sulfonated asphalt	ASPHASOL SUPREME	Additive	KLA-SHIELD WBM
Mixture	FORM-A-BLOK	Contingency	KLA-SHIELD WBM
Cellulose	FORM-A-SET AK	Contingency	KLA-SHIELD WBM
Zinc oxide	Sulf-X	Contingency	KLA-SHIELD WBM
Mixture	Pipelax ENV WH	Contingency	KLA-SHIELD WBM
Mixture	LUBE 945	Contingency	KLA-SHIELD WBM
Mixture	CLEAN SPOT	Contingency	KLA-SHIELD WBM
Surfactant	SCREENKLEEN	Contingency	KLA-SHIELD WBM
Mixture	SAFE-SCAV HS	Contingency	KLA-SHIELD WBM
Corrosion inhibitor	Conqor 404	Base Fluid	Water Based Abandonment Fluids
Hydrogen sulfide scavenger	SAFE-SCAV HS	Base Fluid	Water Based Abandonment Fluids
Oxygen scavenger	Sodium Metabisulfite	Base Fluid	Water Based Abandonment Fluids
Calcium carbonate	SAFECARB-20	Additive	Water Based Abandonment Fluids
Calcium carbonate	SAFECARB-40	Additive	Water Based Abandonment Fluids
Sodium chloride	stock product	Additive	Water Based Abandonment Fluids
Resinated lignite	RESINEX	Additive	Water Based Abandonment Fluids
Sulfonated asphalt	ASPHASOL SUPREME	Additive	Water Based Abandonment Fluids
Sodium bromide brine	NaBr	Additive	Water Based Abandonment Fluids

[1] Source: Shell drilling fluids plan for the Chukchi Sea (MI Swaco 2013)

Table 2.4-2 Gel/Polymer Sweeps/Weighted Polymer Fluid Components in EP Revision 2

Generic Description	Product Name	Maximum Concentration
BASE FLUID		
Biopolymer	DUOVIS	5 lb/bbl
Bentonite	M-I GEL	35 lb/bbl
Bentonite extender	GELEX	0.05 lb/bbl
Polyanionic cellulose	Polypac Supreme UL	5 lb/bbl
ADDITIVES		
Crushed nut hulls	NUT PLUG	20 lb/bbl
CONTINGENCY PRODUCTS		
Barite	M-I WATE	160 lb/bbl
Defoamer	DEFOAM-X	0.3 lb/bbl
Dye	Sodium Fluoresceine Green Dye	.5 gal/bbl in seawater
Caustic soda	stock product	8 lb/bbl
Citric acid	stock product	5 lb/bbl
Sodium acid pyrophosphate (SAPP)	stock product	TBD
Soda ash	stock product	13 lb/bbl
Biocide	Busan 1060	0.4 lb/bbl

Table 2.4-3 Components of the KLA-SHIELD Inhibited WBM in EP Revision 2

Generic Description	Product Name	Maximum Concentration
BASE FLUID		
Soda ash	stock product	12 lb/bbl
Acrylic polymer	IDCAP D	5 lb/bbl
Shale/clay inhibitor	EMI-2009	20 lbs/bbl
Shale/clay inhibitor	KLA-STOP	20 lbs/bbl
Biopolymer	DUOVIS	2 lb/bbl
Biopolymer	Flowzan	2 lb/bbl
Polyanionic cellulose	POLYPAC SUPREME UL	5 lb/bbl
Sodium hydroxide	Caustic Soda	8 lb/bbl
Barite	M-I WATE	160 lb/ bbl
Sodium chloride in brine	Salt/NaCl	100 lb/bbl
ADDITIVES		
Copolymeric shale stabilizer	POROSEAL	19 lb/bbl
Deflocculant	CF Desco®II	4 lb/ bbl
Sodium bicarbonate	stock product	10 lb/bbl
Citric acid	stock product	4 lb/bbl
Biocide	Busan 1060	0.4 lb/bbl
Liquid defoamer	DEFOAM-X	0.3 lb/bbl
Liquid defoamer	DF-9065	0.3 lb/bbl
Crushed nut hulls	NUT PLUG MED	40 lb/bbl
Crushed nut hulls	NUT PLUG FINE	40 lb/bbl
Vegetable, polymer fiber blend	MI SEAL	40 lb/bbl
Cellulose fiber	MIX II Fine	25 lb/bbl
Cellulose fiber	MIX II MED	25 lb/bbl
Graphite	G-SEAL	10 lb/bbl
Calcium carbonate	SAFECARB-20	200 lb/bbl
Calcium carbonate	SAFECARB-40	200 lb/bbl
Calcium carbonate	SAFECARB-250	200 lb/bbl
Sodium chloride	stock product	100 lb/bbl
Resinated lignite	RESINEX	10 lb/bbl
Sulfonated asphalt	ASPHASOL SUPREME	8 lb/bbl
CONTINGENCY PRODUCTS		
Mixture	FORM-A-BLOK	40 lb/bbl
Cellulose	FORM-A-SET AK	Formulation pill
Zinc oxide	Sulf-X	2.5 lb/bbl
Mixture	Pipelax ENV WH	4% v/v
Mixture	LUBE 945	3% v/v
Mixture	CLEAN SPOT	4% v/v
Surfactant	SCREENKLEEN	2% v/v
Mixture	SAFE-SCAV HS	0.1 lb/bbl

[1] Source: Shell drilling fluids plan for the Chukchi Sea (MI Swaco 2013)

Table 2.4-4 Components of the Abandonment Fluids in EP Revision 2

Generic Description	Product Name	Maximum Concentration
BASE FLUID		
Soda ash	stock product	12 lb/bbl
Biopolymer	DUOVIS	2 lb/bbl
Sodium hydroxide	Caustic Soda	8 lb/bbl
Barite	M-I WATE	160 lb/ bbl
Sodium chloride in brine	Salt/NaCl	40 lb/bbl
Corrosion inhibitor	Conqor 404	0.5 lb/bbl
Hydrogen sulfide scavenger	SAFE-SCAV HS	0.1 lb/bbl
Oxygen scavenger	Sodium Metabisulfite	0.5 lb/bbl
ADDITIVES		
Acrylic polymer	IDCAP D	5 lb/bbl
Shale/clay inhibitor	KLA-STOP	20 lbs/bbl
Polyanionic cellulose	POLYPAC SUPREME UL	5 lb/bbl
Copolymeric shale stabilizer	POROSEAL	19 lb/bbl
Deflocculant	CF Desco II	4 lb/ bbl
Sodium bicarbonate	stock product	10 lb/bbl
Citric acid	stock product	4 lb/bbl
Biocide	Busan 1060	0.4 lb/bbl
Liquid defoamer	DEFOAM-X	0.3 lb/bbl
Calcium carbonate	SAFECARB-20	200 lb/bbl
Calcium carbonate	SAFECARB-40	200 lb/bbl
Sodium chloride	stock product	100 lb/bbl
Resinated lignite	RESINEX	8 lb/bbl
Sulfonated asphalt	ASPHASOL SUPREME	8 lb/bbl
CONTINGENCY PRODUCTS		
Sodium bromide brine	NaBr	212 lb/bbl

[1] Source: Shell drilling fluids plan for the Chukchi Sea (MI Swaco 2013)

Drilling wastes as defined here include drill cuttings with adhered drilling fluids and bulk mixed drilling fluids. Drill cuttings are the geologic or earthen materials that are pulverized by the drill bit and brought to the surface by the circulating drilling fluids. Drill cuttings are chips of naturally occurring rocks including clays, limestone, shale, sand and other benign materials that pose no harm to the environment. At the surface, the cuttings are separated from most of the drilling fluids with shakers, de-sanders, and de-silters, although some fluids remain adhered to the cuttings. Drilling fluids will be recovered, reconditioned, and reused when practicable; however, it is expected that all mixed drilling fluids in the reserve pit plus the circulating volume (total of approximately 1,500 bbl) will be discharged at the end of each well.

Drilling wastes will be discharged in accordance with National Pollutant Discharge Elimination System (NPDES) General Permit AKG-28-8100, a new general permit specific to the Chukchi Sea that has been issued since EP Revision 1 was approved. Drilling wastes from the upper well sections, which include MLC and other intervals prior to installation of the marine riser, will be discharged at the seafloor via a seafloor pump as NPDES Discharge 013 (muds, cuttings and cement at the seafloor). Drilling wastes from the lower well sections (intervals drilled after marine riser connection) will be diluted and discharged to the Chukchi Sea via the disposal caisson as NPDES Discharge 001 as described in the EIA. The disposal caisson is a 15-in. (38-cm) diameter open pipe (no float valve) that is welded to the sponson and extends from the main deck level down to a location 19.6 ft (6.0 m) below mean sea level. Because it remains open to the sea at all times, it is constantly filled with water.

Shell has revised its estimates of the volumes of drilling fluids and drill cuttings that would be discharged per well based on its experience in the 2012 drilling season. Estimates of drilling fluid discharge volumes have increased due to a greater drilling fluid to drill cuttings ratio. Drill cuttings estimates have been increased to accommodate the possible use to a larger MLC bit that would drill a larger and deeper MLC, and to accommodate a potential increase in structural casing diameter. The volumes now expected to be generated and discharged are indicated in Tables 2.4-5 and 2.4-6. These are estimated volumes based on wellbore size and well depth; actual volumes will vary due to the specific geologic materials encountered.

Table 2.4-5 Estimated Volume of Drill Cuttings Generated at Each Drill Site

Portion of Well	Burger A [1] (bbl)	Burger F (bbl)	Burger J (bbl)	Burger R (bbl)	Burger S (bbl)	Burger V (bbl)
Upper well (top hole)	5,006	10,573	10,572	10,570	10,572	10,572
Lower well sections	1,043	1,043	915	1,077	1,074	1,153
Total	6,049	11,613	11,487	11,647	11,646	11,725

[1] Upper well section drilled in 2012 season

Table 2.4-6 Estimated Maximum Drilling Fluid Discharges at Each Drill Site

Drilling Fluid	Burger A (bbl)	Burger F (bbl)	Burger J (bbl)	Burger R (bbl)	Burger S (bbl)	Burger V (bbl)	Total (bbl)
Adhered & batch [1]	20,859	35,704	35,005	35,880	35,871	36,303	30,241
Reserve tank [2]	1,500	1,500	1,500	1,500	1,500	1,500	9,000
Total	22,359	37,203	36505	37,380	37,371	37,803	39,241

[1] Adhered fluids includes fluids adhered to cuttings and any discharged due to displacement / dilution; includes upper and lower well sections
[2] Reserve tank fluids to be discharged at the end of the well

Shell has conducted dispersion modeling of the drilling waste discharges using the revised discharge volume estimates. The results of this modeling effort are discussed in Section 4.

2.5 Updated Information Regarding Sound Generation

Measurements of the sound energy generated by drilling or vessel activity with equipment planned to be used by Shell were not available for the Arctic when the EIA for EP Revision 1 was prepared. The sound energies generated by drilling with the *Discoverer* and transiting of most of the vessels likely to be used in future drilling seasons were measured in the Chukchi Sea and/or Beaufort Sea during the 2012 exploration drilling season. The following section provides information resulting from those measurements, which are changes from the EIA for EP Revision 1.

Prior to 2012, sounds from the *Discoverer* and a number of the support vessels had not been measured in the Arctic, and analogs or modeling based on sound measurements outside the Arctic were used to estimate the distances at which the generated sound would attenuate to levels below effects thresholds. Potential impacts associated with the generation of sound energy by the drillship *Discoverer* as discussed in the EIA for EP Revision 1 were based on measurements recorded near the *Discoverer* in the China Sea in 2009 (Austin and Warner 2010), which were then modeled under Chukchi Sea conditions to provide estimated radial distances to various sound energy levels as the sound energy dissipated with distance. The distance from the sound energy source (drillship) at which drilling sounds would likely fall below 120 dB because of transmission loss was estimated in this manner to be 0.814 mi (1.31 km). During its 2012 exploration drilling activities, Shell measured the sounds produced by the *Discoverer* while drilling on the Burger Prospect. A broadband (10 Hz – 32 kHz) source level of 182 dB was calculated for the *Discoverer* based on the measurements recorded when drilling the 26-inch hole interval. Radii to other received sound energy levels based on a best-fit relationship of these measurements are provided in Table 2.5-1.

Radii for support vessels in transit, also based on measurements taken in the Chukchi Sea or Beaufort Sea during the 2012 season, are provided in Table 2.5-2. Sound levels expected to be generated by the zero-offset seismic profile (ZVSP) airgun array have not been measured but were modeled; expected distances to received sound levels are provided in Table 2.5-3.

These new distances to received sound levels shown in Tables 2.5-1, 2.5-2, and 2.5-3 were used to predict the area ensonified to threshold levels around the sound sources, and to then estimate potential exposures of marine mammals.

Table 2.5-1 Distances to Received Sound Levels from Drilling and Related Activities

Received level	Drilling 26-inch Hole [1]	Drilling with Support Vessel in DP [1,2]	MLC Drilling [1]	Ice Management [1]	Anchor Handling [1,3]
≥ 190 db	< 10 m	< 10 m - < 10 m	< 10 m	< 10 m	< 10 m
≥ 180 db	< 10 m	< 10 m - < 10 m	20 m	< 10 m	< 10 m
≥ 170 db	< 10 m	< 10 m - < 10 m	40 m	20 m	14 m
≥ 160 db	< 10 m	< 10 m - 30 m	130 m	60 m	63 m
≥ 150 db	30 m	45 m - 160 m	350 m	200 m	290 m
≥ 140 db	100 m	270 m - 860 m	1,000 m	730 m	1,400 m
≥ 130 db	390 m	1,700 m - 4,600 m	2,800 m	2,600 m	6,300 m
≥ 120 db	1,500 m	10,000 - 25,000 m	8,100 m	9,600 m	29,000 m

[1] Based on linear fit to average sound levels recorded at 4 ranges at Burger A in the Chukchi Sea in 2012; source: Austin et al. 2013
[2] Vessel in DP was the anchor handler in Chukchi Sea, range is while the drillship was drilling different hole sizes
[3] Measurements of anchor handling were collected in Beaufort Sea 2012

Table 2.5-2 Measured Radii to Sound Levels for Transiting Support Vessels

Received level	*Affinity* 8.8 kts [1]	*Fennica* 8.8 kts [1]	*Guardsman / Klamath* [1]	*Aiviq* 8.8 kts [1,2]	*Tor Viking*[1,2] 9 kts	*Sisuaq*[1,2] 8.7 kts	*Arctic Seal* [1,2] 9 kts	*Nordica*[1] 12.1 kts
≥ 190 db	0 m	0 m	< 10 m	0 m	0 m	< 10 m	0 m	<10 m
≥ 180 db	0 m	< 10 m	< 10 m	< 40 m	< 10 m	< 10 m	0 m	< 10 m
≥ 170 db	0 m	< 10 m	17 m	< 10 m	< 10 m	< 10 m	0 m	< 10 m
≥ 160 db	< 10 m	< 10 m	49 m	44 m	25 m	18 m	<10 m	24 m
≥ 150 db	< 10 m	26 m	140 m	280 m	110 m	61 m	<10 m	80 m
≥ 140 db	36 m	97 m	400 m	1,400 m	470 m	200 m	13 m	260 m
≥ 130 db	180 m	360 m	1,100 m	4,600 m	2,000 m	680 m	67 m	860 m
≥ 120 db	900 m	1,300 m	3,300 m	9,500 m	8,700 m	2,300 m	350 m	2,800 m

[1] Determined by Best Fit Lines from measured sound radii in the Chukchi Sea in 2012; source: Austin et al. 2013
[2] No measurements analyzed in the Chukchi Sea in 2012; these distances are from the Beaufort Sea in 2012

Table 2.5-3 Modeled Distances to Received Sound Levels from the ZVSP Airgun Array

Received level	Distance to Received Level	
≥ 190 db	249 ft	76 m
≥ 180 db	1,047 ft	502 m
≥ 160 db	14,140 ft	4,310 m
≥ 120 db	48.5 mi	78 km

2.6 Change to the Relief Well Drilling Unit

In EP Revision 2, the *Discoverer* will continue to serve as its own primary relief well drilling unit. If the *Discoverer* cannot be used to drill the relief well, a second drilling unit, the *Polar Pioneer*, would be brought in for that purpose. The *Polar Pioneer* will be under contract to Shell. Information/specifications regarding the relief well unit will be provided when available. The *Polar Pioneer* will be located in Dutch Harbor and could be mobilized to the Burger Prospect, moored, drill a relief well and kill the flow in 38 days.

2.7 Change to Air Jurisdiction

In EP Revision 1, air emissions for the project were evaluated by applying the requirements under the Environmental Protection Agency's (EPA's) Outer Continental Shelf Prevention of Significant Deterioration (PSD) Permit to Construct No. R10OCS/PSD-AK-09-01. In December 2011, Section 328 of the Clean Air Act (CAA) was revised, transferring air quality jurisdiction for Alaska offshore the North Slope Borough from the EPA to the BOEM. Shell now seeks air approval for the project from BOEM, whose air quality regulations are found at 30 CFR 550.302-304. Shell is providing two analyses of air emissions associated with its exploration drilling program as described in EP Revision 2 (Air Sciences Inc. 2013): an emission inventory as dictated by the regulations at 30 CFR 550 as part of BOEM's Air Quality Regulatory Program (AQRP) and an inventory to support an air quality impact analysis suitable for a National Environmental Policy Act (NEPA) evaluation. The AQRP inventory and analysis can be found in Section 7 and Appendix O of Shell's EP Revision 2. The NEPA inventory is also found in Appendix O and is used throughout this document in the assessment of potential impacts to air quality associated with the exploration drilling program as described in EP Revision 2.

2.8 Changes to Mitigation Measures

Shell successfully implemented the mandatory and voluntary mitigation measures it committed to in the 2012 open water season, and plans to continue the vast majority in EP Revision 2. Shell plans to implement some changes to the mitigation measures currently in EP Revision 1 and accompanying EIA. Some of these changes are required in order to respond to changes in permits and agency requirements, some are in response to lessons learned in the 2012 open water season, and others are no longer practicable. EP Revision 1's mitigation measures will remain in place with the exception of the planned changes indicated below. The discussion that follows includes the reasons for each of the changes to mitigation.

Removal of the following mitigation measures:

- Use of ClearSky lighting technology as a mitigation measure. *The ClearSky lighting was used in the 2012 open water season but is now being removed because the lights were experimental and replacement bulbs are no longer available. While ClearSky lighting had been proposed for use in offshore installations for the purpose of limiting attraction of migratory birds to significant light sources, this mitigation measure has not been demonstrated to provide significant benefits that offset the detriment to safety and operations of using non-standard lighting. As a result of this limited demonstrated benefit as a mitigation measure, the commercial production of ClearSky lighting has been terminated. The radar studies conducted during the 2012 drilling season did not suggest that the rigs represent an attractive hazard to migrating birds. Though bird strikes were recorded, they did not appear to be related to increased densities of birds around a local light source. These radar studies will be continued under EP Revision 2. For EP Revision 2, lighting on the drillship will be shaded to minimize disorientation and attraction of birds to the lighted drillship in order to reduce the possibility of a bird collision.*

- Drilling muds (fluids) will be recycled to the extent practicable based on operational considerations (e.g., whether fluid properties have deteriorated to the point where they cannot be used further) so that the volume of the spent fluid is reduced. *Shell will not recycle used drilling fluids from one drill site to the next because of space restrictions on the drillship and the need for multiple drilling fluid types.*
- Drilling mud (fluid) will be cooled to mitigate any potential permafrost thawing or thermal dissociation of any methane hydrates encountered during exploration drilling, if such are present at the drill site. *Removed as no permafrost has been observed in shallow hazards surveys or during drilling in 2012.*

Addition of the following mitigation measures:

- Helicopters will not operate at an altitude lower than 3,000 ft (914 m) within 1 mi (1.6 km) of walrus groups observed on land. *This is a new requirement in the Incidental Take Regulations (ITRs) promulgated by the U.S. Fish and Wildlife Service (USFWS) on 12 June 2013.*
- If aircraft must be operated below 1,500 ft (457 m) because of weather, the operator will avoid flying within 0.5 mi (805 m) of known walrus or polar bear concentrations. *This is a new requirement in the ITRs promulgated by USFWS on 12 June 2013.*
- Shell has developed an Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses. *This Plan was drafted and approved by the USFWS after EP Revision 1 was approved. These measures were implemented by Shell during drilling in 2012 and will be part of EP Revision 2.*
- Certain engines on *Discoverer* will be Tier-rated. *This change will reduce CO, VOCs, and hazardous air pollutants (HAPs).*

Changes to the following mitigation measures:

- Frequency of blowout preventer (BOP) performance tests has changed from 7 days to 14 days. *This change is consistent with 30 CFR 250.447(b).*
- The second relief well drilling vessel will be the *Polar Pioneer* if the primary drilling vessel is disabled and not capable of drilling its own relief well. *The Kulluk is not available as a relief well drilling unit.*
- Vessels will not operate within 1.0 mi (1.6 km) of walrus or 0.5 mi (0.8 km) polar bears when observed on land. *This change is required per new USFWS Chukchi Sea ITRs; previous distance for walrus on land was 0.5 mi (0.8 km).*
- The ACS and the nearshore response tug and barge will be located in or near Goodhope Bay, Kotzebue Sound. *Positioning the ACS in or near Goodhope Bay, Kotzebue Sound yields a response time to a well control incident at the Burger Prospect that is consistent with the time for the previously stated location for the ACS.*

3.0 RESOURCES AND CONDITIONS

Descriptions of the environmental conditions and the physical, biological and socio-cultural resources of the Burger Prospect that may be affected by the planned exploration drilling program under EP Revision 1 are provided in the EIA for EP Revision 1. The following subsections update the information on the resources and environmental conditions at the Burger Prospect where new information is available.

Additional information on the environmental conditions in the region can be found in the following NEPA documents which were not available when the EIA for EP Revision 1 was completed:

- Final Environmental Assessment for incidental take regulations walruses and polar bears in the Chukchi Sea (USFWS 2013)
- Environmental Assessment – Shell 2013 Ancillary Activities Survey, Chukchi Sea, Alaska. (BOEM 2013)
- Supplemental Draft Environmental Impact Statement on the effects of oil and gas activities in the Arctic Ocean (NOAA 2013b)
- Environmental Assessment for ancillary activities (Statoil shallow hazards surveys) in the Chukchi Sea (BOEMRE 2011a)
- Environmental Assessment (EA) for Shell’s 2012 Exploration Drilling Program in the Chukchi Sea (BOEM 2011)
- Final Supplemental Environmental Impact Statement (SEIS) Chukchi Sea Planning Area, Oil and Gas Lease Sale 193 (BOEMRE 2011c)

The only appreciable changes to the regional resources and conditions since these NEPA analyses and the previous EIA are largely regulatory in nature as follows:

- In a Ninth Circuit court ruling on 6 January 2013, all critical habitat previously designated for the polar bear by the USFWS was vacated and remanded back to the agency
- Effective 26 February 2013, the Arctic subspecies of ringed seal, which occurs in the Chukchi Sea, was listed as threatened under the Endangered Species Act (ESA)
- Effective 26 February 2013, the Beringia distinct population segment of bearded seals, which occurs in the Chukchi Sea, was listed as threatened under the ESA

These changes in regional conditions do not result in a material change to the prior impact analysis presented in the EIA for EP Revision 1.

New Activities in Kotzebue Sound

With EP Revision 2, Shell's exploration drilling program will involve some limited activities in Kotzebue Sound. These activities, which involve the installation of mooring buoys, the mooring of a small number of vessels, and conducting crew changes, are described in Sections 2.1 and 2.3. Analyses of impacts associated with these activities are provided in Section 4 of this document. These analyses are based on resource information provided in published materials and in meetings with representatives of Kotzebue. Prior published documents that have assembled and summarized information on the environmental resources and conditions in the Kotzebue Sound area include:

- Effects of Oil and Gas Activities in the Arctic Ocean DEIS (NMFS 2011)
- Kobuk-Seward Peninsula RMP / FEIS (BLM 2007)
- Subsistence Use of Fish and Wildlife in Kotzebue, a Northwest Alaska Regional Center (Georgette and Loon 1993)
- Marine Mammals of Kotzebue Sound and Southeastern Hope Basin (Frost and Lowry 1986)
- Subsistence Use Area Mapping of Ten Kotzebue Sound Communities (Schroeder et al. 1987)

Impact analyses provided in Section 4 rely on information in these documents, which are incorporated by reference.

New Field Surveys in the Chukchi Sea

Joint industry surveys known as the Chukchi Sea Environmental Studies Program (CSESP) have been conducted in the Chukchi Sea each year from 2008 through 2012. Environmental surveys have been conducted over four study areas known as the Burger Study Area, the Statoil Survey Area, the Klondike Study Area, and the Greater Hanna Shoal Study Area (new Figure 3.0-1). The Burger Study Area and the Greater Hanna Shoal Study Area encompass all of the Burger drill sites. Surveys conducted in these study areas included those for chemical and physical oceanography, benthic and plankton communities, fish, birds, and marine mammals (Table 3.0-2). The EIA for EP Revision 1 utilized data from the 2008 and 2009 surveys. Data from the 2010-2012 CSESP surveys are used below to update Sections 3.4 through 3.8.

Table 3.0-2 CSESP Studies in the Chukchi Sea 2008-2012

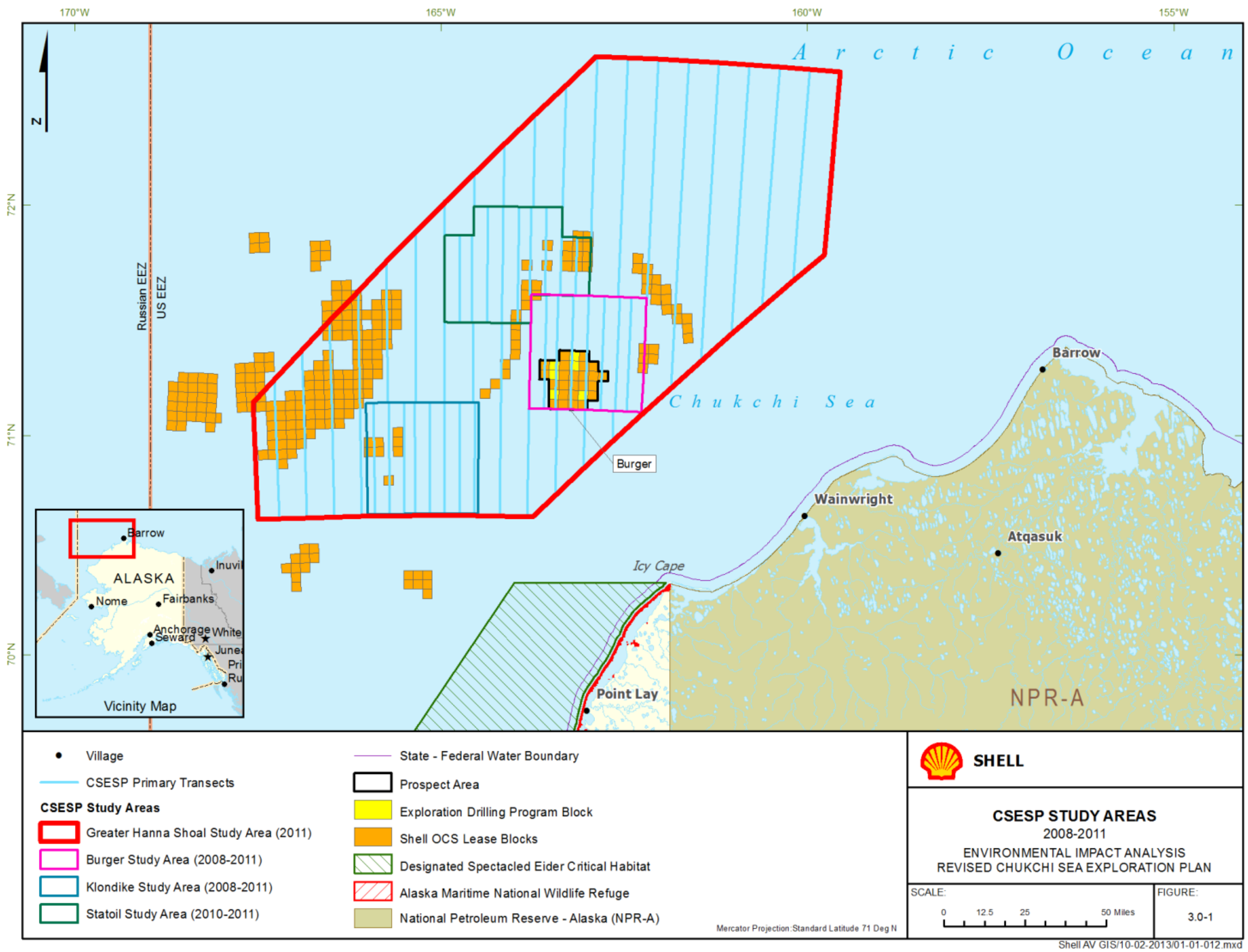
Study Area	Surveys Conducted by Year				
	2008	2009	2010	2011	2012
Burger	physical oceanography, sediment contaminants, benthos, plankton, fish, birds, mammals	physical oceanography, fish contaminants, benthos, plankton, fish, birds, mammals	physical & chemical oceanography, benthos, zooplankton, fish, birds, mammals	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals
Statoil	--	--	physical & chemical oceanography, benthos, zooplankton, fish, birds, mammals	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals
Klondike	physical oceanography, sediment contaminants, benthos, plankton, fish, birds, mammals	physical oceanography, fish contaminants, benthos, plankton, fish, birds, mammals	physical & chemical oceanography, benthos, zooplankton, fish, birds, mammals	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals
Greater Hanna Shoal	--	--	--	chemical oceanography, plankton, fish, birds, mammals	chemical & physical oceanography, benthos, fish, birds, mammals

A BOEM-sponsored two-year study, the Chukchi Sea Offshore Monitoring in Drilling Area: Chemical and Benthos (COMIDA CAB) study, of the sediment chemistry and benthic communities across the Lease Sale 193 Area was conducted in 2009 and 2010 with a final report published in 2012. The COMIDA CAB study area encompassed the Burger Prospect.

Annual aerial surveys for marine mammal across most of the Chukchi Sea, including the Burger Prospect, have continued through 2011 and 2012 as part of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project of BOEM and the National Marine Mammal Laboratory (NMML).

Data from these surveys and other studies have been used in this EIA to update information on existing conditions at the Burger Prospect where appropriate. When no additional information is available on a particular environmental resource or condition the reader is referred to the corresponding subsection in Section 3 of the EIA for EP Revision 1.

Figure 3.0-1 CSESP Study Areas



3.1 Meteorology and Air Quality

3.1.1 Climate

Shell collected meteorological data from a buoy deployed near the Burger Prospect during the open-water season in 2008 through 2012. The previous EIA summarized the data from 2008. That information is updated through 2012 in Figures 3.1.1-1 and 3.1.1-2. Winds have generally originated from the north-northeast 10.4 percent of the time, east-northeast 12.9 percent of the time, northeast 16.9 percent of the time, and east 8.1 percent of the time during this time period.

Figure 3.1.1-1 Wind Speed and Direction, Open-Water Season 2008-2012

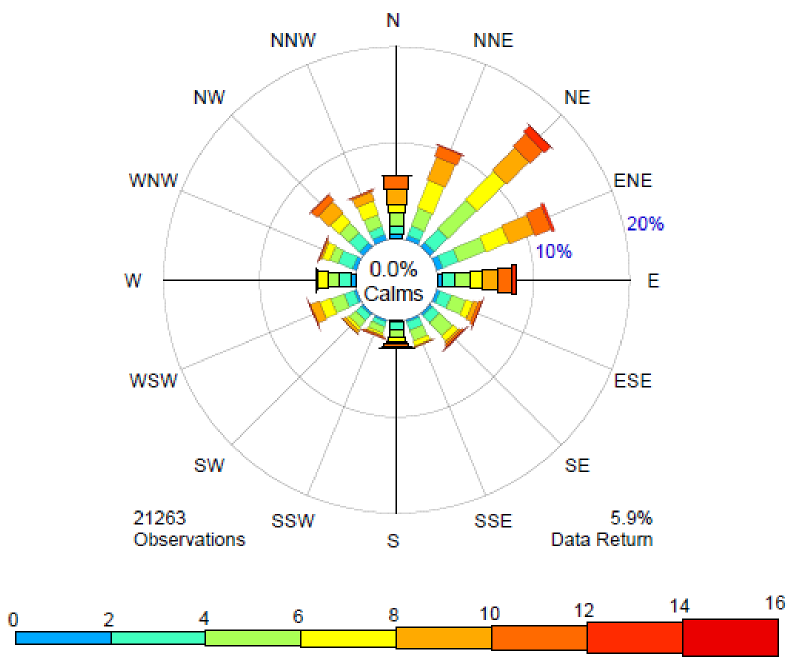
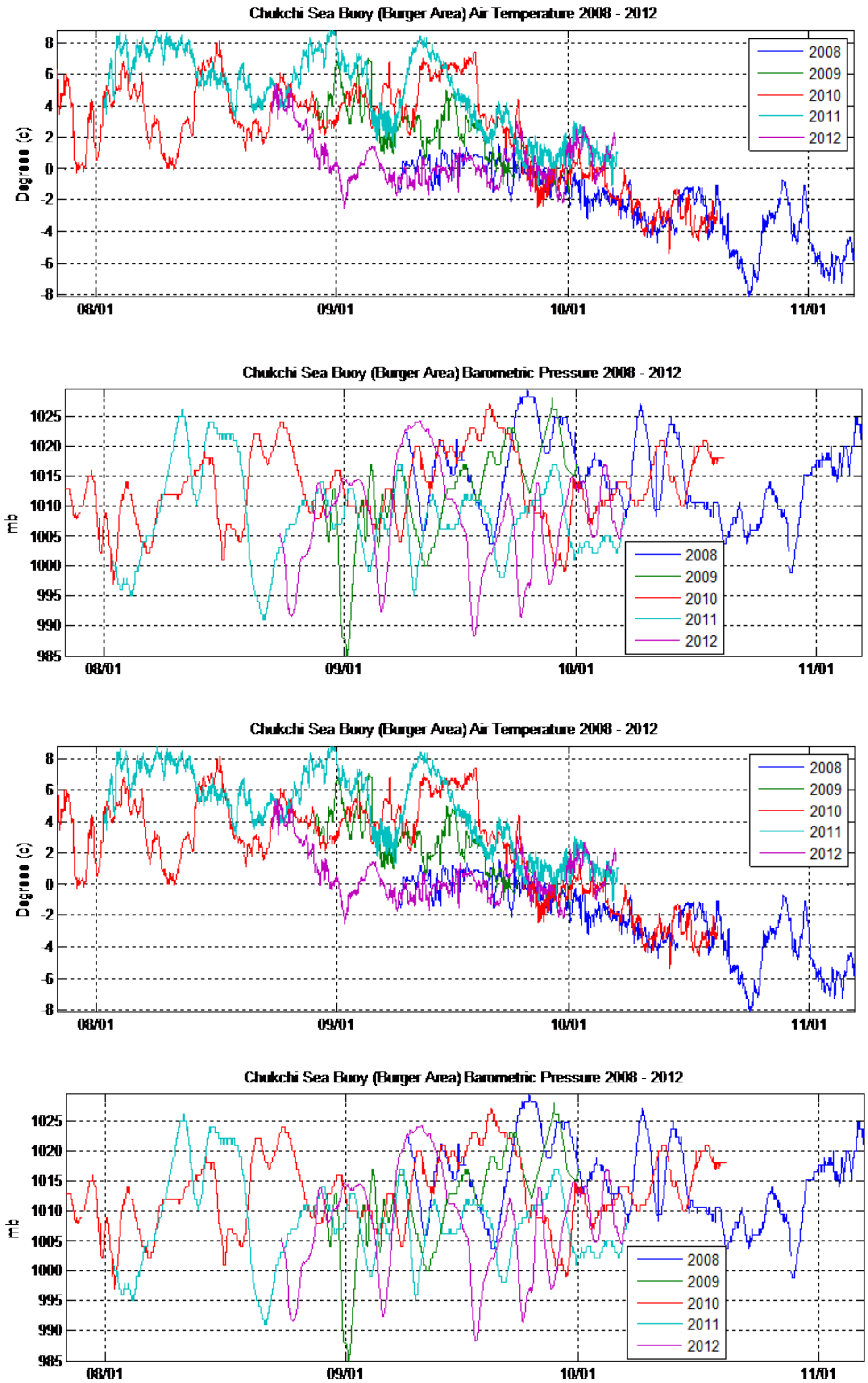


Figure 3.1.1-2 Air Temperatures and Barometric Pressure 2008-2012



Note: X-axis indicates measurement date (e.g., 08/01 = August 1, 09/01 = September 01, etc.).

3.1.3 Air Quality

Onshore Air Quality

Shell (AECOM, Inc. 2010a) established an air quality monitoring station at Wainwright in November of 2008 to collect data in support of air quality permitting efforts. Data for 2008-2010 were summarized in the EIA for EP Revision 1. Short-term average data (e.g., 1-hour, 3-hour, etc.) collected from July through November and full year annual average data for 2009 through 2011 are summarized and compared to the National Ambient Air Quality Standards (NAAQS) and Alaska Ambient Air Quality Standards (AAAQS) in Table 3.1.3-1. All measured concentrations of criteria air pollutants were well below NAAQS and AAAQS during these periods.

Table 3.1.3-1 NAAQS, AAAQS, and Measured Pollutant Concentrations at Wainwright in 2009-2011

Pollutant	Averaging Times	NAAQS [a]	AAAQS [b]	Wainwright [c] (2009-2011)	Wainwright [c] July-Nov (2009-2011)
CO	8-hr avg	9 ppm (10 mg/m^3) [d]	9 ppm [d]	1 ppm	1 ppm
	1-hr avg	35 ppm (40 mg/m^3) [d]	35 ppm[d]	1 ppm	1 ppm
NO_2	Annual (Arithmetic mean)	0.053 ppm (100 µg/m^3) [d]	0.053 ppm [d]	0.00075 ppm	0.001 ppm
	1-hr avg	0.1 ppm 0.2 (188 µg/m^3) [e]	0.1 ppm [e]	0.032 ppm	0.028 ppm
PM_{10}	24-hr avg	150 µg/m^3 [e]	150 µg/m^3 [e]	68 µg/m^3	57 µg/m^3
$PM_{2.5}$	Annual (Arithmetic Mean)	12 µg/m^3 [f]	15 µg/m^3	3.3 µg/m^3	1.5 µg/m^3
	24-hr avg 2005 std	35 µg/m^3 [e]	35 µg/m^3	18 µg/m^3	18 µg/m^3
O_3	8-hour avg 2008 std	0.075 ppm (150 µg/m^3)[e]	0.075 ppm[e]	0.05 ppm	0.05 ppm
SO_x [h]	Annual (Arithmetic mean)	Not Applicable	0.03 ppm (80 µg/m^3)	0.0003 ppm	0.0006 ppm
	24-hr avg	Not Applicable	0.14 ppm (365 µg/m^3)	0.004 ppm	0.002 ppm
	3-hr avg	0.5 ppm (1,300 µg/m^3) [g]	1,300 µg/m^3 [d]	0.007 ppm	0.005 ppm
	1-hr avg	0.075 ppm (196 µg/m^3)[d]	196 µg/m^3	0.007 ppm	0.006 ppm

[a] National Primary and Secondary Ambient Air Quality Standards, 40 CFR Part 50, February 22, 2013
[b] State of Alaska Ambient Air Quality Standards, 18 AAC 50.010, January 4, 2013
[c] Maximum measured values from station at Wainwright for 2009, 2010, and 2011 as reported in quarterly monitoring reports and electronic data provided in reports by AECOM, Inc. Seasonal July-Nov. data is represented by maximum values reported for 3rd and 4th quarters of 2009-2011
[d] No secondary standard
[e] Primary standard is the same as secondary standard
[f] Secondary standard for annual $PM_{2.5}$ is 15 µg/m^3
[g] Secondary standard
[h] SO_x measured as SO_2
[i] Reduced sulfur compounds measured as SO_2

Offshore Air Quality

Background concentrations of air pollutants are expected to be quite low in the drilling lease blocks of the Chukchi Sea because there are no permanent or substantive sources of pollution in the vicinity. The nearest land is 64 mi (103 km) from the lease area, and the ocean is uninhabited except for occasional small groups occupied with seasonal subsistence hunting and fishing. The Prudhoe Bay region is the major source of air pollution along the northern coast of Alaska, but it is located more than 300 mi (482 km) east of the Burger Prospect.

Air quality monitoring of offshore regions is extremely rare because monitors are typically located in regions where air pollution is a concern, such as urban industrialized areas. An exhaustive search reveals no source of offshore background monitoring data within the Arctic except upper atmosphere satellite data. Continuous monitoring at the surface would be difficult, costly, and impractical due to the extreme marine and atmospheric conditions that occur on the Arctic Ocean.

The only monitoring station that could be considered remotely representative to the offshore region in question is a U.S. IMPROVE monitoring station located in Simeonoff, Alaska, an island in the upper Aleutian chain. The IMPROVE monitoring network measures air quality and visibility in sensitive Class I areas within the U.S., which include relatively pristine national parks and wilderness areas. The Simeonoff station recorded $PM_{2.5}$ and PM_{10} background concentrations from September 2001 through December 2004. These concentrations, summarized in Table 3.1.3-3, may provide an indication of background particulate matter concentrations in a relatively pristine near-shore environment in western Alaska.

Table 3.1.3-3 Summary of Simeonoff IMPROVE Station Observations ($\mu g/m^3$) in 2001-2004

Observation	$PM_{2.5}$	PM_{10}
Records	363	365
Min.	0.33	0.95
Max.	16.41	26.5
Average	2.95	7.38
Standard Deviation	2.12	4.97
98th Percentile	9.34	21.9

Onshore ambient air quality monitors located on the North Slope of Alaska may also provide an estimate of the offshore background air quality at the lease blocks. However, due to the proximity to stationary industrial sources, vehicles, wind-blown dust, and other onshore sources, pollutant concentrations measured at onshore monitors would likely be much greater than measurements offshore. Therefore, the onshore data provides very conservative background values.

Onshore monitoring along the North Slope has been conducted sporadically over the past decade by commercial entities such as British Petroleum Exploration Alaska Inc., Conoco Phillips Alaska Inc., and Shell. These sites are concentrated near Prudhoe Bay, but a private station owned by Conoco Phillips Alaska Inc. was located in Wainwright, Alaska. The Wainwright site likely presents the most representative data for the lease blocks considering its proximity, but even these data sets are likely to significantly overstate offshore concentrations. Maximum values measured at the Wainwright site are reported in Table 3.1.3-1.

3.2 Oceanography and Water Quality (no change)

3.3 Geology and Shallow Hazards

3.3.1 Geology

Geology of the Lease Sale 193 Area in general and the Chukchi Shelf, which contains the Burger Prospect, is described in Section 3.3.1 of the EIA for EP Revision 1. The following subsections provide additional information relevant to the Burger Prospect.

Modern Sedimentation Rates

Feder et al. (1989) found modern sedimentation rates of 0.06-0.10 in. (0.16-0.26 cm) per year in the offshore areas of the Chukchi Sea EIA for EP Revision 1. Since then, Cooper and Grebmeier (2012) estimated an average sedimentation rate of ~0.25 cm per year based on core samples in 2009. This estimate was derived from sediment core samples throughout the COMIDA continental shelf study area and is consistent with previous work conducted in the Chukchi Sea area.

Sediment Quality

Sediments in the Chukchi Sea, including the area of Shell's Burger Prospect, are thought to have remained relatively free of pollutants such as metals. Naidu et al. (1997) collected samples of surficial sediments at 31 locations within the Chukchi Sea area, including samples from both the Lease Sale 193 Area and the nearshore coastal waters region, and analyzed them for concentrations of metals. This data was summarized in the previous EIA for EP Revision 1. Trefry et al. (2012) took 207 bottom samples from the eastern Chukchi Sea to test for concentrations of trace metals. Table 3.3.1-4 from the EIA for EP Revision 1 is updated below with the new data from Trefry et al. (2012).

Table 3.3.1-4 Mean Concentrations of Elements in Sediments of Circumpolar Arctic Seas

Shelf[1]	Sample size	Fe	Mn	Org C	Cu	Cr	CO	Ni	Zn	V
Chukchi Sea[2]	89	2.93	356	-	14	72	-	25	72	104
	SD	0.87	109	-	4	19	-	7	22	31
Chukchi Sea	12	3.46	295	0.75	22	82	26	27	79	116
	SD	0.64	37	0.44	6	21	5	6	18	30
Beaufort Sea	23	3.36	410	0.83	33	89	89	47	98	152
	SD	1.12	174	0.20	9	14	14	11	18	26
Pechora Sea	40	-	-	-	21	110	-	43	84	175
	SD	-	-	-	2	15	-	9	9	46
Kara Sea	36	-	-	-	20	110	-	42	-	147
	SD	-	-	-	6	25	-	10	-	27
Svalbard	15	-	-	-	-	153	-	50	107	248
	SD	-	-	-	-	5	-	1	3	11
E. Greenland	10	-	-	-	50	117	-	62	92	167
	SD	-	-	-	36	37	-	27	16	64
W. Baffin Is.	12	-	-	-	29	63	-	22	61	92
	SD	-	-	-	8	19	-	9	14	32

[1] Concentrations of iron and organic carbon are in milligrams per gram (mg/g); other elements are in μg/g
[2] Source: Trefry et al. 2012; all other Shelf locations from Naidu et al. 1997
SD – standard deviation, Fe iron, Mn manganese, org C organic carbon, Cu copper, CO carbon monoxide, Ni nickel, Zn zinc, V vanadium

A new study (Trefry et al. 2012) confirmed findings by Neff et al. 2010 that concentrations of all measured hydrocarbon types were well within the range of non-toxic background concentrations reported by other Alaskan and Arctic coastal and shelf sediment studies.

3.4 Lower Trophic Organisms

The following sections provide updated information from the CSESP surveys in 2010 and 2011. While additional data on species composition and abundance are now available, the description in the EIA for EP Revision 1 of the lower trophic organisms found in the Burger Prospect area remains largely unchanged.

3.4.1 Phytoplankton

Chlorophyll ‘a’ concentrations recorded in the Burger Prospect area during CSESP surveys from July through October 2008-2009 were summarized in Table 3.4.1-1 in the EIA for EP Revision 1; that information is updated with data from 2010 and 2011 below in the revised Table 3.4.1-1.

Table 3.4.1-1 Chlorophyll Concentration in the Burger Prospect 2008-2011

Time Period	Average Chlorophyll Concentration (mg / m[2]) [1]			
	2008	2009	2010	2011
July-August	104.8	21.4	42.7	43.5
August-September	47.1	20.1	40.2	29.3
September-October	30.9	25.1	42.2	--

[1] Source: Hopcroft et al. 2009, 2010, 2011, 2012
[2] Data for Burger Study Area, which encompasses all of the Burger Prospect

Planktonic communities were sampled at 25 stations in the 30 x 30 nmi (55 x 55 km) Burger Study Area from July-October 2008-2011 (Hopcroft et al. 2009, 2010, 2011, 2013). Observed concentrations of nutrients and chlorophyll indicated that the 2008 surveys took place during the spring phytoplankton bloom. In 2009, low concentrations observed throughout the entire water column indicated that the surveys were conducted post-phytoplankton bloom. In 2010 surveys near the Burger Prospect, high subsurface nutrients and chlorophyll persisted throughout the open water season (July through September), suggesting the phytoplankton bloom was still underway (Hopcroft et al. 2011). In 2011, subsurface nutrients and chlorophyll were present in August, but declined in September, indicating the bloom had already occurred (Hopcroft et al. 2013). It is speculated that differing water transport rates and their masses contribute to the differences between years. Historical chlorophyll values for the Lease Sale 193 Area are within 80-200 mg/m^2 (Dunton et al. 2005), but 2010 and 2011 values fell at the low end of this range or completely below it (Hopcroft et al. 2011, 2013).

3.4.2 Zooplankton

Planktonic communities were sampled at 25 stations in the Burger Study Area over Shell’s prospect from July-October 2008-2011 (Hopcroft et al. 2009, 2010, 2011, 2012). Information from the 2008 and 2009 surveys was summarized in Table 3.4.2-1 in the EIA for EP Revision 1. The following text and revised Table 3.4.2-1 update that information with data from the 2010 and 2011 CSESP surveys. The greatest numbers of taxa were observed in the copepods followed by the cnidarians (Table 3.4.2-1). Dominant taxa in the 150 µm and 505 µm nets were similar over the years and are summarized in Table 3.4.2-2 as updated below. Meroplankton formed a substantial part of the community in both abundance and biomass in both sampling years but was greatest in 2008 (Hopcroft et al. 2009, 2010).

In 2010, there was a large increase in several herbivorous and predatory copepod species, many of which have great value to vertebrates that feed on zooplankton (Hopcroft et al. 2011). In 2011, meroplankton groups declined, while large copepods increased. Analysis of water circulation patterns around Hanna and Herald Shoals, Barrow Canyon, and the Central Channel suggest a mechanism for transporting zooplankton species to the Burger area (Hopcroft et al. 2012).

Table 3.4.2-1 Diversity & Abundance of Zooplankton, Burger Prospect, August-October 2008-2011

Year	Number of Species [1,2]			Average Abundance [1,2]			
				Individuals/m^3		Dry Weight mg/m^3	
	Copepods	Cnidarians	Total Taxa	150 µm net	505 µm net	150 µm net	505 µm net
2008	20	9	76	3,330	189	18.5	11.4
2009	23	10	70	7,030	196	20.4	7.0
2010	25	11	77	16,712	158	115.0	33.7
2011	25	11	77	4,662	105	66.7	26.3

[1] Source: Hopcroft et al. 2009, 2010, 2011, 2012; no survey in 2012
[2] Number of species and average abundance in the Burger and Klondike Study Areas combined

Table 3.4.2-2 Top Zooplankton Taxa by Abundance & Biomass in CSESP Study Areas 2008-2011

Parameter	Net	2008 [1,2,3]	2009 [1,2,3]	2010 [1,2,3]	2011 [1,2,3]
Abundance	150 µm net	*Fritillaria borealis* *Pseudocalanus* spp. Barnacle larvae Calanoid copepod nauplii Bivalve larvae	*Fritillaria borealis* *Oithona similis* *Pseudocalanus* spp. *Limacina helicina* Calanoid copepod nauplii	Bivalve larvae *Pseudocalanus* spp. *Oithona similis* *Fritillaria borealis* Copepod nauplii	*Oithona similis* *Fritillaria borealis* *Pseudocalanus* spp. Copepod nauplii *Oikopleura vanhoeffeni*
Biomass	150 µm net	Barnacle larvae *Calanus marshallae* *Parasagitta elegans* *Pseudocalanus* spp. Polychaete larvae	*Calanus marshallae* Barnacle larvae *Parasagitta elegans* *Oithona similis* *Pseudocalanus* spp.	*Parasagitta elegans* *Calanis glacialis/marshallae* Hippolytid decapods *Catablema vesicarium* *Aglanta digitale*	*Calanus glacialis* *Parasagitta elegans* Barnacle larvae *Pseudocalanus* spp. *Aglanta digitale*
Abundance	505 µm net	Barnacle larvae *Fritillaria borealis* *Pseudocalanus* spp. *Oikopleura vanhoeffeni* *Calanus marshallae*	*Fritillaria borealis* *Calanus marshallae/glacialis* *Eucalanus bungii* Barnacle larvae *Parasagitta elegans*	*Calanus marshallae/glacialis* Barnacle larvae *Fritillaria borealis* *Aglanta digitale* *Parasagitta elegans*	*Calanus glacialis* *Oikopleura vanhoeffeni* *Aglanta digitale* Barnacle larvae *Parasagitta elegans*
Biomass	505 µm net	Fish larvae *Parasagitta elegans* *Calanus marshallae* *Aglantha digitale* Barnacle larvae	*Calanus marshallae /glacialis* *Thysanoessa raschii* *Aurelia aurita* *Cyanea capillata* *Mertensia ovum*	*Parasagitta elegans* *Calanus marshallae/glacialis* *Aglantha digitale* *Neocalanus cristatus* *Thysanoessa raschii*	*Calanus glacialis* *Parasagitta elegans* *Aglantha digitale* *Neocalanus cristatus* Crab larvae

[1] Source: Hopcroft et al. 2009, 2010, 2011, 2012; no survey in 2012
[2] Limited to top five taxa by abundance (numbers) and biomass
[3] Study areas in 2008 & 2009 were Burger and Klondike; Burger, Klondike and Statoil in 2010, and Greater Hanna Shoal in 2011 and 2012

Soft Corals

A soft coral, the sea raspberry (*Gersemia rubiformis*), was found at 10 of 58 benthic sampling stations in the CSESP Study Areas. It represented the 2nd most abundant epifaunal taxon by biomass and 8th most abundant taxon by number in the Burger Study Area (Blanchard et al. 2010a). This soft coral is abundant but forms rather discrete colonies in a patchy distribution (Blanchard and Knowlton 2013). The species is found worldwide from Antarctic to Arctic waters, including the Chukchi Sea, and has the widest distributional, temperature, and substrate preference range of any coral species found in Alaska. It is also considered common in waters north of the Alaska Peninsula. Colonies are formed from small polyps and are found attached to stones or shells (NOAA 2013a).

In August 2012, the Center for Biological Diversity petitioned the National Marine Fisheries Service (NMFS) to list 44 species of corals off the coast of Alaska as threatened or endangered under the ESA (the sea raspberry was not included in the petition). NMFS found that the petition did not present substantial information to indicate that a listing action was warranted for any of the requested species (NMFS 2013).

3.5 Fish Resources

Major studies of fish distribution and abundance in the northeastern Chukchi Sea have taken place in the last 50 years, culminating in the CSESP surveys (Norcross 2011, Priest et al. 2011a, NRC 2012). The CSESP (Figure 3.0-1) built on past studies (Alverson and Wilimovsky 1966, Quast 1972, Frost and Lowry 1983, Fechhelm et al. 1984, Barber et al. 1997), and continues to investigate the fish resources in the Chukchi Sea. These studies have documented the occurrence of more than 80 fish species in the northeastern Chukchi Sea (Barber et al. 1997, Gallaway et al. 2011). The CSESP and other studies documented fish that are largely restricted to marine habitats and diadromous migratory fish that utilize both marine and freshwater habitats.

Discussions regarding species of both types of fish that are found in the Lease Sale 193 Area and in Shell's Burger Prospect are provided below in Sections 3.5.1 and 3.5.2. This information has been updated with the results of CSESP surveys conducted in the Burger Prospect area in 2010-2012, which were not available when the EIA for EP Revision 1 was prepared.

3.5.1 Marine Fish

Updated information indicates over 80 fish species have been documented in the Chukchi Sea, Arctic cod dominate as the most abundant species (Barber et al. 1997, Gallaway et al. 2011, Priest et al. 2011a), and other species occur frequently. Some of the more common species are listed in Table 3.5.1-1 of the EIA for EP Revision 1. The distribution of marine fish species in the Chukchi Sea is driven by environmental factors, such as salinity, water depth, and percent of gravel in the sediments (Barber et al. 1997, Priest et al. 2011a), and often shifts as seasonal changes occur. The Chukchi Sea is influenced by water influx from the Bering Sea, importing fish and nutrients into the Arctic (Priest et al. 2011a). Species richness was found to be low when compared to non-Arctic communities. Both the number of species and fish biomass found in the northeastern Chukchi Sea are similar to the southern Chukchi Sea and Bering Sea, but the diversity is much lower due to the predominance of arctic cod and sculpins (Barber et al. 1997, Priest et al. 2011b).

Barber et al. (1994) surveyed demersal marine fish in the northeastern Chukchi Sea in 1990 and 1991; that information was provided in Table 3.5.1-2 of the EIA for EP Revision 1. The distributions of these marine fish assemblages in the Burger Study Area are indicated in the updated Figure 3.5.1-2 provided below.

Goodman et al. (2012) conducted pelagic and bottom trawls in 2011 across the Burger, Klondike, and Statoil Study Areas as part of the CSESP. They captured individuals of at least 20 species. In numbers, the five most abundant fish species captured when both trawl types were considered were Pacific sandlance, arctic cod, an unidentified eelblenny, capelin, and shorthorn sculpin. Abundance estimates of the most commonly captured fish species in the bottom trawls in the Burger Study Area are provided in Table 3.5.1-3 below. This is new information that was not in the EIA for EP Revision 1.

Figure 3.5.1-2 Fish Assemblages, EFH, and Anadromous Streams

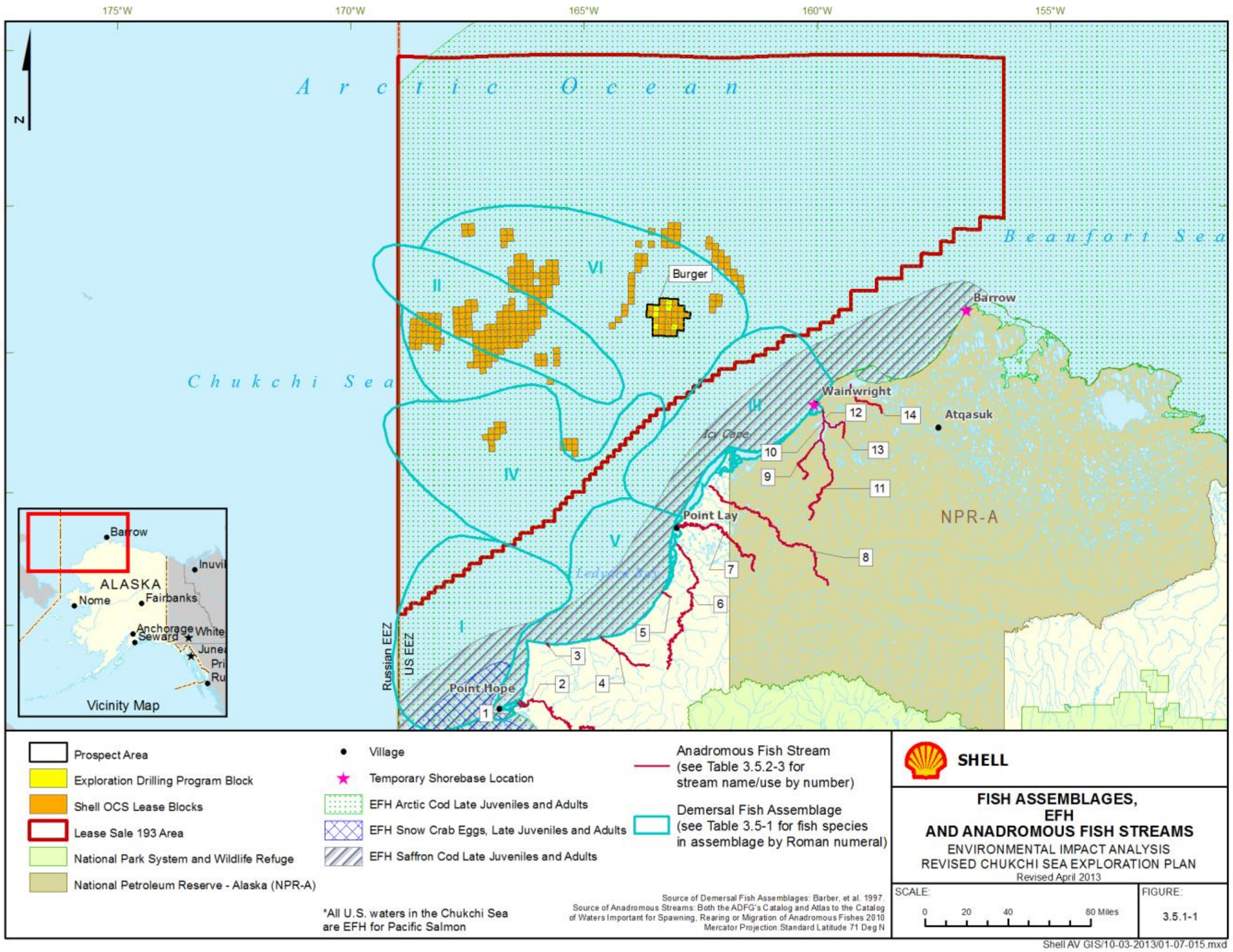


Table 3.5.1-3 Abundance of Major Fish Species in Burger Study Area Bottom Trawls

Bottom Trawl ID [2] (trawled in 2011)	Estimated Abundance (millions of fish/study area) of Major Fish Species Captured in Bottom Trawls in Burger Study Area in 2011 [1,2]			
	Arctic Cod	Capelin	Polar Eelpout	Marbled Eelpout
Burger 14B	7.30	1.83	0.00	3.65
Burger 15B	6.59	0.00	0.00	2.03
Burger 17B	2.67	0.00	0.53	0.53
Burger 18B	2.92	0.49	0.49	0.49
Total CPUE (fish/ac)	7.89	0.93	0.41	2.67
Total CPUE (fish/ha)	19.49	2.31	1.02	6.60
Average CPUE (fish/ac)	2.95	0.74	0.00	1.48
Average CPUE (fish/ha)	7.30	1.83	0.00	3.65

[1] Source: Goodman et al (2012), abundance is millions of fish per study area (Greater Hanna Shoal), CPUE is catch per unit effort
[2] Trawl identification number of each of the four trawls with a 400 Eastern bottom trawl conducted in Burger Study Area with a total trawled area of 308,899 ha.

3.5.2 Diadromous Fish

Diadromous fish of the northeastern Chukchi Sea include both anadromous and amphidromous forms. A recent study by Gallaway et al. (2011) confirms the information presented in Table 3.5.2-1 of the EIA for EP Revision 1.

The Alaska Department of Fish and Game's (ADF&G) catalogue of streams supporting anadromous fish species has been updated (Johnson and Daigneault 2012) identifying additional streams along the Alaskan Chukchi Sea coast as being used by anadromous fish species. Table 3.5.2-3 from the EIA in EP Revision 1 has been updated with this new information and provided below. Figure 3.5.1-2 of the EIA for EP Revision 1 has been updated to indicate the locations of these streams and is provided above. The nearest anadromous stream (Utukok River) is more than 90 mi (145 km) from the Burger drill sites.

Table 3.5.2-3 Northeastern Chukchi Sea Rivers Supporting Anadromous Fish Species

Stream Name [2]	Use by Selected Diadromous Fish Species [1]			
	Chum Salmon	Pink Salmon	Coho Salmon	Dolly Varden
1 - Sulupoaktak Channel		spawning	--	present
2 - Kukpuk River		spawning	--	present
3 - Ayugatak Creek		spawning	--	--
4 - Pitmegea River	spawning	spawning	--	present
5 - Kuchiak Creek	spawning	--	spawning	--
6 - Kukpowruk River	present	spawning	--	present
7 - Kokolik River	present	spawning	--	present
8 - Utukok River	present	spawning	--	present
9 - Ivisaruk River	--	spawning	--	--
10 & 11 - Kuk River	present	present	--	--
12 & 13 - Kungok River	present	present	--	--
14 - Kugrua River	spawning	spawning	--	--

[1] Source: Johnson and Daigneault 2012
[2] Stream number corresponds to identifier on Figure 3.5.1-2
[3] -- is not present

3.5.3 Essential Fish Habitat

The updated catalogue of anadromous streams (Johnson and Daigneault 2012) indicates that pink salmon are found in the Sulupoaktak Channel, Kukpuk River, Ayugatak Creek, Pitmegea River, Kukpowruk River, Kokolik River, Utukok River, Ivisaruk River, Kuk River, Kungok River, and Kugrua River, and small stocks of chum salmon are found in the Pitmegea River, Kuchiak Creek, Kukpowruk River, Kokolik River, Utukok River, Kuk River, Kungok River, and Kugrua River.

NPFMC (2009) designated EFH for arctic cod, saffron cod, and snow crab in 2009 with finalization of the Fishery Management Plan for Fish Resources of the Arctic Management Area. The EFH includes all areas of suitable habitat where the life stages are found within the stated geographic areas as indicated in Table 3.5.3-1 of the EIA for EP Revision 1, which is updated below, designated arctic cod and saffron cod EFH encompass most of the northeastern Chukchi Sea including Shell's Burger Prospect as shown in the updated Figure 3.5.1-2 (above).

Table 3.5.3-1 Designated EFH in the Northeastern Chukchi Sea

Species	Eggs	Early Juvenile	Late Juvenile	Adult
Arctic cod	-	-	Pelagic/epipelagic 0-1640 ft (0-500 m) and often deeper when associated with ice floes[2]	Pelagic/epipelagic 0-1640 ft (0-500 m) and often deeper when associated with ice floes[1]
Saffron cod	-	-	Pelagic/epipelagic 0-164 ft (0-50 m) with substrates of sand & gravel	Pelagic/epipelagic 0-164 ft (0-50 m) with substrates of sand & gravel
Snow crab	Inferred [2]	-	Pelagic/epipelagic 0-328 ft (0-100 m) south of Cape Lisburne with mud substrate	Pelagic/epipelagic 0-328 ft (0-100 m) south of Cape Lisburne with mud substrate

[1] Table 3.5.3-1 Limits of Arctic Cod EFH includes EFH on the continental slope and shelf. Table 3.5.3-1 in EIA for EP Revision 1 addressed only EFH on the continental shelf.

3.6 Coastal and Marine Birds

The Chukchi Sea and adjacent onshore areas are important habitat for non-breeding, staging, and migratory birds from May to September, including a number of species of alcids, gulls, terns, jaegers, loons, waterfowl, and shorebirds. Recent surveys have confirmed widespread bird use in coastal and offshore waters (Gall and Day 2012), and that distribution of seabirds particularly the planktivorous species, are strongly influenced by advective processes that transport oceanic species of zooplankton from the Bering Sea to the Chukchi Sea (Gall and Day 2011). The distances from the drill sites to the closest nesting colony are provided in the new Table 3.6-2 provided below.

Table 3.6-2 Distances from Drill Sites to Nearest Bird Colonies

Prospect	Distance to Nearest Bird Colony [1]					
	Peard Bay	Akoliakatat Pass	Icy Cape	Kasegaluk Lagoon	Ledyard Bay	Cape Lisburne
Burger A	106 mi (170 km)	83 mi (134 km)	75 mi (120 km)	79 mi (128 km)	149 mi (239 km)	183 mi (295 km)

[1] Distance to nearest bird colony by area as designated on Figure 3.6-1 in EIA for EP Revision 1

3.6.6 Bird Use of the Burger Prospect Area

Bird surveys have been conducted annually in four study areas in the northeastern Chukchi Sea in 2008-2011 as part of the CSESP; one of the 30 x 30 nmi (55 x 55 km) study areas, the Burger Study Area encompasses the Burger Prospect. The results of CSESP surveys for 2008 and 2009 were summarized in Section 6.6 of the previous EIA for EP Revision 1. That information is updated below with the results of CSESP surveys conducted in 2010-2012.

Bird species observed in the Burger Study Area in 2008 and 2009 were provided in Table 3.6.6-2 in the EIA for EP Revision 1. Table 3.6.6-2 is updated below to incorporate the results of the CSESP avian surveys conducted in 2010-2012. Densities of the most commonly observed species and total birds in the Burger Prospect area during the CSESP surveys are provided below in Table 3.6.6-3, which is also an updated table from the EIA for EP Revision 1.

Table 3.6.6-2 Bird Species Observed during CSESP Surveys in the Burger Prospect Area 2008-2012

Species	Year/Season Observed[1]		
	August	September	September-October
WATERFOWL			
Spectacled Eider	-	2009	2010
King Eider	-	2008, 2010, 2012	2008, 2010
Common Eider	2012	2008	2010
White-winged Scoter	-	-	2008, 2010
Long-tailed Duck	-	2008, 2009, 2010, 2012	2008, 2010
LOONS			
Red-throated Loon	-	2008, 2011	-
Pacific Loon	-	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010
Yellow-billed Loon	-	2008, 2009, 2010, 2011	2009
TUBENOSES			
Northern Fulmar	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010, 2012	2008, 2009, 2010
Short-tailed Shearwater	2009, 2010, 2011, 2012	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010
PHALAROPES			
Red Phalarope	2009, 2010, 2011, 2012	2008, 2009, 2010, 2012	2009, 2010
Red-necked Phalarope	2009, 2010, 2011, 2012	2008, 2009, 2010, 2011	2009
LARIDS			
Black-legged Kittiwake	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010
Ivory Gull	-	2012	2008
Sabine's Gull	2008, 2009, 2010, 2011, 2012	2008, 2010, 2012	2009
Ross's Gull	-	2009, 2011	2008, 2009, 2010
Herring Gull	2009	2009, 2010	2008
Glaucous Gull	2008, 2009, 2010, 2011	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010
Arctic Tern	2009, 2010, 2012	2008, 2009	-
Pomarine Jaeger	2008, 2009, 2010, 2011	2008, 2009, 2010, 2011, 2012	-
Long-tailed Jaeger	2009	2008, 2010	-
Parasitic Jaeger	2008, 2012	2010	-
ALCIDS			
Dovekie	-	-	2008, 2010
Common Murre	2011, 2012	2009, 2010, 2011, 2012	2009
Thick-billed Murre	2008, 2009, 2010, 2011	2009, 2010, 2011, 2012	2008, 2009, 2010
Black Guillemot	2008, 2010, 2011	2012	2008, 2010
Pigeon Guillemot	2008	-	-
Kittlitz's Murrelet	-	2010, 2011, 2012	2009
Parakeet Auklet	-	2010, 2012	2008, 2010
Least Auklet	2009, 2010, 2011, 2012	2008, 2009, 2010, 2011, 2012	2008, 2009, 2010
Crested Auklet	2009, 2010, 2011	2008, 2009, 2010,2011, 2012	2008, 2009, 2010
Ancient Murrelet	-	2010, 2011, 2012	2010
Horned Puffin	2008, 2009, 2010, 2012	2010	-
Tufted Puffin	2012	2010	-

[1] Source Gall and Day 2013, includes on-transect and off-transect observations within the study area

Table 3.6.6-3 Densities of the Common Birds in the Burger Prospect Area in 2008-2012

Species	Year	Season Observed [1,2,3]					
		August		September		September-October	
		birds/km^2	birds/mi^2	birds/km^2	birds/mi^2	birds/km^2	birds/mi^2
Phalaropes	2008	0.00	0.00	0.71	1.84	0.00	0.00
	2009	3.01	7.80	1.44	3.73	0.10	0.26
	2010	0.05	0.13	0.66	1.71	0.03	0.08
	2011	0.54	1.40	0.29	0.75	NS	NS
	2012	0.83	2.15	0.03	0.08	NS	NS
Northern Fulmar	2008	0.04	0.10	0.04	0.10	0.06	0.16
	2009	1.04	2.69	0.20	0.52	0.15	0.39
	2010	0.16	0.41	0.05	0.13	0.01	0.03
	2011	0.21	0.54	0.00	0.00	NS	NS
	2012	0.47	1.22	0.05	0.13	NS	NS
Shearwaters	2008	0.00	0.00	1.36	3.52	0.29	0.75
	2009	1.45	3.76	1.63	4.22	0.29	0.75
	2010	0.03	0.08	1.63	4.22	0.02	0.05
	2011	1.64	4.25	1.82	4.71	NS	NS
	2012	2.73	7.07	0.60	1.55	NS	NS
Black-legged Kittiwake	2008	0.09	0.23	0.63	1.63	0.10	0.26
	2009	0.13	0.34	1.66	4.30	0.15	0.39
	2010	0.10	0.26	0.27	0.70	0.00	0.00
	2011	0.05	0.13	1.15	2.98	NS	NS
	2012	0.09	0.23	0.52	1.35	NS	NS
Glaucous Gull	2008	0.04	0.10	0.16	0.41	0.12	0.31
	2009	0.06	0.16	0.39	1.01	0.37	0.96
	2010	0.04	0.10	0.06	0.16	0.07	0.18
	2011	0.01	0.03	0.10	0.26	NS	NS
	2012	0.00	0.00	0.33	0.85	NS	NS
Thick-billed Murre	2008	0.02	0.05	0.16	0.41	0.01	0.03
	2009	0.12	0.31	0.11	0.28	0.09	0.23
	2010	0.15	0.39	0.05	0.13	0.01	0.03
	2011	0.30	0.78	0.21	0.54	NS	NS
	2012	0.09	0.23	0.52	1.35	NS	NS
Least Auklet	2008	0.00	0.00	0.01	0.03	0.03	0.08
	2009	1.66	4.30	0.83	2.15	0.34	0.88
	2010	0.24	0.62	1.88	4.87	0.50	1.29
	2011	0.00	0.00	0.13	0.34	NS	NS
	2012	2.05	5.31	1.01	2.62	NS	NS
Crested Auklet	2008	0.00	0.00	0.01	0.03	0.17	0.44
	2009	30.16	78.11	26.57	68.82	0.13	0.34
	2010	4.66	12.07	3.74	9.69	5.16	13.36
	2011	1.73	4.48	9.48	24.55	NS	NS
	2012	24.83	64.31	3.46	8.96	NS	NS
Total Birds	2008	0.060	0.16	0.620	1.61	0.430	1.11
	2009	6.580	17.04	7.750	20.07	0.400	1.04
	2010	1.230	3.19	2.500	6.47	1.430	3.70
	2011	ND	ND	ND	ND	ND	ND
	2012	ND	ND	ND	ND	ND	ND

[1] Source: Gall and Day 2013
[2] Densities observed in the CSESP Burger Study Area, which encompasses Shell's Burger Prospect
[3] NS = no survey, ND = no data provided in cited report

The abundance of birds in the CSESP study areas was found to vary greatly across the years (new Table 3.6.6-5). Seabirds were most abundant in the Burger Study Area in 2009 and 2012 and least abundant in 2008; abundance was similar in 2010 and 2011, but generally lower than that in 2009 and higher than in 2008. Abundance also varied across season, but with no consistent pattern over the five survey years. The crested auklet was the most abundant bird during each of the five survey years (Gall and Day 2013). The investigators (Gall and Day 2013) reported the western portion of the Greater Hanna Shoal Study Area (Figure 3.0-1) including the Klondike Study Area appears to be a more pelagically-dominated system with a greater abundance of diving alcids and short-tailed shearwaters and higher biomass of copepods (in 2008–2010), while the northeastern half of Greater Hanna Shoal Study Area, including the Burger Study Area, appears to be a benthically-dominated system with a greater abundance of surface-feeding larids and higher abundance, biomass, and number of benthic taxa than seen to the south and west (Gall and Day 2013).

Table 3.6.6-5 Abundance of Marine Birds in the CSESP Burger Study Area 2008-2012

Season	Estimate of Total Bird Abundance in the CSESP Burger Study Area (birds/study area)				
	2008	2009	2010	2011 [2]	2012 [2]
August	800	116,800	17,300	14,000	98,900
September	11,500	106,600	26,800	45,000	24,400
September/October	7,000	7,400	19,400	--	--

[1] Source: Gall and Day 2013
[2] Surveys not conducted in September/October

Gall and Day (2012, 2013) compared the CSESP bird survey data from 2008-2010 to historical data from the same area collected in 1975–1981. Eight of the 10 most abundant species were shared between the two data sets. However, eight species recorded during the 2008-2011 surveys (king eider, common eider, white-winged scoter, red-throated loon, yellow-billed loon, red-necked phalarope, and pigeon guillemot) were not recorded on the historical surveys. The greater species richness recorded in the recent surveys is likely due to more intensive nature of the recent surveys (Gall and Day 2012). Total seabird abundance was found to have declined over this time period (37 years), with the abundance of omnivorous and piscivorous species declining and the abundance of planktivorous species generally increasing (Gall and Day 2013).

3.6.7 Important Coastal Avian Habitats in the Chukchi Sea

Some areas along the Chukchi Sea coast are particularly important habitat for a number of species. These areas remain unchanged from those identified in the EIA for EP Revision1.

Important avian habitats include nesting colony sites and locations where large numbers of birds congregate for staging, foraging, or molting, as well as migration routes. The locations of known coastal nesting colonies are shown in Figure 3.6-1 in the EIA for EP Revision 1. Distances from the Burger Prospect drill sites to other important avian habitat areas are identified below in the new Table 3.6.7-1.

Table 3.6.7-1 Distances from Drill Sites to Important Avian Habitats along the Chukchi Sea

Prospect [1]	Ledyard Bay LBCHU	Kasegaluk Lagoon SA	Peard Bay SA	Alaska Maritime NWR	HSWUA	Cape Lisburne Bird Colony
Burger	58 mi (93 km)	65 mi (104 km)	86 mi (138 km)	65 mi (104 km)	7 mi (12 km)	172 mi (277 km)

[1] Distance from sensitive area per Figure 3.9-1 to nearest drill site within the Burger Prospect

3.7 Mammals

Section 3.7 of the EIA for EP Revision 1 discusses both marine mammals that could be present in the Chukchi Sea near the project area, and terrestrial mammals using the Chukchi coastal areas during Shell's exploration drilling activities. Marine mammals found in the Chukchi Sea were listed in Table 3.7-1 of the EIA for EP Revision 1. The only change to that table is that the bearded seal and the ringed seal are both now "threatened" species and no longer a "candidate" species (see Table 3.8-1 below). The following section provides updated information on the occurrence of marine mammals in the area of Shell's Burger Prospect based on CSESP surveys in 2010-2012 and marine mammal monitoring reports from industry for 2010-2012.

Marine mammal observations from monitoring efforts associated with seismic surveys, development surveys and exploratory drilling activities in July-October, 2006-2012, in the Lease Sale 193 Area and near Shell's Burger Prospect are summarized in Table 3.7-3 (update of Table 3.7.3 in the EIA for EP Revision 1).

Table 3.7-3 Marine Mammals Observed by PSOs on Seismic and Support Vessels in the Northeastern Chukchi Sea during the Open Water Season 2006-2012

Species	Marine Mammal Sightings (Individuals) [1,2,3]							
	2006	2007	2008	2009	2010	2011	2012	Total
Ringed seal	718 (807)	117 (132)	228 (248)	38 (40)	69 (72)	20 (20)	79 (85)	1,269 (1,404)
Spotted seal	189 (228)	28 (44)	51 (57)	2 (2)	18 (24)	1 (1)	68 (79)	357 (435)
Bearded seal	265 (306)	56 (73)	124 (142)	17 (17)	178 (184)	59 (61)	149 (162)	848 (945)
Ribbon Seal	2 (2)	1 (1)	1 (1)	0	3 (5)	0	0	7 (9)
Pacific walrus	187 (1,275)	490 (3,421)	105 (791)	70 (131)	513 (1,572)	81 (147)	338 (8,678)	1,784 (16,015)
Harbor porpoise	22 (38)	11 (28)	18 (30)	3 (10)	5 (13)	0	1 (6)	60 (125)
Dall's porpoise	0	0	1 (5)	0	0	0	1 (4)	2 (9)
Killer whale	2 (7)	1 (1)	2 (2)	0	1 (2)	0	2 (5)	8 (17)
Beluga	4 (42)	0	1 (2)	0	0	1 (2)	1 (2)	7 (48)
Bowhead whale	27 (50)	7 (10)	18 (60)	1 (2)	19 (27)	0	117 (319)	189 (468)
Fin Whale	0	0	3 (6)	0	0	0	1 (1)	4 (7)
Gray whale	36 (91)	39 (75)	103 (226)	3 (3)	33 (103)	128 (256)	128 (256)	350 (787)
Humpback whale	0	4 (6)	2 (4)	0	1 (1)	0	2 (6)	9 (17)
Minke whale	8 (8)	5 (6)	26 (34)	0	9 (11)	0	10 (12)	58 (71)

1 Source: Funk et al. 2011 for 2006-2010, 2011 data from Hartin et al. 2011, 2012 data from Bisson et al. 2013
2 The number of times marine mammals of that taxon were observed (the total number of individuals of that taxon summed across all sightings) by the PSOs on seismic vessels, drillships, and support vessels during industry surveys in the open water season
3 Some values have changed since EIA for EP Revision 1 due to different cited sources or inclusion of mammals on ice

Vessel-based marine mammal surveys were conducted as part of CSESP in a survey area that encompasses Shell's Burger Prospect (Burger Study Area) in July-October 2008-2012. Results of the surveys conducted in 2008 and 2009 were summarized in Table 3.7-5 in the EIA for EP Revision 1. Table 3.7-5 (below) has been revised to reflect the results of surveys conducted in 2010-2012. Seal and cetacean sighting rates from these surveys are provided below in new Table 3.7-6.

Table 3.7-5 Marine Mammal Sightings during CSESP Surveys July-October 2008-2012

Common Name	Marine Mammal Sightings (Individuals) [1,2]					
	2008	2009	2010	2011	2012	Total
Ringed/spotted seal	161 (178)	67 (72)	67 (68)	127 (139)	280 (299)	702 (756)
Ringed seal	101 (116)	19 (19)	14 (14)	74 (74)	76 (88)	284 (311)
Spotted seal	55 (60)	16 (17)	24 (24)	53 (54)	53 (62)	201 (217)
Bearded seal	111 (116)	32 (33)	112 (114)	186 (188)	257 (263)	698 (714)
Ribbon seal	6 (6)	0	0	2 (2)	0	8 (8)
Unidentified seal	333 (467)	49 (49)	63 (65)	143 (150)	186 (191)	774 (922)
Pacific walrus	51 (967)	128 (314)	56 (133)	153 (289)	603 (4,709)	991 (6,412)
Unidentified pinniped	28 (32)	12 (12)	14 (14)	16 (16)	0	70 (74)
Unid. marine mammal	0	0	0	3 (3)	0	3 (3)
Harbor porpoise	3 (7)	2 (3)	1 (3)	2 (3)	6 (13)	14 (29)
Dall’s porpoise	1 (1)	2 (5)	0	0	0	3 (6)
Killer whale	2 (9)	0	0	6 (7)	3 (41)	11 (57)
Bowhead whale	2 (2)	2 (3)	36 (54)	15 (21)	75 (105)	130 (185)
Gray whale	15 (22)	42 (96)	14 (19)	8 (10)	79 (120)	158 (267)
Fin whale	0	1 (3)	0	0	6 (11)	7 (14)
Minke whale	1 (1)	3 (3)	0	3 (5)	3 (3)	10 (12)
Unidentified whale	9 (11)	3 (3)	3 (3)	6 (8)	108 (128)	129 (153)
Polar bear	7 (9)	3 (4)	3 (3)	0	14 (18)	27 (34)
Survey Effort	8,231 km	7,104 km	7,938 km	7,103 km	9,690 km	40,066 km
	5,115 mi	4,414 mi	4,932 mi	4,414 mi	6,020 mi	24,895 mi

[1] Source: Aerts et al. 2013
[2] Includes all observations, on-transect and off, in study areas and out

Table 3.7-6 Seal and Cetacean Sighting Rates in the CSESP Burger Study Area 2008-2012

Common Name	Sighting Rates (sightings/km) in July-October [1,2]				
	2008	2009	2010	2011	2012
Ringed/spotted seal	0.008	0.009	0.004	0.004	0.023
Ringed seal	0.004	0.004	0.000	0.001	0.010
Spotted seal	0.005	0.001	0.001	0.002	0.003
Bearded seal	0.016	0.007	0.013	0.007	0.036
Ribbon seal	0.001	0.000	0.000	0.000	0.000
Unidentified seal	0.015	0.006	0.008	0.009	0.033
Harbor porpoise	0.000	0.000	0.000	0.000	0.000
Dall’s porpoise	0.000	0.000	0.000	0.000	0.000
Killer whale	0.000	0.000	0.000	0.000	0.000
Bowhead whale	0.072	0.073	0.679	0.414	1.136
Gray whale	0.036	0.037	0.036	0.000	0.087
Fin whale	0.000	0.000	0.000	0.000	0.000
Minke whale	0.000	0.000	0.000	0.000	0.087
Unidentified whale	0.000	0.037	0.071	0.166	0.961
Survey Effort	2,500 km	2,686 km	2,714 km	1,031 km	1,144 km
	1,553 mi	1,669 mi	1,686 mi	641 mi	711 mi

[1] Source: Aerts et al. 2013

3.8 Threatened and Endangered Species

Effective 26 February 2013, the Arctic subspecies of ringed seal, and the Beringia distinct population segment (DPS) of bearded seals, both of which occur in the Chukchi Sea, were listed as threatened under the ESA. On October 3, 2013, USFWS announced a 12-month finding on a petition to list the Kittlitz’s murrelet; USFWS determined that the listing of the species is not warranted at this time (FR Vol 78 No.

192:6174). The ESA status of listed species found in the northeastern Chukchi Sea was provided in Table 3.8-1 in the EIA for EP Revision 1. Table 3.8-1 (provided below) has been updated to reflect these changes in listing status.

Table 3.8-1 ESA Designation of Species Present in the Chukchi Sea 2013

Common Name	Scientific Name	ESA Status	Extralimital (Yes/No)
Spectacled eider	*Somateria fischeri*	Threatened	No
Steller's eider	*Polysticta stelleri*	Threatened	No
Kittlitz's murrelet [1]	*Brachyramphus brevirostris*	Candidate	No
Yellow-billed loon	*Gavia adamsii*	Candidate	No
Ringed seal	*Phoca hispida*	Threatened	No
Bearded seal	*Erignathus barbatus*	Threatened	No
Pacific walrus	*Odobenus rosmarus divergens*	Candidate	No
Polar bear	*Ursus maritimus*	Threatened	No
Bowhead whale	*Balaena mysticetus*	Endangered	No
Fin whale	*Balaenoptera physalus*	Endangered	Yes
Humpback whale	*Megaptera novaeangliae*	Endangered	Yes

3.8.1 Spectacled Eider

Avian surveys conducted as part of CSESP study program (Gall and Day 2013) recorded one spectacled eider in each of 2009 and 2010 surveys in the Burger Study Area at the Burger Prospect during five years (2008-2012) of intensive surveys (24,896 mi / 40,066 km) in the Chukchi Sea (Figure 3.0-1).

3.8.2 Steller's Eider

Steller's eider use of offshore waters in the Burger Prospect area is unlikely but possible. None were observed during five seasons (2008-2012) of intensive avian surveys (21,656 mi / 34,851 km of survey transects) conducted as part of the CSESP studies in and around Shell's prospect (Gall and Day 2010, 2011).

3.8.3 Kittlitz's Murrelet

Sightings of Kittlitz's murrelets in the Burger Prospect area during CSESP surveys in 2008-2009 were summarized in the EIA for EP Revision 1. This information is provided below in the new Table 3.8.3-1, which reflects the results of surveys conducted in 2010-2012. A total of 84 Kittlitz's murrelets (Table 3.8.3-1) were observed in August-September during avian surveys conducted as part of the CSESP baseline surveys (Figure 3.0-1), 23 in the Burger Study Area that encompasses the Burger Prospect (Gall and Day 2012). These data indicate that Kittlitz's murrelet could occur in small numbers in the Burger Prospect during the planned exploration drilling program.

Table 3.8.3-1 Kittlitz's Murrelets Observed in the Chukchi Sea during CSESP Surveys 2008-2012

Study Area	Individuals Observed [1,2,3]					
	2008	2009	2010	2011	2012	Total
Klondike	0	1	3	6	1	11
Burger	0	6	1	14	2	23
Statoil	--	--	1	5	0	6
Greater Hanna Shoal	--	--	--	35	9	44
All	0	7	5	60	12	84

[1] Source: Gall and Day 2013
[2] Includes only birds seen on transects
[3] Survey linear distance: Klondike 6,168 mi (9,927 km), Burger 6,260 mi (10,075 km), Statoil 2,131 mi (3,429 km), Greater Hanna Shoal 2,088 mi (53,361 km), total 24,896 mi (40,066 km)of transects

3.8.4 Yellow-billed Loon

Yellow-billed loons could occur in small numbers in the Burger Prospect during the planned exploration drilling program. Sightings of yellow-billed loons in the Burger Prospect area during 2008 and 2009 CSESP surveys were summarized in the EIA for EP Revision 1. This information is provided below in the new Table 3.8.4-1, which incorporates the results of surveys conducted in 2010-2012. A total of 34 yellow-billed loons have been observed in the Burger Study Area that encompasses the Burger Prospect during 2008-2012 avian surveys (Table 3.8.4-1). Almost all of these observations occurred during August-September.

Table 3.8.4-1 Yellow-billed Loons Observed in the Chukchi Sea during CSESP Surveys 2008-2012

Study Area	Individuals Observed [1,2,3]					
	2008	2009	2010	2011	2012	Total
Klondike	4	10	0	0	0	14
Burger	2	24	0	8	0	34
Statoil	--	--	0	0	0	0
Greater Hanna Shoal	--	--	--	8	0	8
All	6	34	0	16	0	56

[1] Source: Gall and Day 2013
[2] Includes only birds seen on transects
[3] Survey linear distance: Klondike 6,168 mi (9,927 km), Burger 6,260 mi (10,075 km), Statoil 2,131 mi (3,429 km), Greater Hanna Shoal 2,088 mi (53,361 km), total 24,896 mi (40,066 km) of transects

3.8.5 Polar Bear

USFWS published a final rule on 7 December 2010 designating critical habitat for the threatened polar bear, effective 6 January 2011 (75 FR 76086-76137); however, on 10 January 2013 the US District Court for the District of Alaska, vacated and remanded the Final Rule to USFWS. There is currently no designated critical habitat for polar bears.

Small numbers of polar bears were observed in the area during the drilling of most of the historical exploration wells in the Chukchi (Table 3.7-2 in EIA for EP Revision 1), and while monitoring open water oil and gas surveys. The results of three additional years (2010-2012) of CSESP marine mammal surveys have become available since submittal of the EIA for EP Revision 1. A total of 34 polar bears have now been observed over the five seasons of marine mammals surveys conducted for CSESP (Brueggeman 2009a, 2010, Aerts et al. 2011, 2012, 2013). Twenty-seven of the observed polar bears were on pack ice and the remaining seven were sighted in the water; all of these observations occurred when sea ice was present.

3.8.6 Bowhead Whale

Shell's Burger Prospect is located seaward of most of the generalized spring migration route for the Western Arctic stock of bowhead whales. An updated Figure 3.8.6-1 shows bowhead whale seasonal movements. In the fall bowheads migrate westward along the U.S. Beaufort Sea coast across the Chukchi Sea to Russian waters and then south through the Bering Strait to the Bering Sea (Figure 3.8.6-1) (Citta et al. 2012). The EP lease blocks in Shell's Burger Prospect are located within the generalized fall migration route (Quakenbush et al. 2010).

Sightings of bowhead whales in the Burger Prospect area during CSESP surveys for 2008 and 2009 were summarized in Table 3.7-5 of the EIA for EP Revision 1. This information is updated below in the new Table 3.8.6-1 to reflect the results of subsequent surveys conducted in 2010-2012. A total of 185 bowheads were observed over all CSESP study areas during the five seasons of vessel-based marine mammal surveys, 55 in the Burger Study Area, which encompasses the Burger Prospect (Table 3.8.6-1).

Bowhead whales were only sighted twice in the Burger Study Area in 2008 and 2009, but were the most commonly observed cetaceans in 2010-2012. In 2008–2010, bowhead whales were only observed during their fall migration (late September or October), but bowheads were observed throughout the month of August and September in 2011 and 2012.

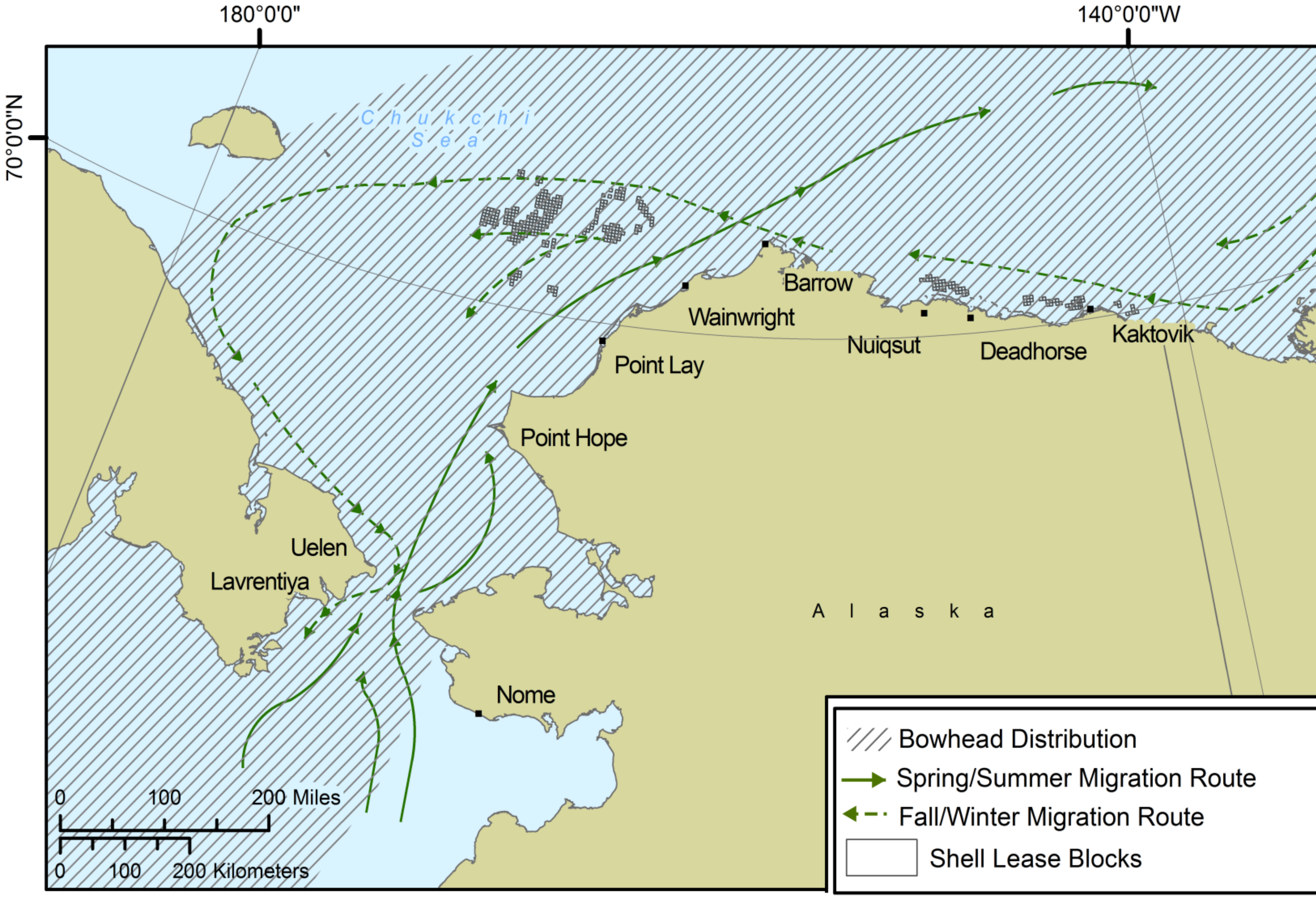
Bowheads were the second most commonly observed cetacean (second to the gray whale) in this area of the northeastern Chukchi Sea during marine mammal monitoring associated with seismic and shallow hazards surveys in 2006-2012 (Table 3.7-3 above). No bowhead whales were observed during monitoring surveys (Brueggeman et al. 1990, 1991b) conducted near exploration drilling in the Burger, Crackerjack, Klondike, and Popcorn Prospects in 1989 and 1990. These data indicate that small numbers of bowheads may be found in the Burger Prospect during Shell's planned exploration drilling program.

Table 3.8.6-1 Bowhead Whale Sightings and Sighting Rates during CSESP Surveys 2008-2012

Year	Burger Study Area [1,2]			
	Sightings	Individuals	Sightings/100 mi	Sightings/100 km
2008	2	2	0.116	0.072
2009	2	3	0.117	0.073
2010	19	28	1.093	0.679
2011	5	8	0.666	0.414
2012	13	14	0.962	1.136
2008-2012	41	55	0.620	0.385

[1] Source: Aerts et al. 2013
[2] Includes only whales observed on transects

Figure 3.8.6-1 Bowhead Whale Seasonal Movements



3.8.7 Fin Whale

Recently published range maps confirm that the Alaska stock of fin whales is restricted to the Gulf of Alaska and the Bering Sea in U.S. waters, and the southwestern Chukchi along the Russian coast (Allen and Angliss 2012). They are therefore considered to be extralimital in the Lease Sale 193 Area. However, they have recently been observed in the Lease Sale 193 area (Funk et al. 2011), and their range may be expanding.

Four groups totaling seven fin whales were observed in the Lease Sale 193 Area during the monitoring program for recent seismic surveys (Table 3.7-3 above), and they have been detected acoustically in the area in 2007 and 2009 (Hannay et al. 2009; Martin et al. 2008; Delarue and Martin 2009; D. Hannay pers. comm. 2010 in Aerts et al. 2012). Three sightings of fin whales were recorded within the Greater Hanna Shoal Study Area (Figure 3.0-1) while conducting the CSESP vessel-based marine mammal surveys during August and October 2008-2012 (Aerts et al. 2013). Fin whales could potentially occur in the Burger Prospect during the planned exploration drilling program but would not be expected.

3.8.8 Humpback Whale

A few humpback whales have been observed in the northeastern Chukchi Sea during monitoring for seismic surveys (Funk et al. 2011, Bisson et al. 2013), and during COMIDA aerial surveys in the Chukchi Sea (Clark et al. 2011, NMML unpublished reports 2012). No humpback whales were observed in the CSESP study areas while conducting baseline marine mammal surveys for the CSESP during August and October 2008-2012 (Aerts et al. 2013). Humpback whales could potentially occur in the Burger Prospect during the planned exploration drilling program but would not be expected.

3.8.9 Ringed Seal

On 28 December 2012, NMFS published a final rule listing the Arctic, Okhotsk, and Baltic subspecies as threatened and the Ladoga subspecies as endangered under the ESA (77 FR 76706 December 28, 2012). The only subspecies that occurs in the northeastern Chukchi Sea is the Arctic subspecies. NMFS has not proposed to designate critical habitat for the Arctic ringed seal, because it is not currently determinable.

Marine mammal monitoring while drilling legacy exploration wells in the Chukchi Sea have shown up to 402 ringed seals in the area of a single well site (Table 3.7-2 in EIA for EP Revision 1). Observers aboard industry vessels in 2006-2012 recorded a total of 1,404 ringed seals in the northeastern Chukchi Sea while monitoring seismic surveys and drilling activities (Table 3.7-3 above). A total of 311 were observed in July-October 2008-2012 during CSESP marine mammal surveys (Table 3.7-5). Densities of seals in the prospect area calculated from CSESP marine mammal surveys for 2008-2012 are provided in the new Table 3.8.9-1. It is likely that some ringed seals will occur in the Burger Prospect during the planned exploration drilling program.

Table 3.8.9-1 Ringed, Spotted, and Bearded Seal Densities in the Burger Prospect Area 2008-2012

Study Area	Year	Ringed/Spotted Seal [1,2]		Bearded Seal [1]		Ratio	
		Seals/mi^2	Seals/km^2	Seals/mi^2	Seals/km^2	Ringed/Spotted	Bearded
Burger	2008	0.127	0.049	0.096	0.037	57%	43%
	2009	0.083	0.032	0.036	0.014	70%	30%
	2010	0.041	0.016	0.083	0.032	33%	67%
	2011	0.070	0.027	0.060	0.023	55%	45%
	2012 [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]

[1] Source: Aerts et al. 2012 for 2008-2011 data
[2] Densities for ringed and spotted seals are combined as in many observations the species cannot be determined
[3] ND = no data provided in 2012 annual report

3.8.10 Bearded Seal

On 28 December 2012, NMFS published a final rule listing two distinct population segments (DPS) of the bearded seal (the Okhotsk DPS found in the Sea of Okhotsk and the Beringia DPS found in the Bering, Chukchi, and Beaufort Seas) as threatened (75 FR 76740). NMFS currently has not proposed to designate critical habitat for either the Beringia DPS or the Okhotsk DPS of bearded seals.

The occurrence of bearded seals is common and regular throughout the Chukchi Sea, including the area of Shell's Burger Prospect. PSOs aboard industry vessels recorded a total of 945 bearded seals in the northeastern Chukchi Sea while monitoring seismic surveys and drilling activities in 2006-2012 (Table 3.7-3 above). A total of 714 were observed in July-October 2008-2012 during baseline marine mammal surveys in the Chukchi Sea (Table 3.7-5 above). Observations during the CSESP surveys resulted in calculated bearded seal densities of 0.036-0.096 / mi^2 (0.014-0.037 / km^2) in the Burger Study Area (Table 3.8.9-1 above). These survey results indicate that is likely that some bearded seals will occur in the Burger Prospect area during the planned exploration drilling program.

3.8.11 Pacific Walrus

In 2009-2011, walrus concentrated in large haul outs, that at times exceeded 20,000 near Point Lay in late August thru September (Jay et al. 2012). A total of 16,015 walrus were observed in the vicinity of Lease Sale 193 Area over a period of seven years (2006-2012) by vessel-based PSOs while monitoring seismic surveys and drilling activities in this area of the northeastern Chukchi Sea (Table 3.7-3 above). A total of 6,412 were observed over five years (2008-2012) of CSESP marine mammal surveys in the northeastern Chukchi Sea (Table 3.7-5 above). Observed densities of walrus in the Burger CSESP Study Areas are presented below in the new Table 3.8.11-1.

Table 3.8.11-1 Walrus Densities in CSESP Burger Study Area 2008-2012

Year	Walrus/mi²	Walrus/km²	Walrus/mi²		Walrus/km²	
			Jul/Aug	Sep/Oct	Jul/Aug	Sep/Oct
2008 [1]	0.031	0.012	0.003	0.049	0.001	0.019
2009 [1]	0.070	0.027	0.096	0.013	0.037	0.005
2010 [1]	0.044	0.017	0.054	0.039	0.021	0.015
2011 [1]	0.647	0.250	0.054	0.262	0.021	0.101
2012 [2]	ND	ND	ND	ND	ND	ND

[1] Source: Aerts et al. 2012
[2] ND = no data provided in report for 2012 surveys

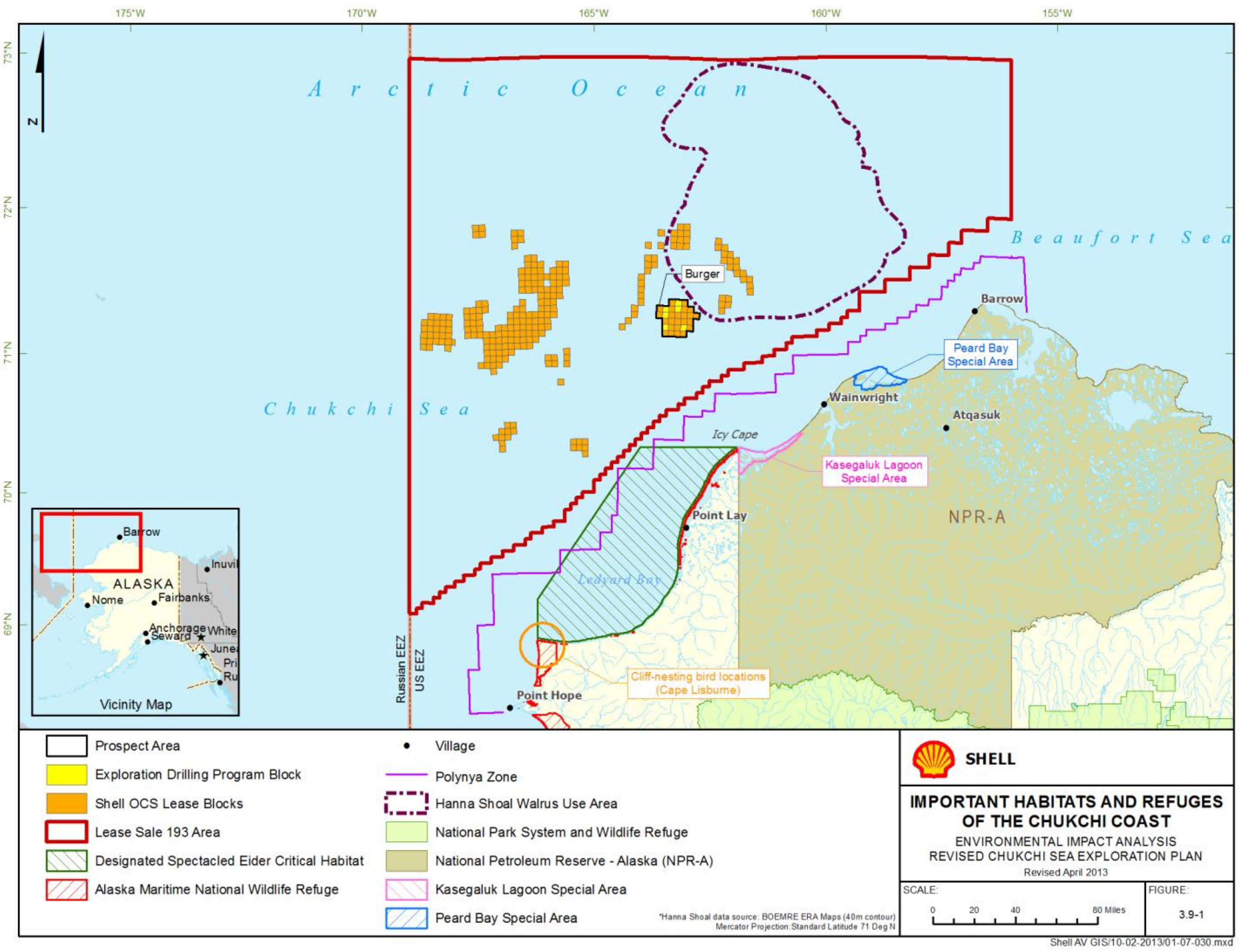
In 2007, 2009, 2010, and 2011, walruses were observed hauling out in large numbers with mixed sex and age groups along the Chukchi Sea coast of Alaska in late August, September, and October (Thomas et al. 2009; Service 2010, unpublished data; Garlich-Miller et al. 2011b; MacCracken 2012). Monitoring studies conducted in association with oil and gas exploration suggest that the use of coastal haulouts along the Arctic coast of Alaska during the summer months is dependent upon the availability of sea ice. For example, in 2006 and 2008, walruses foraging off the Chukchi Sea coast of Alaska remained with the ice pack over the continental shelf during the months of August, September, and October. However in 2007 and 2009, the pack ice retreated beyond the continental shelf and large numbers of walruses hauled out on land at several locations between Point Barrow and Cape Lisburne, Alaska (Ireland et al. 2009; Thomas et al. 2009; Service 2010, unpublished data; Garlich-Miller et al. 2011a), and in 2010 and 2011, at least 20,000 to 30,000 walruses were observed hauled out approximately 3 mi (4.8 km) north of the Native Village of Point Lay, Alaska (Garlich-Miller et al. 2011b). The likelihood of encountering a walrus in or near Shell's 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 Shell's Burger Prospect during the planned exploration drilling program.

During the process of developing and promulgating incidental take regulations under the Marine Mammal Protection Act (MMPA) for the Chukchi Sea, the USFWS delineated an area of heavy use by walrus that they termed the Hanna Shoal Walrus Use Area (HSWUA). The limits of the HSWUA were based on walrus utilization distributions determined from walrus tagged with satellite telemetry. USFWS overlaid the 50% utilization distributions in Jay et al. (2012) for both foraging and occupancy in the Hanna Shoal area, as defined bathymetrically by Smith (2011), for the months of June through September. The utilization distributions vary throughout this time period. Figure 3.9-1 from the EIA for EP Revision 1 has been updated (below) to indicate the greatest extent of the HSWUA, which totals approximately 9,500 mi² (24,600 km²).

3.9 Sensitive Biological Resources

There are still no areas in the immediate vicinity of Shell's Burger Prospect identified as being especially sensitive or productive as biological habitat. The locations of important habitats and refuges (including the HSWUA) in relation to the Burger Prospect are provided in an updated Figure 3.9-1.

Figure 3.9-1 Important Habitats and Refuges of the Chukchi Sea Coast



3.10 Cultural Resources (no change)

3.11 Socioeconomic Resources

3.11.8 Minority and Lower Income Groups

In 2010, a total of 365 out of 11,605 households in the NSB were below the poverty income threshold, a substantial increase since 2003 when the number of households was only 100 (NSB 2010). A higher percentage of Iñupiat households (23.2 percent) fall below the poverty income threshold level compared to all households (21.3 percent). Table 3.11.8-1 in the EIA for EP Revision 1 presented the number of households below the poverty level in 2003. This table has been updated to indicate poverty levels in the NSB villages closest to Shell's exploration drilling program (Barrow, Point Lay, Point Hope, and Wainwright) as of 2010, and is provided below.

Table 3.11.8-1 Poverty Levels in Barrow, Point Lay, Point Hope, and Wainwright 2010

Community	Poverty Level [1] (Number of Households)	Total Households Reporting [1]
Barrow	227	943
Point Lay	10	50
Point Hope	26	165
Wainwright	20	134

[1] Source: NSB 2010

4.0 ENVIRONMENTAL IMPACTS

Impact Factors and Screening Analyses

Based on a review of the project description, monitoring reports from past surveys, relevant literature, and impact factors identified in the EIA for the exploration drilling program, the following aspects of the exploration drilling program as described in EP Revision 2 were identified as having potential to impact the environment:

- air pollutant emissions
- vessel discharges
- aircraft traffic – presence and sound energy
- vessel traffic – presence and sound energy
- drilling sound
- drilling waste discharges
- shorebase presence

Associations of these impact factors with the program modifications detailed in EP Revision 2 are indicated in Table 4.0-1. Some exploration drilling program modifications detailed in Section 2 of EP Revision 2 are not listed in the table because they have no associated environmental impacts or because the impacts are also associated one or more other modifications and are addressed with respect to those modifications. For example, any potential environmental effects associated with changes in air jurisdiction in the OCS are addressed in the consideration of impacts associated with air pollutant emissions from vessel traffic, aircraft traffic, and shorebase construction/operation, and changes to mitigation measures are similarly considered in the assessment of potential impacts associated with changes in vessels and vessel routes, aircraft and aircraft routes, and changes in drilling fluids and drilling waste discharges. Substituting the relief well drilling unit will have no environmental impact.

Table 4.0-1 Impact Factors Associated with EP Revision 2

EP Revision 2	Impact Factor [1]						
	Air Pollutant Emissions	Vessel Discharges	Aircraft Traffic	Vessel Traffic	Drilling Sound	Drilling Wastes	Shorebase Presence
Vessels & Vessel Routes	Y	Y	--	Y	--	--	--
Aircraft & Aircraft Routes	Y	--	Y	--	--	--	--
Shorebases	Y	--	--	--	--	--	Y
Drilling Fluids & Wastes	--	--	--	--	--	Y	--
Drilling Sound Generation	--	--	--	--	Y	--	--
Relief Well Drilling Unit[2]	--	--	--	--	--	--	--

1 A (Y) indicates the impact factor is associated with the identified revisions to the exploration drilling program and may affect resources in the area

2 Under EP Revision 2, the *Polar Pioneer* will serve as the secondary relief well drilling unit and will not be in the Lease Sale 193 Area.

Environmental resources that could potentially be affected by the above-referenced impact factors are indicated below in Table 4.0-2. Information presented in Tables 4.0-1 and 4.0-2 was then used to identify the impact analyses to be addresses in this EIA for EP Revision 2. The results of this screening analysis are presented below in Table 4.0-3; a Y indicates the analyses that were conducted for this EIA. Potential direct and indirect impacts on these resources from the identified impact factors, as identified in the analyses, are described below in Sections 4.1 through 4.5. Cumulative impacts are addressed in Section 4.6.

Table 4.0-2 Environmental Resources Potential Effects from EP Revision 2

Resource	Impact Factor [1]						
	Air Pollutant Emissions	Vessel Discharges	Aircraft Traffic	Vessel Traffic	Drilling Sound	Drilling Wastes Discharges	Shorebase Presence
Air Quality	Y	--	--	--	--	--	--
Water Quality	--	Y	--	--	--	Y	--
Sediments	--	--	--	Y	--	Y	--
Lower Trophic	--	Y	--	--	Y	Y	--
Fish	--	Y	--	Y	Y	Y	--
Birds	--	Y	Y	Y	Y	Y	Y
Mammals	--	Y	Y	Y	Y	Y	Y
T&E Species	--	Y	Y	Y	Y	Y	Y
Sensitive Areas	--	Y	Y	Y	Y	Y	--
Subsistence	--	Y	Y	Y	Y	Y	Y
Socioeconomics	--	--	--	--	--	--	Y

[1] Cells with a (Y) indicate the impact factor could potentially affect the identified resource; a (--) indicates no potential effect

Table 4.0-3 Results of Screening Analyses – Impact Analyses Conducted in the EIA for EP Revision 2

Resource	Impact Analysis / EIA Section [1]					
	Vessels & Routes 4.1		Aircraft & Routes 4.2	Shorebase 4.3	Drilling Sound Generation 4.4	Drilling Fluids & Wastes 4.5
	Vessel Traffic	Vessel Discharges				
Air Quality	Y	--	Y	Y	--	--
Water Quality	--	Y	--	--	--	Y
Sediments	Y	--	--	--	--	--
Lower Trophic	--	Y	--	--	--	Y
Fish	Y	Y	--	--	--	Y
Birds	Y	Y	Y	--	--	Y
Mammals	Y	Y	Y	--	Y	Y
Sensitive Areas	Y	--	Y	--	--	Y
Cultural Resources	--	--	--	--	--	--
Subsistence	Y	Y	Y	--	--	Y
Socioeconomics	--	--	--	Y	--	--

[1] Cells with a (Y) indicate the analyses conducted for this EIA and described below in Sections 4.1 through 4.5

With few exceptions (e.g., mooring the ACS and other vessels in Kotzebue Sound), the impact analyses are limited to the theater of operations within the Chukchi Sea Planning Area. Shell's EP Revision 2 incorporates Shell's prior exploration drilling plan (EP Revision 1) with the minor revisions described in EP Revision 2. The effects analysis for each resource in Section 4 accounts for Shell's entire drilling program, including the changes set forth in EP Revision 2. A level of effects determination (i.e., negligible, minor, moderate, or major) is provided for each environmental resource. These determinations are based on the definitions provided in Appendix B of BOEM's EA for Shell's EP Revision 1 (BOEM 2011).

Air Quality Modeling, Impact Criteria, and Analysis

Shell conducted dispersion modeling of emissions associated with the drilling program as described in EP Revision 2. Two modeling efforts were conducted, one evaluating potential onshore air quality impacts and another evaluating potential impacts to offshore air quality in subsistence use areas. The modeling methods and results are described in the documents *Shell OCS Exploration Program – Chukchi Sea Air Quality Technical Report* (ENVIRON 2013a) and *OCS Exploration Program – Chukchi Sea Air Quality Technical Report* (ENVIRON 2013b) respectively (attached hereto as Attachments B and C). These modeling efforts were based on the emissions detailed in the report *Revised Outer Continental Shelf Lease Exploration Plan Chukchi Sea Alaska Emissions Inventory* (Air Sciences Inc. 2013), found in Appendix O of the EP. Criteria used in the assessment of level of impact to offshore air quality and other information concerning the air quality impact analyses are detailed in Attachment A of this document. The results of the dispersion modeling and impact analyses are summarized below in Sections 4.1.1, 4.2.1, and 4.3.1.

EP Revision 2 / Summary of Analyses

The EIA prepared in support of Shell's EP Revision 1 determined that the potential impacts of Shell's exploration drilling program to the environmental resources of the Chukchi Sea and the North Slope of Alaska would be minimal, ranging from no effect to minor effects for the various resources (Table 4.0-3 below). BOEM (2011) similarly determined the impacts range from negligible to minor (Table 4.0-3 below), and that none of the identified potential impacts were significant. The following section summarizes the findings of the analyses completed as part of the EIA prepared for Shell's updated exploration drilling program as described in EP Revision 2.

Table 4.0-4 Previous Impact Assessments of Shell's Exploration Drilling Program

Resource	BOEM EA (BOEM 2011)	EP Revision 1
Air quality	minor	minor
Water quality	minor	minor
Lower trophic	minor to moderate	minor
Fish and fish habitat	minor	minor
Birds and T&E birds	minor	negligible to minor
Marine mammals & T&E mammals		none to minor
Sensitive resources	--	no effect
Cultural resources	negligible	no effect
Socioeconomics	negligible	limited/minor
Subsistence	no to minor	negligible

Air Quality: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to alter air quality include changes in the number of support vessels (increased number of vessels and trips), changes to aircraft (increased trips), and changes to shorebases (expansion of Barrow man camp). As presented in the analyses below, which is supported by additional information included in EIA Attachments A, B and C, as well as Appendix O to EP Revision 2, Shell has concluded that the potential effects on air quality from the exploration program as described in EP Revision 2 are not significant, and will have only minor impacts on overall air quality (Table 4.0-5 below).

Table 4.0-5 Potential Effects of Shell's Exploration Drilling Program on Air Quality

Resources / Analyzed Activity	EP Revision 2	EP Revision 1
Air Quality	minor	minor
Vessel traffic and drilling	negligible	acceptable
Aircraft traffic	negligible	negligible
Shorebase expansion	negligible	--

Water Quality: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect water quality include changes in the number of support vessels (vessel discharges) and changes to drilling fluids and waste discharges (increased volumes of cuttings and drilling fluids). As presented in the analyses below, Shell has concluded that the potential effects on water quality from the exploration program as described in EP Revision 2 are not significant, and the potential overall effect of Shell's exploration drilling program on water quality will be negligible (Table 4.0-6).

Table 4.0-6 Potential Effects of Shell's Exploration Drilling Program on Water Quality

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Water Quality	negligible	minor
Drill cuttings and fluids	negligible	minor
Vessel discharges	negligible	minor

Lower Trophic Organisms: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect lower trophic organisms include changes in the number of support vessels (vessel discharges) and changes to drilling fluids and waste discharges (increased volumes of cuttings and additional drilling fluid components). As presented in the analyses below, Shell has concluded that the potential effects on lower trophic organisms from the exploration program as described in EP Revision 2 are not significant, and the overall effects of Shell's exploration drilling program on lower trophic organisms remains minor as described in the EIA for EP Revision 1 (Table 4.0-7).

Table 4.0-7 Potential Effects of Shell's Exploration Drilling Program on Lower Trophic Organisms

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Lower Trophic Organisms	minor	minor
Drill cuttings and fluids	minor	minor
Vessel discharges	negligible	negligible

Fish and EFH: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect fish or EFH include permitted vessel discharges, vessel traffic (mooring in Kotzebue Sound) and changes to drilling waste discharges (construction of the MLCs, changes in drilling fluids, and discharge of increased volumes of cuttings and drilling fluids). As presented in the analyses below, Shell has concluded that the potential effects on fish and EFH from the exploration program as described in EP Revision 2 are not significant, and the overall effect of Shell's exploration drilling program on fish and EFH is negligible (Table 4.0-8).

Table 4.0-8 Potential Effects of Shell's Exploration Drilling Program on Fish and EFH

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Fish and EFH	negligible	minor
Vessel traffic and drilling	negligible	little or no
Drill cuttings and fluids	negligible	minimal
Vessel discharges	negligible	minor

Birds: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect birds, including birds designated as threatened or endangered, include permitted vessel discharges, vessel traffic (avian collisions, disturbance, mooring in Kotzebue Sound) and changes to drilling waste discharges (construction of the MLCs, changes in drilling fluids, and discharge of increased volumes of cuttings and drilling fluids). As presented in the analyses below, Shell has concluded that the potential effects on birds from the exploration program as described in EP Revision 2 are not significant, and the overall effect of Shell's exploration drilling program on birds remains minor as described in the EIA for EP Revision 1 (Table 4.0-9).

Table 4.0-9 Potential Effects of Shell's Exploration Drilling Program on Birds

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Birds and T&E Birds	minor	--
Vessel traffic and drilling	negligible (disturbance), minor (collisions)	negligible (disturbance), minor (collisions) temporary
Aircraft traffic	negligible, brief	minor, short term
Drill cuttings and fluids	negligible	negligible
Vessel discharges	negligible	little or no direct, negligible indirect

Marine Mammals: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect marine mammals, including marine mammals designated as threatened or endangered, includes changes in the number of support vessels and travel corridors (vessel traffic, vessel discharges), changes in aircraft traffic and flight corridors (aircraft traffic), changes in estimates of the sound energy generated by vessels and drilling, and changes to drilling waste discharges (construction of the MLCs, changes in drilling fluids, and discharge of increased volumes of cuttings and additional drilling fluids components). As presented in the analyses below, Shell has concluded that the potential effects on marine mammals from the exploration program as described in EP Revision 2 are not significant, and the overall effect of Shell's exploration drilling program on marine mammals will be minor and short term (Table 4.0-10).

Table 4.0-10 Potential Effects of Shell's Exploration Drilling Program on Marine Mammals

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Marine Mammals and T&E	negligible	--
Vessel traffic and drilling	negligible	none to minor
Aircraft traffic	negligible	negligible to minor
Sound energy – drilling, ice mgt	negligible	short term disturbance
Drill cuttings and fluids	negligible	negligible
Vessel discharges	none to minor, temporary	--

Sensitive Area: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect sensitive biological resources and habitats includes changes in the number of support vessels (vessel traffic, vessel discharges), changes to aircraft and aircraft routes (aircraft traffic), and changes to drilling fluids and waste discharges (increased volumes of cuttings and drilling fluids). As presented in the analyses below, Shell has concluded that exploration drilling program as described in EP Revision 2 will have no effect on these resources (Table 4.0-11).

Table 4.0-11 Potential Effects of Shell's Exploration Drilling Program on Sensitive Resources

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Sensitive biological resources	none	none
Vessel traffic and drilling	none	none
Aircraft traffic	none	none
Drill cuttings and fluids	none	none

Cultural Resources: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect cultural resources includes changes in vessel traffic (mooring in Kotzebue Sound) and changes to drilling waste discharges (construction of the MLCs, and discharge of increased volumes of cuttings and drilling fluids). As presented in the analyses below, Shell has concluded that exploration drilling program as described in EP Revision 2 will have no effect on cultural resources (Table 4.0-12).

Table 4.0-12 Potential Effects of Shell's Exploration Drilling Program on Cultural Resources

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Cultural resources	none	none
Vessel traffic & drilling, mooring	none	none
Drill cuttings and fluids	none	none

Subsistence: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect subsistence resources and activities includes changes in the number of support vessels and travel corridors (vessel traffic, mooring in Kotzebue Sound, vessel discharges), changes in aircraft traffic and flight corridors (aircraft traffic), and changes to drilling waste discharges (construction of the MLCs, changes in drilling fluids, and discharge of increased volumes of cuttings and additional drilling fluids components). As presented in the analyses below, Shell has concluded that the potential effects on subsistence resources and activities from the exploration program as described in EP Revision 2 are not significant, and the overall effect of Shell's exploration drilling program on subsistence resources and activities remains as described in the EIA for EP Revision 1 (Table 4.0-13).

Table 4.0-13 Potential Effects of Shell's Exploration Drilling Program on Subsistence

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Subsistence	negligible	negligible, temporary
Vessel traffic and drilling	negligible	--
Aircraft traffic	negligible	--
Drill cuttings and fluids	none	none
Vessel discharges	negligible	--

Socioeconomics: The updates to Shell's exploration drilling program as described in EP Revision 2 with the potential to affect the socioeconomics in the Chukchi Sea villages are limited to the shorebase expansion. As presented in the analyses below, Shell has concluded that the potential effects on the socioeconomics in the Chukchi Sea villages is not significant, and the overall effect of Shell's exploration drilling program on the socioeconomics of the Chukchi Sea villages remains as described in the EIA for EP Revision 1 (Table 4.0-14).

Table 4.0-14 Potential Effects of Shell's Exploration Drilling Program on Socioeconomics

Resource / Analyzed Activity	EP Revision 2	EP Revision 1
Socioeconomics	negligible	limited
Shorebase expansion	negligible	none

4.1 Changes to Vessels and Vessel Routes

Direct and indirect effects of the support vessels and vessel routes with the planned exploration drilling activities as detailed in EP Revision 2 are described below.

4.1.1 Impact of Vessel and Drilling Emissions on Air Quality

The addition of six vessels (an ice management vessel, an anchor handler, a science vessel and a re-supply tug and barge, a support tug, and a nearshore OSR barge and tug) and changes to activity levels increases total emissions associated with the exploration drilling program. Emissions were calculated by Air Sciences (2013) for each of the engines and other emission units on board the *Discoverer* and associated vessels; including the vessels added as a part of EP Revision 2 (see Appendix O). Air quality modeling was conducted to estimate ambient concentrations of air pollutants resulting from the proposed drilling program at onshore locations and for the offshore areas used for subsistence hunting and fishing.

Through agreement with BOEM[3], CALPUFF was determined to be an appropriate model for use to simulate the dispersion of emissions from the *Discoverer* and its associated vessels because it is the EPA-recommended air quality dispersion model for distances greater than 31 mi (50 km). It should be noted that BOEM lists CALPUFF as an approved air quality model for the Gulf of Mexico OCS Region[4]. All onshore areas and offshore areas used for subsistence in the Program Area are located at distances greater than 31 mi (50 km) from the *Discoverer* drillship. CALPUFF requires three additional types of input information: emission source information, meteorological data and receptor locations. Meteorological data for CALPUFF are in the form of three-dimensional wind fields for each hour; the wind fields are generated by the Weather Research and Forecasting (WRF) model, developed by the National Center for

[3] Meeting held between Shell staff and BOEM on May 15, 2013 in BOEM's offices in Anchorage, Alaska.

[4] http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Gulf-of-Mexico-Region/Approved-Air-Quality-Models-for-the-GOMR.aspx

Atmospheric Research. Surface and upper-air meteorological data are used by the WRF model to create the three-dimensional wind fields. Separate modeling efforts with different receptors were conducted for onshore and offshore areas because different impact assessment criteria are appropriate for each geographic area. Details of the models, meteorological data sets and receptor locations can be found in two reports - one for the onshore receptors (ENVIRON 2013a) found in Attachment B, and a second report for the subsistence area receptors (ENVIRON 2013b) found in Attachment C.

The following section summarizes the results of these modeling analyses and evaluates the potential impacts to onshore and offshore air quality from emissions related to the exploration program. Potential impacts to air quality from aircraft associated with the exploration drilling program are discussed in Section 4.2.1, and impacts to air quality from shorebase expansions are described in Section 4.3.1

Potential Impacts to Onshore Air Quality

As discussed in Section 7 of EP Revision 2, Section 2.7 (above), Attachment A hereto, and Appendix O to EP Revision 2, the project emissions are less than the exemption formulas under the AQRP and no modeling is required under the AQRP regulations. Under NEPA, BOEM also evaluates impacts to air quality as a result of oil and gas activities on the Alaska OCS at the nearest onshore areas, particularly the area of maximum impact over an area of at least 7.7 mi^2 (20 km^2). According to BOEM's *Final Supplemental Environmental Impact Statement for Lease Sale 193* BOEM (BOEMRE 2011), 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 (NO_X); or

(2) design concentrations violate the NAAQS or the Alaska Ambient Air Quality Standards.

Concentrations were calculated at 5,034 receptors for the onshore air assessment. Maximum onshore concentrations, background concentration, and design concentrations (project emissions plus background) for each pollutant are summarized in Table 4.1.1-1. The modeling indicates that concentrations attributable to the *Discoverer* and its associated support vessels are far less than half the NAAQS and are far less than half the Maximum Allowable Increases (MAI) at all onshore receptors. Furthermore, design concentrations (maximum existing or background concentrations plus concentrations attributable to the exploration activity) are far less than the NAAQS. Based on this analysis, the impact of emissions of air pollutants associated with the exploration drilling program as described in EP Revision 2 is deemed to be not significant and will have only a minor impact on air quality at coastal villages or elsewhere on the North Slope.

Table 4.1.1-1 Maximum Predicted Concentrations at Onshore Receptors (µg/m³)

Pollutant	Averaging Time	Max. Conc.[1]	50% NAAQS Criteria	50% MAI Criteria	Background Conc.[2]	Design Conc.	NAAQS
NO_2	1-hour	7	96	NA	53	60	188
	Annual	0.007	50	25	2	2	100
PM_{10}	24-hour	1.4	75	30	57	58	150
$PM_{2.5}$	24-hour	1.4	17.5	9	18	19	35
	Annual	0.005	6	4	2	2	12
CO	1-hour	8	20,000	NA	1,145	1,153	40,000
	8-hour	4	5,000	NA	1,145	1,149	10,000
SO_2	1-hour	0.8	98	NA	16	17	196
	3-hour	0.6	650	512	13	14	1,300
	24-hour	0.2	182.5	90	5	5	365
	Annual	0.0006	40	20	2	2	80

[1]Averaged over a 20 square kilometer area

[2] See Table 3.1.3-1.

Potential Impacts on Offshore Air Quality

Pollutant concentrations were calculated at 1,800 receptors in the offshore subsistence use area. By agreement with BOEM, the areas to be evaluated for subsistence are the areas offshore in the Program Area and the coastal areas in between the two. The areas of offshore subsistence use in the Chukchi Sea are identified in Figure 3.11.7-11 of the EIA for EP Revision 1.

BOEM has not formally established impact criteria for offshore locations, and there are no examples of offshore air quality analyses conducted by BOEM in the Gulf of Mexico lease areas. As discussed in Attachment A, NAAQS are not appropriate offshore because (especially in the Chukchi Sea) this is a hostile environment and not accessible by the general public. Shell, therefore, proposes that conservative limits based occupational health criteria are appropriate measures of impact to subsistence hunters who may venture into the subsistence areas off the coast of Alaska because these individuals are present, if at all, only for limited periods of time and are comparatively healthier than the more susceptible population that NAAQS are designed to protect (see Attachment A).

Table 4.1.1-2 provides the maximum predicted offshore design concentrations at offshore subsistence area receptors attributable to the exploration program along with the applicable offshore impact criteria in the subsistence use area. Model-predicted design concentrations are far below these criteria for offshore receptors (see Attachment A); therefore, the impact of emissions of air pollutants associated with the exploration drilling program as described in EP Revision 2 is deemed to be not significant and will have only a minor impact on overall offshore air quality. The analysis evaluates the subsistence area because it is reasonable to expect human activity in this area. However, human presence is increasingly unlikely beyond the area modeled offshore. Consequently, locations seaward of the subsistence use area are not evaluated in this modeling assessment.

Table 4.1.1-2 Maximum Predicted Concentrations at Offshore Receptors

Pollutant	Averaging Time	Peak CALPUFF Model Predicted Offshore Subsistence Area Concentration ($\mu g/m^3$)	Background Concentration ($\mu g/m^3$)	Design Concentration ($\mu g/m^3$)	Offshore Impact Criteria ($\mu g/m^3$)[1]
Nitrogen Dioxide (NO_2)	1-hour	12.4	53	65	3,760
Particulate Matter (PM_{10})[2]	1-hour	5.9	143	149	500
Particulate Matter ($PM_{2\ 5}$)	1-hour	5.9	143	149	500
Carbon Monoxide (CO)	1-hour	10.8	1,145	1,156	55,000
Sulfur Dioxide (SO_2)	1-hour	1.3	16	17	5,200

[1] See Attachment A for additional detail.
[2] PM_{10} monitoring data is reported on a 24-hour basis because that is the averaging period for the NAAQS. To estimate hourly values, the "persistence factor" of 0.4 was applied to the monitoring data value of 24 $\mu g/m^3$. This value has historically been used with EPA's SCREEN3 dispersion model; when using SCREEN3, modelers multiply the 1-hour prediction by 0.4 to estimate daily emissions.

Greenhouse Gas Emissions

The estimated GHG emission for the *Discoverer* and support vessels is approximately 93,134 tons (Appendix O). The *Discoverer* and the support vessels combined projected CO_2 emissions will account for approximately 0.17 percent of the Alaska 2005 total statewide estimated GHG emissions of 53 million tons and 0.60 percent of the Alaska 2005 statewide oil and gas industry estimated GHG emissions of 15 million tons. The projected CO_2 emissions from the proposed Shell exploration drilling activities will be insignificant in relationship to the Alaska 2005 total statewide and Alaska oil and gas industry GHG/CO_2 emissions.

Arctic Haze

Arctic haze is a winter and early spring phenomenon caused by anthropogenic air pollution from the Eurasian continent. Because Shell's exploration drilling activities will occur in the Arctic summer and early fall months of July through October, Shell's exploration drilling activities will not contribute to Arctic haze.

4.1.2 Impact of Vessel Discharges on Water Quality

Support vessels being added to the exploration drilling program as part of EP Revision 2, will discharge wastewaters that are part of normal vessel operation into the Chukchi Sea. These vessels will be at various scattered locations across the Chukchi Sea when in transit or on standby, while the ephemeral impacts associated with vessel discharges will be generally limited to the area within 330 ft (100 m) of the vessel. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). Given the size of the Chukchi Sea and the distribution of the vessels, the increase of the number of support vessels and number of wells to be drilled will not appreciably increase the effect of discharges from the support vessels on the water quality of the Chukchi Sea.

Waste water discharges associated with the exploration drilling program as described in EP Revision 2 will be of the same types described in the EIA for EP Revision 1 and will include graywater (domestic wastewaters), blackwater (sanitary wastewaters), deck drainage, cooling water, bilge water, and ballast water. The increase in total volume of these discharges will be approximately commensurate with the increase in number of support vessels. In Federal waters, all such discharges will be conducted in accordance with requirements set forth in MARPOL and U.S. Coast Guard (USCG) regulations. Any discharges in State waters would be authorized by, and conducted under, the EPA's NPDES Vessel General Permit (VGP).

Revised estimates of graywater and blackwater discharges are provided in Table 4.1.2-1. Graywater includes wastewaters from showers, sinks, laundries, and galleys on the vessel. Graywater does not require treatment prior to discharge as only environmentally friendly soaps and solutions (phosphate free, water soluble, nontoxic, biodegradable) are used aboard the vessels. Organic compounds in the wastes will result in some increases in biological oxygen demand (BOD) in ambient waters and increased suspended solids. These effects will be limited to the area immediately surrounding the discharge location as they would be quickly diluted and dispersed due to the water depths and currents found in the Lease Sale 193 Area, and would last only minutes longer than the discharges.

Table 4.1.2-1 Graywater and Blackwater Discharge Estimates

Vessel	Crew Size	Graywater		Blackwater	
		bbl/well	bbl/program	bbl/well	bbl/program
Ice Mgt Vessel	82	6,248	43,733	1,339	9,371
Ice Mgt Vessel	82	6,248	43,733	1,339	9,371
Anchor Handler	64	4,876	34,133	1,045	7,314
OSV	50	3,810	26,667	816	5,714
OSV	50	3,810	26,667	816	5,714
Science Vessel	50	3,810	26,667	816	5,714
Landing Craft	22	1,676	11,733	359	2,514
Support Tug	13	990	6,933	212	1,486
Resupply Barge Tug	11	838	5,867	180	1,257
OSR vessel	41	3,124	21,867	669	4,686
OSR barge tug	6	457	3,200	98	686
OST	25	1,905	13,333	408	2,857
Nearshore OSR Tug	8	610	4,267	131	914
ACS Tug	10	762	5,333	163	1,143
ACS Barge	72	5,486	38,400	1,176	8,229
ACS Anchor Handler	64	4,876	34,133	1,045	7,314
All	650	49,524	346,667	10,612	74,286

[1] Based on 100 gal/crew/day graywater and 9 gal/crew/day blackwater, and total vessel berths as crew size

Blackwater discharges (Table 4.1.2-1) are subject to Section 302 of the Clean Water Act (CWA) and USCG regulations at 33 CFR Part 159. Primary pollutants of concern in blackwater are BOD, total suspended solids (TSS), coliform bacteria, and residual chlorine. No sanitary wastewater will be discharged in State waters within three miles of the coastline. Only blackwater that is first treated in a Type II marine sanitation device (MSD) will be discharged in Federal waters. Treatment will reduce coliform bacteria and suspended solids to levels to which are 100 colonies / 100 ml fecal coliform and 150 mg/L respectively, or lower, as stipulated by MSD regulations. Organic compounds in the wastes will result in some increases in BOD in ambient waters and increased suspended solids. Increases in BOD, TSS and chlorine will be limited to the area immediately surrounding the discharge location as they would be quickly diluted and dispersed due to the water depths and currents found at the prospect, and would last only minutes longer than the discharges. The impact of graywater and blackwater discharges associated with the exploration drilling program as described in EP Revision 2 is deemed to be not significant and will have only a negligible impact on overall water quality.

Deck drainage is water that collects on impervious surfaces of the vessel and consists largely of rainwater, sea spray, and washwater. Deck drainage is collected and discharged, except if it is contaminated with oil or grease then it is treated in an oily water separator before discharge. During a storm or high sea event, the contingency plan is to open up the rubber plugs and scuppers and allow discharge overboard as long as the deck drainage is not contaminated with oil or grease. The primary pollutant of concern in deck drainage is oil that could be entrained in the waters as they move across oily surfaces on the deck and elsewhere. Vessel operators will minimize the introduction of on-deck debris, garbage, residue and spill into deck washdown and runoff discharges. Machinery on deck will have coamings or drip pans to collect any oily water from machinery and prevent spills, and the drip pans must be drained to a waste container for proper disposal and/or periodically wiped and cleaned.

Seawater cooling systems use ambient seawater to absorb the heat from propulsion and auxiliary mechanical systems. The water is circulated through an enclosed system and does not come in direct contact with machinery, but still may contain small amounts of sediment from water intake and traces of hydraulic or lubricating oils. The temperature of the discharged cooling water is elevated over the temperature of the receiving seawater. Fluid Dynamix (2013a) modeled the thermal plume created by cooling water discharges from the *Discoverer*, which are much larger in total volume of than those associated with support vessels. The modeling results indicate that such discharges are only slightly warmer than ambient waters when returned to the environment, and that the cooling water quickly returns to ambient conditions due to rapid dilution and dispersion given the open water conditions. The modeling indicated that the small initial difference in temperature of approximately 2.5 °F (1.4 °C) would be reduced by 99 percent within 33-164 ft (10-50 m). Any measureable effects on water quality due to these discharges would be restricted to the immediate vicinity of the discharge.

Ballast water is seawater pumped into or out of ballast water tanks to manage vessel draft, buoyancy, and stability. Discharge volumes and rates vary by vessel type; larger vessels have ballast water capacities of over 6,000 bbl. Ballast water may contain rust inhibitors, flocculent compounds, epoxy coating materials, zinc or aluminum (from anodes), iron, nickel, copper, bronze, silver, and other material or sediment from inside the tank, pipes, or other machinery (EPA 2008). USCG regulations (33 CFR 151 Subpart D) mandate that vessel operators maintain a ballast water management plan, discharge the minimal volumes necessary for operations, clean ballast tanks regularly to remove sediments, and minimize or avoid uptake of ballast waters near sewage outfalls, areas of active dredging, or where propellers may stir up sediments. Given these requirements and practices, contaminants would be expected to be in low concentrations such that any effects on water quality would be negligible.

The EPA has evaluated the environmental impact of these types and quantities of vessel discharge in territorial seas as part of their NPDES program prior to issuing their general permits for vessels (VGP) and oil and gas exploration (EPA 2006, 2008, 2012), and concluded they would not result in unreasonable degradation of ocean waters of the Chukchi Sea, which means they will not result in:

- major adverse changes in the ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities;
- a threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms; or
- loss of aesthetic, recreational, scientific, or economic values.

Water quality effects of discharges of deck drainage, cooling water, ballast water, and bilge water, as described in EP Revision 2, is deemed to be not significant and will have only a negligible impact on water quality.

4.1.3 Impacts of Vessel Discharges on Lower Trophic Organisms

The discharge of sanitary and domestic wastes from vessels added to the exploration drilling program as described in EP Revision 2 will have little to no effect on lower trophic organisms. The discharges will be approximately the same as those associated with other support vessels described in the EIA for EP Revision 1. Some changes in water quality, such as increases in TSS, BOD, and chemical oxygen demand will occur but will be limited to the area immediately adjacent to the discharge site due to rapid dilution and dispersion into the water column. Discharges of sanitary and domestic wastewaters will increase the amount of organic materials and nutrients in the water, which could result in a brief increase in primary productivity.

Discharge of non-contact cooling water, ballast water, desalination unit wastes, and deck drainage would also have minor effects on water quality such as changes in temperature, salinity, and pH. These effects would largely be limited to the area within 328-656 ft (100-200 m) of the discharge location, and would not be expected to affect plankton or benthos in the area. Cooling water discharges will be only a few degrees above ambient and that difference will likely be reduced by 99 percent or more within 164 ft (50 m) of the discharge location. Some entrainment of meroplankton (larval fish and fish eggs) and zooplankton will occur in the seawater but entrainment effects would not be sufficient to result in a noticeable change in regional zooplankton or fish populations. Thus, these impacts are considered negligible and short term, lasting less than one year.

Under the United States ballast water management regulations 33 CFR151 Subpart D, all vessels equipped with ballast water tanks must develop and maintain a Ballast Water Management Plan. In Alaskan waters, 33 CFR 151 requires vessels traveling from international waters or from one Captain of the Port Zone (COTPZ) to another, undergo a mid-ocean exchange of ballast waters (or federally approved biocide or ozone) before entering the COTPZ to prevent exotic species from being brought from one ocean to another or into coastal waters. Shell's exploration drilling operations will be conducted in compliance with these regulatory mandates, which will minimize the risk of the introduction of exotic species and impacts to lower trophic resources.

As described in EP Revision 2, the numbers and total volume of these vessel discharges will increase as the number of operational and OSR vessels supporting the drilling unit *Discoverer* will be increased. These vessels will be at various locations across the Chukchi Sea when in transit and on standby. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). The ephemeral impacts associated with vessel discharges are generally limited to the area within 330 ft (100 m) of the vessel. Given the size of the Chukchi Sea and the distribution of the vessels, the increase in the number of support vessels will not appreciably increase the effect of discharges from the support vessels on the lower trophic organisms in the Chukchi Sea. No significant impacts on lower trophic organisms will occur from discharges of deck drainage, cooling water, ballast water and bilge water from vessels associated with the exploration drilling program described in EP Revision 2; all such impacts on lower trophic organisms will be negligible.

4.1.4 Impact of Vessel Discharges on Fish and EFH

The discharges of sanitary and domestic wastes from vessels added to the exploration drilling program as described in EP Revision 2 will have only negligible impacts on fish or EFH. Some changes in water quality, such as increases in turbidity, and biological and chemical oxygen demand, would occur in the area immediately adjacent to the discharge site, but would be limited due to rapid dilution and dispersion into the water column. These waste streams are not hazardous (see, e.g., discussion above detailing characteristics of discharges) so impacts to fish, if any, would be temporary and short term consisting largely of attraction or avoidance.

Discharge of non-contact cooling water, ballast water, desalination unit wastes, and deck drainage would also have minor effects on water quality such as minor changes in temperature, salinity, and pH. These effects would largely be limited to the area within 328 ft (100 m) of the discharge location, and would not affect fish in the area. Cooling water discharges will be only a few degrees above ambient and will likely reach ambient temperatures within about 164 ft (50 m) or less, of the outfall. Some entrainment of juvenile and larval fish and fish eggs could occur in the intake. Entrainment effects would not be sufficient to result a noticeable change in regional fish populations, the limited number of ballast water exchanges, and the high natural mortality rates. Any effects of permitted vessel discharges on fish would be negligible and temporary lasting only minutes or hours after the discharge ceases, likely consisting only of displacement of adult fish and some entrainment of eggs and larvae.

As described in EP Revision 2, the numbers and total volume of these vessel discharges will increase as the number of support vessels will be increased. However, these vessels will be at various locations across the Chukchi Sea when in transit and on standby. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). The ephemeral impacts associated with vessel discharges are generally limited to the area within 330 ft (100 m) of the vessel. Given the size of the Chukchi Sea and the distribution of the vessels, the increase in the number of support vessels will not appreciably increase the effect of discharges on fish and EFH in the Chukchi Sea. No significant impacts on fish or EFH will occur from discharges of sanitary and domestic wastes from vessels associated with the exploration drilling program described in EP Revision 2. The impact of discharges of sanitary and domestic wastes on fish and EFH will only have negligible impacts on fish and EFH.

4.1.5 Impact of Vessel Traffic (Mooring) on Sediments / Seafloor

Vessel traffic will generally have no effect on the seafloor, but the mooring of the drillship and vessels, and construction of MLCs will disturb seafloor sediments.

As described in EP Revision 2, several vessels including the resupply tug and barge, nearshore OSR barge and tug, the ACS, and a shallow water landing craft may be moored as a group at a coastal location. Two to four more mooring buoys may be installed at the location. These mooring buoys will be attached to the seafloor with mooring anchors that weigh approximately 20,000 lb (9,072 kg) or more. The anchors are expected to be embedment-type anchors and therefore designed to penetrate the seafloor to the depth of the anchor and drag through the seafloor sediments for a distance two or three times the anchor length itself before becoming firmly set in the seafloor. Setting the anchors and subsequent anchor removal disturbs the seafloor and commonly leave a depression on the seafloor, referred to as an anchor scar. The anchor chain will also be dragged along the seafloor creating a trough equal to the dragged chain length. The total scar is the sum of the anchor scar plus the chain scar. The dimensions of these scars vary with the size of the anchor, the length of the anchor chain and the consistency of the seafloor sediments. The mooring anchors are similar in size to those used on the *Discoverer* (see EIA for EP Revision 1); an anchor of this size could be expected to produce a scar with a seafloor area of 2,027 ft^2 (188 m^2) displacing 390 yd^3 (298 m^3) of seafloor sediments. A single anchor is required for each mooring buoy.

The physical manifestations of these anchor scars will attenuate after removal over time by the natural movement of seafloor sediments and ice scours. Duration is therefore dependant on water depth, currents, characteristics of the sea bottom sediments, and the frequency of ice gouging and sediment disturbance by biota such as gray whales, walrus, and benthic infauna. Durations on the order of five to ten years have been reported for anchor scars in low energy areas such as portions of the North Sea (DTI 2003). Centaur & Associates, Inc. (1984) reported that anchoring in sand or muddy sand sediments may not result in anchor scars or may result in scars that do not persist. A tentative location for the moorings has been identified in Kotzebue Sound near Goodhope Bay. Water depths near the location range from 36-48 ft (11-15 m), with muddy seafloor sediments. The physical effects of anchor scars would be restricted to a very small portion of the Chukchi Sea seafloor, and would be expected to be obscured in five to ten years. These moorings will not appreciably change to the total direct seafloor impact due to the exploration drilling program, which, as detailed in the EIA for EP Revision 1, was expected to be about 3.1 ac (12,619 m^2), and with the program changes as described in EP Revision 2 is now expected to be 3.4 ac (13,554 m^2). The seafloor impacts associated with Shell's exploration drilling program as described in EP Revision 2 are therefore expected to be negligible.

4.1.6 Impact of Vessel Traffic on Fish and EFH

There have been no documented cases of mortality to fish from vessel noise (Normandeau & Associates, Inc. 2012). Vessel traffic could, however, briefly disturb and displace fish. Fish have been shown to react when engine and propeller sounds exceeds certain levels (Olsen et al. 1983, Ona 1988, Ona and Godo 1990). Avoidance reactions have been observed in fish such as cod and herring when vessel sound levels were 110-130 dB (Nakken 1992, Olsen 1979, Ona and Godo 1990, Ona and Toresen 1988); however, others have reported that fish such as polar cod, herring, and capelin may be attracted to vessels (Rostad et al. 2006). Vessel sound source levels in the audible range for fish are typically 150-170 dB re 1 μPa/Hz (Richardson et al. 1995a). In calm weather, ambient sound levels in audible parts of the spectrum lie between 60-100 dB re 1 μPa.

Sound energy expected to be generated by support vessels associated with the drilling program were quantified and discussed in the EIA for EP Revision 1. Sound energy levels associated with transit of support vessels as described in EP Revision 2 are provided below in Table 4.1.6-1, similar information on other support vessels is provided in Table 2.6-2. Vessels in the exploration drilling program, including those added as described in EP Revision 2, would be expected to produce levels of 170-180 dB when in transit but received sound levels would be reduced to 160 dB within a few yards, and to 130 dB within 744-1,203 yd (680-1,100 m). Based on reported source levels for these types of vessels and ambient sound levels of 80-100 dB, there may be some avoidance by fish of the area near Shell's vessels when in transit. Any avoidance reactions will last only minutes longer than the vessel is at a location, and would be limited to a relatively small area (Mitson and Knudsen 2003, Ona et al. 2007).

Table 4.1.6-1 Estimated Sound Energy Radii from Added Vessels in EP Revision 2

Additional Vessel	120 dB		130 dB		160 dB		170 dB		180 dB	
	m	yd	M	yd	m	yd	m	yd	m	yd
Ice Mgt Vessel [1]	2,800	3,062	860	940	24	26	<10	<11	<10	<11
Anchor Handler [2]	9,500	10,389	4,600	5,030	44	48	<10	<11	<10	<11
OSV [3]	2,300	2,515	680	744	18	20	<10	<11	<10	<11
Science Vessel [3]	2,300	2,515	680	744	18	20	<10	<11	<10	<11
Resupply Barge Tug [4]	1,200	1,312	320	350	<10	<11	<10	<11	0	0
Nearshore OSR Tug [5]	610	667	160	175	<10	<11	<10	<11	0	0

[1] Best fit estimates of sound energy radii for the *Nordica* transiting at 12.1 kts, as determined from measured rms SPL versus range data in the Chukchi Sea (Austin et al. 2013)
[2] Best fit estimates of sound energy radii for the *Aiviq* transiting at 3.4 kts, as determined from measured rms SPL versus range data in the Chukchi Sea (Austin et al. 2013)
[3] Best fit estimates of sound energy radii for the *Sisuaq* transiting at 8.7 kts, as determined from measured rms SPL versus range data in the Beaufort Sea (Austin et al. 2013)
[4] Best fit estimates of sound energy radii for the *Lauren Foss* towing the *Tuuq* transiting at 6.5 kts, as determined from measured rms SPL versus range data in the Beaufort Sea (Austin et al. 2013)
[5] Best fit estimates of sound energy radii for the *Point Oliktok* transiting at 8.7 kts, as determined from measured rms SPL versus range data in the Beaufort Sea (Austin et al. 2013)

There are no commercial or recreational fisheries in the area that could be disrupted by such effects. Commercial fisheries are prohibited in the Chukchi Sea. No especially important spawning habitats are known to occur within the Lease Sale 193 Area. There are anadromous streams or intertidal and subtidal spawning areas that might be used by capelin or herring. Vessel traffic will occur in areas designated as

EFH for salmon, arctic cod, saffron cod, and opilio crab. Although vessel traffic will traverse EFH and could result in brief disturbance of fish, the vessel traffic would have no lasting effect on the habitat. Any impacts from vessel traffic on fish and fish habitat will be negligible, localized, and brief. As described in EP Revision 2, vessel traffic associated with the exploration drilling program will increase as the number of support vessels will be increased. These vessels will be at various locations across the Chukchi Sea when in transit and on standby. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area itself being 53,125 mi^2 (137,593 km^2). The ephemeral impacts associated vessel discharges are generally limited to the area within 330 ft (100 m) of the vessel. Given the size of the Chukchi Sea and the distribution of the vessels, the impacts of vessel traffic under EP Revision 2 will remain as described in the EIA for EP Revision 1. No significant impacts on fish or EFH will occur as a result of sound energy generated from vessels associated with the exploration drilling program described in EP Revision 2. The exploration drilling program as described in EP Revision 2 will have no negligible impacts on fish and EFH.

4.1.7 Impact of Vessel Discharges on Birds, Including Birds Designated as Threatened or Endangered

Vessel discharges associated with the vessels added to the exploration drilling program as described in EP Revision 2 will be conducted under MARPOL and USCG regulations. There will be no discharge of free oil, floating solids, or trash that could potentially oil, entangle, or otherwise affect marine birds. Only sanitary wastes treated in a MSD will be discharged. Food wastes, which could potentially attract birds, will not be discharged; food wastes will be incinerated on most vessels and the drillship. Discharges will result in slight changes in pH, temperature, TSS, and BOD within the immediate vicinity of the vessel, but these water quality effects would have no effect on birds. The effect of discharges from the vessels associated with the exploration drilling program as defined in EP Revision 2 on birds, including threatened and endangered birds, will be the same as described in the EIA for EP Revision 1. The discharges from the exploration drilling program as described in EP Revision 2 will have no or only negligible effects on birds and no effect on bird populations. Any indirect effects on bird prey or habitat would be negligible and short term, lasting only as long as the discharge is ongoing.

4.1.8 Impact of Vessel Traffic on Birds, Including Birds Designated as Threatened or Endangered

Vessel traffic could potentially affect birds though disturbance and displacement of resting, feeding, or nesting birds or by collisions of birds with vessels, as described below.

Avian Disturbance

Vessel traffic can disturb birds and temporarily displace foraging and resting birds. Some species such as some gulls are attracted to vessels. Disturbances from vessels are generally limited to the flushing of birds away from vessel pathways. Larger bird species generally have been found to have greater flushing distances and different types of vessels result in different flushing distances; flushing distances for some waterbird species have been shown to be 66-164 ft (20-50 m) for personal watercraft and 75-190 ft (23-58 m) for an outboard-powered boat (Rodgers and Schwikert 2002). As a vessel passes an area, birds will likely move some distance away and then soon after continue on with foraging and resting. Disturbances from offshore vessel traffic are generally short term, lasting only as long as the activity, and restricted to the immediate vicinity of the vessel. While there is some energetic cost associated with bird disturbance, the brief disturbance would have only negligible effect on birds and no effect on bird populations. Lacroix et al. (2003) investigated the effects of a marine seismic survey, including vessel traffic, on molting long-tailed ducks in the Beaufort Sea. The seismic program involved traffic of five vessels with lengths of 75-

135 ft (23-41 m), as well as the use of airguns behind some of these vessels. The survey program was found to have no effect on the movements, diving behavior, or site fidelity of the ducks.

Potential for effects due to vessel incursion is greater near bird nesting colonies where disturbance could result in lowered productivity due to nest abandonment, direct loss of eggs or chicks, increases in predation rates on eggs and chicks, and in important habitats where birds are concentrated for feeding, molting, or staging. Rojek et al. (2007) observed the responses of common murres and Brandt's cormorants at a nesting colony in California to commercial fishing boats. Disturbance of these birds occurred when vessels approached within 660 ft (200 m) of the colony, but most such disturbance consisted of head-bobbing and other alert behaviors. Nearly all of the disturbances occurred when vessels approached within 330 ft (100 m) of the colony; 78 percent of the disturbance events occurred when vessels approached to a distance of 164 ft (50 m).

As described in EP Revision 2, Shell's planned exploration drilling program in the Chukchi Sea involves a drillship, support vessels, and an OSR vessels. These vessels would generally be operating at slow speeds of 10 knots or less (<19 km/hr) along an established travel corridor. As vessels pass an area, birds would likely move some distance away and then soon after, continue on with foraging and resting. Most vessel traffic would take place offshore in the vicinity of the drill sites; the Burger drill sites are more than 64 mi (103 km) from shore where bird densities are relatively low. Bird species that will be most commonly encountered by vessels in offshore waters will likely be Pacific loons, northern fulmars, short-tailed shearwaters, black-legged kittiwakes, glaucous gulls, thick-billed murres, least and crested auklets. If the vessel transits closer to shore, other loon (red-throated loon) and waterfowl (long-tailed ducks, king eider, common eider) species are likely to be more commonly encountered. Disturbances from the vessel traffic will be short term lasting only about as long as the activity, and would occur in the immediate vicinity of the vessel and therefore a very small portion of the Chukchi Sea. Vessels will not traverse areas know to be especially important to resting, staging, or molting birds, such as Ledyard Bay or Peard Bay. All efforts will be expended to follow the established offshore travel corridor and avoid the polynya zone where bird densities tend to be higher than in areas further offshore. Disturbances from vessel traffic are not anticipated to result in bird mortality and will not affect birds on a population level.

Threatened and endangered species in the northeastern Chukchi Sea include Steller's and spectacled eiders, yellow-billed loons, and Kittlitz's murrelet. Disturbance of these birds will occur at very low frequencies based upon the frequency of observations of these species during five years of vessel-based avian surveys conducted in the area in 2008-2012. The frequency of observations of these birds during 7,125 mi (11,467 km) of vessel-based surveys in the Burger Study Area over the Burger Prospect is provided below in Table 4.1.8-1.

Table 4.1.8-1 Frequency of Observation of T&E Birds During CSESP Surveys at the Burger Prospect 2008-2012

Year	Kittlitz Murrelet birds observed /1,000 mi (km)				Spectacled Eider birds observed / 1,000 mi (km)				Yellow-billed Loon birds observed / 1,000 mi (km)			
	Burger [1,2]		Total [1,3]		Burger [1,2]		Total [1,3]		Burger [1,2]		Total [1,3]	
	km	mi	km	mi	km	mi	km	mi	km	mi	km	mi
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.6	2.2	3.5
2009	2.3	3.6	13.4	21.5	0.4	0.6	1.2	2.0	13.9	22.4	16.8	27.0
2010	0.3	0.5	2.8	4.5	0.6	1.0	1.0	1.7	0.3	0.5	2.1	3.3
2011	15.2	24.5	19.4	31.1	0.0	0.0	2.0	3.2	8.0	12.8	4.5	7.2
2012	2.3	3.7	5.2	8.3	0.0	0.0	2.6	4.2	0.0	0.0	3.2	5.1
All	2.7	4.4	8.1	13.0	0.3	0.4	1.4	2.2	4.5	7.3	5.5	8.9

[1] Source: Gall and Day 2013
[2] Birds observed within 300 m of vessel on and off transects on Burger Study Area July-October 2008-2012
[3] Birds observed within 300 m of vessel on and of transects on all Study Areas July-October 2008-2012

No disturbance of nesting colonies is expected to occur. The Burger drill sites are located more than 64 mi (103 km) from shore and more than 100 mi (160 km) from the large cliff nesting colonies in the Cape Lisburne area. Vessel traffic (Figure 2.1-1) will occur no closer than 50 mi (80 km) from these large cliff nesting colonies. Birds from these colonies are known to forage as far as 75 mi (120 km) from the colony, so vessel traffic could potentially result in some disturbance of these birds when foraging, but these effects would be negligible due to the small number of vessel trips per season.

Small colonies of arctic terns, glaucous gulls, horned puffins, and common eiders are located on spits and islands along the northeastern Chukchi Sea coastline. Most vessel traffic will occur far offshore. Any vessel traffic between the Burger Prospect and the Wainwright shorebase or the Barrow shorebase would bring the vessel no closer than 12 mi (20 km) of any identified nesting colony along the Chukchi Sea (Table 4.1.8-2) and should therefore have no effect on nesting birds.

Table 4.1.8-2 Distances from Prospect-Shore Vessel Routes to Nearest Nesting Colonies

Vesel Route	Distance from Vessel Route to Nearest Nesting Colonies							
Prospect to Wainwright	**Icy Cape Spit**		**Seahorse Island**		**E. Akoliakatat Pass**		**S.E. Spit Peard Bay**	
	40 mi	65 km	36 mi	57 km	32 mi	51 km	39 mi	62 km
Prospect to Barrow	**Pt Barrow Spit**		**Seahorse Island**		**Cooper Island**		**Deadmans Island**	
	10 mi	16 km	29 mi	47 km	25 mi	40 km	12 mi	20 km

[1] Source: Colony locations from Beringia Seabird Catalog (USFWS 2000)

Any disturbance impacts from vessel traffic on birds, including threatened and endangered birds, will be negligible, localized, and brief. Vessel traffic associated with the exploration drilling program will increase slightly as a result of the changes to the exploration drilling program as described in EP Revision 2, as the number of support vessels will be increased, the number of OSV trips will increase from 17 to 24, and a contingency vessel route from the Burger Prospect to Barrow has been added. The increased vessel traffic will result in an increased number of bird disturbances. However, the impact of increased vessel traffic on birds, including threatened and endangered birds, will be the same as described in the EIA for EP Revision 1.

Avian Collisions

Vessels and structures in open waters also pose a collision risk to some species of birds. Growing scientific evidence also indicates some bird species are attracted to certain light sources, increasing the risk of bird strikes. Most studies note that increased darkness, coupled with inclement weather, particularly foggy and misty conditions or low cloud cover, increases the attraction to lighted vessels and structures. Birds drawn to light sometimes become disoriented and collide with these structures, resulting in injury and death. Little information is currently available on the cause and effect of light-induced bird strikes. The most relevant studies in the Arctic Ocean are those assessing the behavior of birds at the Endicott and Northstar facilities (Day et al. 2005). Northstar and Endicott are oil production facilities located on artificial islands in nearshore waters of the Alaskan Beaufort Sea.

Shell monitored vessel surface areas for bird strikes during the 2012 exploration drilling programs in the Chukchi Sea and the Beaufort Sea. A total of 79 bird strikes were recorded at the drilling unit and support vessels while in the Chukchi Sea during the 2012 (Table 4.1.8-3). None of these strikes involved threatened and endangered species. Not all strikes resulted in fatalities; approximately 28 percent of the birds were alive when discovered and returned to the sea.

Table 4.1.8-3 Bird Strikes with the Chukchi Sea Fleet in the Chukchi Sea in 2012

Bird Strikes [1]					
Alcid [2]	**Passerine [3]**	**Seaduck [4]**	**Shorebird [5]**	**Tubenose [6]**	**Total**
1	47	23	5	3	79

[1] Source: d'Entremont et al. 2013
[2] Alcids included
[3] Eiders included king eiders, common eiders
[4] Passerines included arctic warbler, northern wheatear, unidentified
[5] Seaducks included long-tailed duck, common eider, king eider
[6] Shorebirds included red-necked phalarope
[8] Tubenoses included short-tailed shearwaters, storm-petrels

A similar number of bird strikes would be expected during future exploration drilling seasons. No bird strikes involving threatened or endangered species are expected. Under EP Revision 2, the number of vessels supporting the drilling unit *Discoverer* will be increased, re-supply trips will be increased from 17 to 24, and as a contingency there could be vessel-based crew changes between the Burger Prospect and Barrow. These changes could result in a slight increase in bird strikes, but the number of strikes in 2012 appeared to be more related to inclement weather than the number of vessels. These strikes would have no effect on local or regional bird populations as the numbers of mortalities are minute compared to overall population numbers and mortality rates experienced by these populations due to natural causes and hunting. The effects of avian collisions on bird populations would therefore be minor and temporary with no effect on birds, including those designated as threatened or endangered.

4.1.9 Impact of Vessel Discharges on Marine Mammals, Including Marine Mammals Designated as Threatened or Endangered

Vessel discharges associated with the vessels added to the exploration drilling program as described in EP Revision 2 will be conducted under MARPOL and USCG regulations. There will be no discharge of free oil, floating solids, or trash that could potentially oil, entangle, or otherwise affect marine mammals. Only sanitary wastes treated in a MSD will be discharged. Food wastes, which could potentially attract marine mammals, will not be discharged; all food wastes will be incinerated. Discharges will result in slight changes in pH, temperature, TSS, and BOD within the immediate vicinity of the vessel, but these water quality effects would have no effect on marine mammals, including marine mammals designated as threatened or endangered. The effect of vessel discharges associated with the exploration drilling program as described in EP Revision 2 on marine mammals, including threatened or endangered marine mammals, will be the same as described in the EIA for EP Revision 1. The discharges from vessels associated with the exploration program will have no or at most only negligible effects on marine mammals and no effect on marine mammal populations. Any indirect effects on marine mammal prey or habitat would be negligible and short term, lasting only as long as the discharge is ongoing.

4.1.10 Impact of Vessel Traffic on Mammals, Including Mammals Designated as Threatened or Endangered

Vessel Strikes

Most marine mammals actively avoid ships that are under way. Few vessel strikes of marine mammals have been reported in the Chukchi Sea. To minimize the potential for strikes, all Shell vessels will have PSOs onboard to assist in spotting marine mammals. The PSOs' observations will be used to help avoid marine mammals and possible vessel strikes. Per mitigation measures, vessels will reduce speed during inclement weather, and will reduce speed and avoid course changes when within 900 ft (274 m) of marine mammals. Vessels will also not operate when within 0.5 mi (0.8 km) of polar bears or walrus observed on land or ice.

Oil and gas exploration has been conducted in the Chukchi and Beaufort Seas for 30 years and there have been no reported marine mammal vessel collisions. Shell has successfully operated a large number of vessels in the Chukchi Sea since 2006, and conducted exploration drilling programs in 2012 without any marine mammal strikes. Further, George et al. (1994) examined subsistence-harvested bowheads and quantified how many of them had scars that appeared to have been inflicted by vessels. Among 236 whales examined between 1976 and 1992, they found two whales that exhibited evidence of past interactions with vessels, and one with questionable scarring. One carcass was reported more recently that appeared to have been struck by a vessel (Rosa 2009).

Collisions between ice seals and vessels have seldom been reported and would not be expected to occur with Shell's exploration drilling program. Sternfield (2004) documented only one ice seal stranding in Alaska from 1982 to 2004 that may have resulted from a propeller strike, and that incident involved a spotted seal that took a blow to the skull in Bristol Bay, Alaska.

With the continued implementation of the PSO program, the probability of a ship strike with a marine mammal occurring during the exploration drilling program is remote. Even if a ship strike were to occur, it would impact an individual animal, but would not affect animal populations in the project area. As described in EP Revision 2, re-supply trips will be increased from 17 to 24, and as a contingency there could be vessel-based crew changes between the prospect and Barrow. The resulting increase in vessel traffic does appreciably change the probability of a marine mammal strike. These effects therefore remain as described in the EIA for EP Revision 1 and are considered negligible.

<u>Vessel Disturbances of Baleen Whales, Including Baleen Whales Designated as Threatened or Endangered</u>

The results of four years of vessel-based marine mammal surveys in the northeastern Chukchi Sea are presented in Table 4.1.10-1. Based on these and other data, the most common occurrences of baleen whales in the area where vessel traffic will take place will likely be gray whales and bowhead whales. Small numbers of minke whales may also be encountered. Increased vessel traffic in the Chukchi Sea associated with EP Revision 2 could potentially result in behavioral disturbances of these whales.

Table 4.1.10-1Baleen Whales Observed in CSESP Study Areas, Chukchi Sea, July-October 2008-2012

Marine Mammal	Individuals Observed [1,2,3]							
	2008	2009	2010	2011	2012	Total	Ind / 1,000 km	Ind / 1,000 mi
Bowhead whale	2	3	30	15	46	96	3.58	4.38
Gray whale	4	1	2	2	2	11	0.41	0.48
Minke whale	0	1	0	2	1	4	0.15	0.24
Unidentified whale	0	1	3	5	77	86	3.21	5.17

[1] Source: Aerts et al. 2012
[2] Includes marine mammals seen on transects in four large study area: Burger (2008-2012), Klondike (2008-2012), Statoil (2010-2011), and Greater Hanna Shoal (2011-2012)
[3] Based on surveys along a total of 16,648 mi (26,792 km) of transects

Bogoslovskaya et al. (1981) observed avoidance behaviors by gray whales when vessels came within 980 ft (300 m), but saw no reaction to vessels further away. During a study by Schulberg et al. (1989), many gray whales showed no deflection or change of behavior until vessels came within 98 ft (30 m). Underwater sound may also elicit a response in whales to avoid vessels moving within their immediate area. Any avoidance responses due to vessel traffic are expected to be minimal and temporary. Gray whales may be present in and around the project area throughout the drilling season; however, concentrations of gray whales are often seen along the Alaskan Chukchi Sea coast near Icy Cape, particularly in the Peard Bay area. Gray whales also frequent areas near Hanna Shoal to the north of the Burger Prospect and use the area for feeding, although heavy use of this area has not been observed in recent years. These gray whale concentration areas are north and east of the drill sites and Wainwright and therefore would be expected to receive little vessel traffic. Vessels conducting contingency vessel-based crew changes (Figure 2.1-1) may traverse portions of these areas; however, this vessel traffic is only for contingency purposes and will therefore occur at very low frequencies if at all. It is unlikely that vessel traffic in the area will disturb feeding whales or cause avoidance of this area.

Palka and Hammond (2001) analyzed line transect census data in which the orientation and distance off transect line were reported for large numbers of minke whales. Minor changes in locomotion speed, direction, and/or diving profile were reported at ranges from 1,847-2,352 ft (563-717 m) at received levels of 110-120 dB. Based on past observations (e.g., Table 4.1.10-1) it is unlikely that minke whales will be encountered by vessels associated with the exploration drilling program as described in EP Revision 2; however, if such encounters occur they are expected to be in very low numbers and result in only temporary behavioral disturbances.

Reports of observations of the reactions of bowhead whales to vessels have been variable and somewhat contradictory; however, they indicate that vessel traffic often results in some temporary avoidance behaviors. When a vessel approaches a bowhead whale, the most likely response is to swim away from the vessel (Richardson and Malme 1993). Hobbs and Goebel (1982) reported that bowheads react more strongly to boats with outboard motors than to diesel ships. 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 et al. (1985b) studied the reactions of bowheads to small crew boats, fishing vessels, and large supply vessels and icebreakers in the Canadian Beaufort. The bowheads were found to react more strongly to vessel traffic than other industrial disturbances such as aircraft overflights and drilling. Most bowheads began to turn away when vessels approached within 0.6-2.5 mi (1-4 km) of the whale. The whales typically tried to outrun the boat; when the vessel was within a few hundred yards; the whales turned away from the vessel path or dove. Groups of whales scattered, fleeing generally stopped a few minutes after the vessel passed but the scattering was evident for a longer period of time – perhaps an hour or more. Additional behavioral responses to vessel traffic included changes in respiration rates. Similar responses to vessels have been observed in fin (Ray et al. 1978 in Richardson et al. 1985b) and humpback whales (Baker et al. 1983 in Richardson et al. 1985b).

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. On two occasions, the support vessel passed within 0.6-1.9 mi (1.0-3.0 km) of the whales, all of which moved directly away from the vessel, some as far as 2.5-3.7 mi (4.0-6.0 km). 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 was little if any effect on use of the area by whales.

Wartzok et al. (1989) followed radio-tagged whales in the Canadian Beaufort and observed their response to vessel traffic. They reported that bowheads generally ignored a small ship at distances greater than 1,640 ft (500 m). Over 180 whales voluntarily approached within 1,640 ft (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 whales will react more strongly than others to vessel traffic. 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. The drillship and support vessels will not enter the Chukchi Sea until after July 1 when most of the spring bowhead migration is complete. Fall migrating bowheads could encounter support vessels associated with the exploration drilling operations as they move west across the Chukchi Sea to feeding areas along the Russian coast before moving down the Russian coast into the Bering Sea wintering grounds. The fall migratory path that bowheads use through the Chukchi Sea is variable with some whales traveling well north of project area while others move through the area south of Hanna Shoal near and through the proposed drilling area. Still other whales appear to move south along the Alaskan Chukchi Sea coast. Given the above-referenced observations of whale-vessel interactions and the variable and widespread nature of the migration route, only a small number of whales, representing a very small portion of the population, will be encountered by the support vessels, and the vessel traffic associated with the exploration drilling program as described in EP Revision 2 will have no more than a temporary effect on their behavior with no lasting impacts on individuals or the population.

Per Shell's mitigation measures, vessels associated with the exploration 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. Vessel speed will be reduced during inclement weather in order to avoid collisions with marine mammals. With these mitigation measures in place, any effects on baleen whales from vessel traffic will be minor, lasting only minutes or hours after the vessel has passed. Effects on baleen whales from vessel traffic associated with the exploration drilling program as described in EP Revision 2 will be negligible.

Vessel Disturbances of Toothed Whales

Harbor porpoise are known to tolerate ships and may approach moving ships to bow ride (Richardson et al. 1995a). This species is present but not common in the Chukchi Sea and any impacts from vessel traffic would likely only affect a few individuals. Similarly, only a few individuals of killer whales are likely to encounter Shell operations in the Chukchi Sea.

Fraker et al. (1978) observed startle responses in belugas when vessels moved through areas with a high concentration of whales. Reactions of beluga whales to vessels will likely vary among individuals. The amount of avoidance exhibited by an individual beluga would depend upon the amount of previous exposure to moving vessels, and the level of need for the beluga to be in the same area as vessel traffic (Finley and Davis 1984). In some studies, more intense reactions to large vessels have been noted, but these observations were made in deep water (Finley et al. 1990, LGL and Greeneridge 1996), and it is not clear that the intensity of the reaction was specifically related to the size of the ship.

Vessel traffic related to the exploration drilling program as described in EP Revision 2 may encounter beluga whales, but the numbers encountered are expected to be few if any. No belugas were observed within Chukchi Sea prospect in most years during historical exploration drilling programs in this area of the Chukchi Sea (Brueggeman et al. 1990, 1991b, 1992a), and no belugas were observed during baseline marine mammal surveys conducted across a broad area of the northeastern Chukchi Sea (including the Burger Prospect) in July-October 2008-2012 (Table 4.1.10-2). Most beluga whales move north during spring before drilling operations in the Chukchi Sea are planned to begin. Some beluga whales migrate north during April through June (Moore et al. 1993), while others congregate in nearshore areas of the Chukchi Sea near Omalik and Kasegaluk lagoons in late June and early July (Huntington et al. 1999, Suydam et al. 2001b) before moving north. Additionally, most belugas migrate relatively close to shore during the spring, and therefore would be approximately 40-50 mi (approximately 64-80 km) from Shell's area of exploration drilling operations, though the specific routes and timing depends on the extent and location of sea ice (MMS 2003a). Most beluga whales continue north into the Beaufort Sea and remain offshore near the continental shelf break or continue into the Canadian Beaufort Sea and Amundsen Gulf where they spend the summer. Evidence indicates that beluga whales occupy areas near or beyond the continental shelf break during summer in the eastern Chukchi Sea, often near the pack ice margin or in areas of dense ice (Suydam et al. 2005a). Moore et al. (2000) identified the importance of deeper water for belugas in areas sloping downward from the continental shelf. These preferred habitats are well north of the Chukchi Sea EP drill sites. In late September through October and into November beluga whales move back into and through the Chukchi Sea. This fall movement back through the Chukchi Sea is more spread out than during spring and animals migrate through waters farther from shore. Beluga whales are most likely to encounter Shell's operations during this period. Vessels conducting contingency vessel-based crew changes (Figure 2.1-1) may traverse areas where beluga are more common; however, this vessel traffic is only for contingency purposes and will therefore occur at very low frequencies if at all. Because belugas do not follow a specific corridor during the fall migration avoidance of the Shell drilling operations by some individuals is unlikely to have more than a minor, short term affect on some individuals in the population. Any behavioral reactions of belugas to vessels are expected to be temporary in nature and localized.

Table 4.1.10-2 Odontocetes Observed in CSESP Study Areas in the Chukchi Sea, July-October 2008-2012

Marine Mammal	Individuals Observed [1,2,3]							
	2008	2009	2010	2011	2012	Total	Ind / 1,000 km	Ind / 1,000 mi
Harbor porpoise	7	0	0	2	0	9	0.34	0.54
Killer whale	9	0	0	4	0	13	0.49	0.78

[1] Source: Aerts et al. 2012
[2] Includes marine mammals seen on transects in four large study area: Burger (2008-2012), Klondike (2008-20112), Statoil (2010-2012), and Greater Hanna Shoal (2011-2012)
[3] Based on surveys along a total of 16,648 mi (26,792 km) of transects

Per Shell's mitigation measures, vessels associated with the exploration drilling program that are underway will reduce speed, avoid separating members from a group of toothed whales and avoid multiple course changes when within 300 yd (275 m) of all whales Vessel speed will be reduced during inclement weather conditions in order to avoid collisions with marine mammals. With these mitigation measures in place, any effects on toothed whales from vessel traffic will be minor, lasting only minutes or hours after the vessel has passed. Effects on toothed whales from vessel traffic associated with the exploration drilling program as described in EP Revision 2 will be negligible.

Vessel Disturbances of Pinnipeds, Including Pinnipeds Designated as Threatened or Endangered

Ringed, bearded, spotted seals, and walrus are the most commonly observed marine mammals in the project area (Tables 3.7-6, 4.1.10-3), and would be expected to be encountered by vessels associated with the exploration drilling program. Small numbers of ribbon seals may also be encountered. However, available data and reported responses of ringed, bearded, and spotted seals to vessels as well as to other noisy human disturbances (Richardson et al. 1995a) suggest that seals often show considerable tolerance of vessels. 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. Blees et al. (2010) reported that the most common reaction of seals (ringed and bearded) to seismic survey monitoring vessels near Burger Prospect were looking at the vessel (63 percent) and no reaction (39 percent), while about nine percent exhibited reactions of increasing swim speed, changing direction, or splashing. Seals are not expected to be adversely impacted by vessel sounds or the presence of vessels associated with the exploration drilling program as described in EP Revision 2.

Table 4.1.10-3 Pinnipeds Observed CSESP Study Areas in the Chukchi Sea, July-October 2008-2012

Marine Mammal	Individuals Observed [1,2,3]							
	2008	2009	2010	2011	2012	Total	Ind / 1,000 km	Ind / 1,000 mi
Ringed/spotted seal	122	61	43	92	61	379	14.15	22.77
Ringed seal	71	15	5	60	27	178	6.64	10.69
Spotted seal	33	10	9	34	14	100	3.73	6.01
Bearded seal	73	27	98	124	113	435	16.24	26.13
Ribbon seal	6	0	0	2	0	8	0.30	0.48
Unidentified seal	322	37	43	103	70	575	21.46	34.54
Pacific walrus	238	67	66	266	647	1,284	47.92	77.13

[1] Source: Aerts et al. 2013
[2] Includes marine mammals seen on transects in four large study area: Burger (2008-2012), Klondike (2008-2012), Statoil (2010-2012), and Greater Hanna Shoal (2011-2012)
[3] Based on surveys along a total of 16,648 mi (26,792 km) of transects

Walruses have been observed during the CSESP marine mammal surveys in and near the Burger Prospect (Tables 3.7-5, 3.8.11-1), and relatively large numbers have been observed during past drilling operations (Table 3.7-2 EIA for EP Revision 1). They are strongly associated with pack ice and would be expected when ice is present. The ice management vessels associated with the exploration drilling program as described in EP Revision 2 would therefore be the most likely vessels to encounter walruses. Documented reactions of walrus to vessels include waking up, head raising, and entering the water (Richardson et al. 1995a). Reaction distance depends on ship speed and sound, and is likely influenced by sight of the ship as well (Fay et al. 1984). Brueggeman (1990, 1991a, 1992b) also found that the probability and type of reactions exhibited by walrus hauled out on ice depended on distance from the vessel. Walrus in open water appear to be less responsive than those on ice, showing little reaction unless the ship was very near to the animals (Fay et al. 1984). Brueggeman et al. (1990, 1991a) monitored the behavior of walrus in response to vessels associated with exploration drilling at the Burger Prospect in 1989 and 1990. They reported that none of the observed groups of walrus exhibited escape behavior in response to anchored or drifting vessels, while responses to moving vessels varied, ranged from nothing to approaching the vessel or escape behavior, and varied with distance (Table 4.1.10-4); most reactions occurred when the vessel approached within about 550 yd (500 m) of the walrus.

Table 4.1.10-4 Walrus Reactions to Transiting Support Vessels in the Chukchi Sea

Distance	Number of Walrus Groups Exhibiting Response by Distance [1,2]							
	None		Approached		Head Raise		Escape	
	1989	1990	1989	1990	1989	1990	1989	1990
0.0-0.14 m (0.0-0.23 km)	3	4	0	1	0	-	4	3
0.14-0.28 mi (0.23-0.46 km)	2	11	0	0	0	-	4	1
0.28-0.58 mi (0.46-0.93 km)	0	33	0	1	0	-	2	1
>0.58 mi (>0.93 km)	0	18	0	0	0	-	1	1

[1] Brueggeman et al. 1990a, 1991a
[2] Number responding out of 16 observations in 1989 and 74 observations in 1990

Historically walrus have not been known to use terrestrial haulouts along the Chukchi Sea, but in recent years, they have hauled out along the Chukchi Sea shoreline apparently in response to lack of pack ice. In 2007, 2009, 2010, and 2011, walruses were also observed hauling out in large numbers with mixed sex and age groups along the Chukchi Sea coast of Alaska in late August, September, and October (USFWS 2013). At least 20,000 to 30,000 walruses were observed hauled out approximately 3 miles (4.8 km) north of the Native Village of Point Lay, Alaska in 2010 and 2011 (Garlich-Miller et al. 2011 in USFWS 2013). Disturbance of large groups of hauled out walruses can sometimes lead to stampedes with resulting injuries and mortalities, especially to walrus calves. Such a mortality event was documented along the Chukchi Sea near Icy Cape in 2009 (Fischback et al. 2009). Although the cause of the disturbance was not determined, 131 walrus carcasses were observed, apparently the result of stampedes. Salter (1979) reported no detectable response by walrus at a terrestrial haulout site to approach by outboard motorboats at distances of 1.1-4.8 mi (1.8-7.7 km). The vessel traffic associated with the exploration drilling program will primarily be located offshore, where it cannot affect walrus at shoreline haulouts. Vessels conducting contingency vessel-based crew changes (Figure 2.1-1) would by definition approach the shoreline, but at Barrow, which is not known to be used as a walrus haulout. In addition, this vessel traffic is only for contingency purposes and will therefore occur at very low frequencies if at all. It is unlikely that vessel traffic along this route would result in disturbance of hauled out walruses.

The identified vessel routes between the prospect and Barrow traverse the southern portion of the HSWUA (Figure 2.1-1). This area was identified by USFWS and delineated based on high utilization of the area by tagged walrus. HSWUA changes by month through the June-September seasonal time frame. For much of the drilling season the extent of the HSWUA will be smaller than that shown on Figure 3.9-1 and the vessel route will lie outside its boundary. Mitigation measures, as described below, will minimize the potential for any walrus disturbance due to vessel traffic in this area.

Potential effects on seals and walrus from vessel traffic associated with the exploration drilling program will be avoided or minimized with implementation of Shell's mitigation measures. These measures prohibit vessels from operating within 0.5 mi (800 m) of walrus when observed on ice, and 1.0 mi (1.6 km) of walrus observed on land. Vessels underway must reduce vessel 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. Given these mitigation measures and pinniped tolerance of vessels, any impacts of vessel traffic on seals and walruses will be minor and short term, consisting only of temporary displacement or temporary deflection away from the vessel. In general, seals and walrus may leave the ice, make hasty dives or move away from the area. Brueggeman et al. (1991a) noted that the behavioral effect on walrus was very brief, with displaced walrus occasionally re-occupying ice floes as soon as the vessel passed. Effects on seals and walruses from vessel traffic associated with the exploration drilling program will be negligible.

4.1.11 Impact of Vessel Traffic on Sensitive Areas

Vessel traffic will have little or no effect on the identified sensitive resources. Regular vessel traffic will be along corridors identified in Figure 2.1-1. Some portions of the vessel route corridor traverses the polynya zone, but such crossing would occur outside of the period when sensitivities in the area would occur. Other identified sensitive areas are located no closer than 17 mi (28 km) from the vessel corridor (Table 4.1.11-1). At these distances, the vessel traffic associated with the exploration drilling program as described in EP Revision 2 will have no discernible effect on the identified sensitive resources.

Table 4.1.11-1 Distances from Vessel Corridor to Sensitive Resources and Habitats

Vessel Corridor Section	Polynya Zone	Ledyard Bay LBCHU	Kasegaluk Lagoon SA	Alaska Maritime NWR	Peard Bay SA
Wainwright-Burger	traverses	41 mi (66 km)	17 mi (28 km)	40 mi (65 km)	18 mi (29 km)
Barrow-Burger	traverses	64 mi (104 km)	60 mi (97 km)	66 mi (107 km)	27 mi (44 km)
Dutch Harbor-Burger [2]	traverses	19 mi (30 km)	61 mi (99 km)	32 mi (51 km)	90 mi (145 km)

[1] Based on minimum distances from vessel corridors on Figure 2.1-1
[2] Corridor sections between Dutch Harbor and prospect only address portion within Chukchi Sea

4.1.12 Impact of Vessel Discharges on Subsistence

Vessel discharges will have no or only a negligible effect on subsistence. These discharges will be conducted under MARPOL and USCG regulations, there will be no discharge of free oil, floating solids, or trash that could potentially oil, entangle, or otherwise affect fish, marine birds, and marine mammals. Only sanitary wastes treated in a MSD will be discharged. Food wastes, which could potentially attract fish, marine birds, and marine mammals, will not be discharged; all food wastes will be incinerated. Discharges will result in slight changes in pH, temperature, TSS, and BOD within the immediate vicinity of the vessel, but these water quality effects would have no effect on subsistence or subsistence resources. These water quality effects will be limited to the area within about 328 ft (100 m) of the vessel, and will cease almost immediately after the discharged is stopped. Most vessel traffic will be in offshore waters seaward of areas used for subsistence. Vessel traffic will be coordinated through Shell's system of Com Centers and SAs in such a manner as to avoid areas where subsistence is occurring, thus vessel discharges will not occur in such areas. EP revision 2 includes an increase in the number of support vessels, increases in resupply trips, and contingency vessel-based crew changes between the prospect and Barrow. These changes may result in a slight increase in total vessel discharge volumes, and may result in vessel traffic near Barrow. However, the effect of vessel discharges on subsistence remains the same as described in the EIA for EP Revision 1, the vessel discharges will have no or only a negligible effect on subsistence.

4.1.13 Impact of Vessel Traffic on Subsistence

Shell's Burger Prospect drill sites are located over 78 mi (126 km) from the nearest village, 64 mi (103 km) offshore of the coastline (Table 3.0-1 in EIA for EP Revision 1) and more than 30 mi (48 km) from areas known to be used for subsistence (EIA, Shell 2011b). Vessel locations, travel routes, and the frequencies and durations of vessel trips are provided in Table 2.1-3. Primary vessel transit corridors are indicated in Figure 2.1-1. Most, but not all, of the vessel traffic associated with the exploration drilling program will take place in Federal waters near the EP blocks in and around the Burger Prospect, between the prospect and Dutch Harbor, and between the prospect and the OSR vessels. These areas are well offshore of areas where subsistence activities are known to be conducted. Under normal circumstances, the vessels that would be expected to operate within areas used for subsistence include the nearshore OSR tug and barge, OSR workboats, the shallow water landing craft, and other vessels that are lightering crews or supplies to the landing craft. Trips in these areas are expected to be infrequent.

Vessel traffic could potentially affect subsistence by interrupting hunts or by displacing, deflecting, or otherwise affecting the behavior of subsistence resources. The effects of vessel traffic on subsistence resources such as fish, marine birds, and marine mammals, as described herein and the EIA for EP revision 1, are temporary and restricted to areas very near the vessel, consisting of temporary displacement or deflection of their path of movement. Shell will implement a number of mitigation measures to minimize any such effects from vessels that travel within areas where subsistence occurs, including:

- Vessels will not enter the Chukchi Sea until after July 1
- Vessels will avoid the polynya zone when in transit, unless forced there by ice
- All vessel traffic will be communicated to and coordinated with subsistence users through a system of Com Centers, SAs, and Community Liaisons
- Other procedures in Shell's Communication Plan and Conflict Avoidance Agreement with the Alaska Eskimo Whaling Commission

With these measures, effects of vessel traffic on subsistence resources and activities will be negligible and short term. Effects on specific subsistence hunts are discussed below.

Bowhead Whale Hunting

Residents of Barrow, Wainwright, and Point Hope hunt bowheads during the spring migration. Point Lay began hunting bowheads in the spring of 2008. Spring hunts are conducted in open leads in the ice typically from late March or early April until the first week of June. Shell's operations will commence in July when these spring hunts are over so the exploration program would have no impact on whaling subsistence activities.

In the recent past, residents of Wainwright have been prevented from conducting successful fall whaling by weather (wind / waves) or the location of the migrating bowheads being too far offshore. However, Wainwright crews conducted fall whaling in 2010, and harvested the first fall bowhead by the northeastern Chukchi Sea villages in over 90 years (Table 4.1.13-1). The whale was harvested offshore of Point Franklin north of Wainwright. Wainwright residents subsequently conducted fall hunts in 2011 and 2012, and have expressed interest in continuing fall whaling efforts in the future. Barrow residents also hunt bowheads in the fall; since 1994 Barrow fall bowhead harvests have taken place between September 4 and October 23 (Table 4.1.13-2). Almost all of this fall hunting is conducted east of Barrow; however, some whaling is occasionally conducted in the Chukchi Sea west of Barrow (Suydam et al. 2008).

Table 4.1.13-1 Bowhead Harvest Periods for Point Hope, Point Lay, and Wainwright

Year	Point Hope [1]		Point Lay [1]		Wainwright [1]	
	Whales Harvested	Harvest Period	Whales Harvested	Harvest Period	Whales Harvested	Harvest Period
1984	2	Apr 24 – May 26	0	--	2	May 18 – May 21
1985	1	May 10 – May 10	0	--	2	May 11 – May 18
1986	2	May 24- Jun 01	0	--	3	May 04 – Jun 24
1987	5	Apr 30 – May 28	0	--	4	May 05 – Jun 02
1988	5	Apr 27 – Apr 30	0	--	4	Apr 25 – May 08
1989	0	--	0	--	2	May 15 – May 27
1990	3	Apr 21 – Apr 30	0	--	5	May 06 – May 13
1991	6	Apr 17 – Apr 26	0	--	4	Apr 29 – May 04
1992	2	Apr 30 – May 01	0	--	0	--
1993	2	Apr 26 – May 04	0	--	5	Apr 29 – May 30
1994	5	May 03 – Jun 04	0	--	4	May 06 – Jun 06
1995	1	Jun 06 – Jun 06	0	--	5	May 09 – Jun 16
1996	3	Apr 14 – Apr 22	0	--	3	May 02 – May 23
1997	4	Apr 17 – Apr 26	0	--	3	May 08 – May 18
1998	3	May 22 – May 24	0	--	3	Apr 29 – May 27
1999	2	May 17 – May 17	0	--	5	Apr 30 – Jun 09
2000	3	Apr 17 – Jun 04	0	--	5	Apr 30 – May 24
2001	4	Apr 23 – May 01	0	--	6	May 01 – May 17
2002	0	--	0	--	1	May 08 – May 08
2003	4	Apr 20 – Apr 23	0	--	5	Apr 18 – May 12
2004	3	Apr 20 – May 12	0	--	4	Apr 18 – May 11
2005	7	Apr 30 – May 23	0	--	4	Apr 28 – May 19
2006	0	--	0	--	2	May 10 – May 11
2007	3	Apr 16 – May 17	0	--	4	May 05 – May 29
2008	2	May 08 – May 25	0	--	2	May 18 – May 26
2009	1	May 30	1	May 5	1	June 5
2010	2	May 20 – Jun 7	0	--	2	May 4 – May 25[1]
					1	Oct 7
2011	3	Apr 22 – April 30	1	May 13	3	Apr 29 – May 24[1]
					1	Oct 28
Total	78	Apr 14 – Jun 07	2	--	96	Apr 18 – Jun 24

[1] Source: George and Tarpley 1986, George et al. 1987, 1988, 1990, 1992, 1994, 1995, 1998, 1999, 2000; Suydam et al. 1995, 1996, 1997, 2001a, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2011, 2012

Table 4.1.13-2 Bowhead Harvest Periods for Barrow 1984-2011

Year	Spring Harvest [1]		Fall Harvest [1]		Total Harvest [1]
	Whales Harvested	Harvest Period	Whales Harvested	Harvest Period	Whales Harvested
1984	4	May 19 – May 21	--	--	4
1985	4	May 09 – May 28	1	Oct 13 – Oct 13	5
1986	7	Apr 27 – May 06	--	--	7
1987	5	May 01 – Jun 15	2	Oct 22 – Oct 29	7
1988	8	Apr 24 – May 06	3	Sep 15 – Sep 17	11
1989	3	Apr 23 – May 28	7	Oct 02 – Oct 28	10
1990	6	May 09 – May 24	5	Oct 01 – Oct 14	11
1991	8	Apr 28 – May 16	4	Sep 27 – Oct 04	12
1992	2	May 28 – May 29	20	Aug 31 – Oct 13	22
1993	9	Apr 21 – May 02	--	--	9
1994	15	May 03 – May 20	1	Oct 01 – Oct 01	16
1995	8	May 06 – Jun 01	11	Sep 04 – Oct 17	19
1996	5	Apr 25 – May 29	19	Sep 10 – Sep 26	24
1997	10	May 04 – Jun 04	21	Sep 11 - Oct 21	31
1998	9	May 08 – May 27	16	Sep 19 – Oct 07	25
2000	5	Apr 24 – May 30	13	Sep 26 – Oct 08	18
2001	20	Apr 28 – May 18	7	Oct 07 – Oct 09	27
2002	3	May 03 – May 30	19	Sep 30 – Oct 25	22
2003	10	Apr 19 – Jun 01	6	Oct 08 – Oct 14	16
2004	6	Apr 23 – Jun 04	15	Sep 18 – Oct 23	21
2005	16	Apr 28 – May 23	13	Oct 01 – Oct 05	29
2006	3	May 11 – May 18	19	Sep 25 – Oct 03	22
2007	13	Apr 24 – May 27	7	Oct 07 – Oct 11	20
2008	9	Apr 27 – May 11	12	Oct 05 – Oct 23	21
2009	4	May 17 – May 23	15	Sep 26 – Oct 10	19
2010	14	May 1 – May 15	8	Oct 7 – Oct 11	22
2011	7	Apr 26 – May 22	11	Oct 8 – Oct 30	18
All years	213	Apr 23 – June 15	240	Aug 31 – Oct 30	468

[1] Source: George and Tarpley 1986, George et al. 1987, 1988, 1990, 1992, 1994, 1995, 1998, 1999, 2000; Suydam et al. 1995, 1996, 1997, 2001a, 2002, 2003, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2011, 2012

Vessel traffic associated with the exploration drilling program as described in EP Revision 2 includes an increase in re-supply trips, contingency vessel crew changes between the prospect and Barrow, and a general increase in vessel traffic associated with the increase in number of support vessels. The additional re-supply trips will occur between the prospect and Dutch Harbor and will therefore be located more than 60 mi (97 km) west and more than 30 mi (48 km) offshore of areas known to be used for the fall bowhead hunts. Because bowheads are migrating generally in an east to west direction during the fall, and the vessel corridors are located west of areas commonly used by Barrow fall whaling crews, any effects on bowhead behavior or movements would have no impact on Barrow's fall whaling. Primary vessel corridors are well offshore of areas thought to be used by Wainwright whaling crews in the fall. The contingency vessel crew change will occur in or near areas where whaling occurs. Shell's mitigation measures include a system of SA, Community Liaisons, and Com Centers that will be established and utilized on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects from vessel traffic on fall whaling. With these mitigation measures in place, the impacts of vessel traffic associated with the exploration drilling program on whaling will remain as described in the EIA for EP Revision 1.

Beluga Whale Hunting

Beluga are occasionally hunted by Barrow residents in coastal waters during July and August, primarily after the spring bowhead hunt, but beluga represented only about 0.5 percent of the total Barrow subsistence harvest from 1962 to 1982. Interviewed local hunters reported that belugas have not been commonly hunted by Barrow residents in recent years (Sound Enterprises and Associates 2008). Wainwright residents are similarly reluctant to hunt beluga during the spring as it might disrupt the bowhead hunt, but hunt for beluga in spring leads when bowheads are not present and also during July and August in coastal waters.

The beluga is a more important subsistence resource to Point Lay residents based on the weight of meat harvested. The Point Lay beluga hunt is concentrated in the first two weeks of July (but sometimes continues into August), when belugas are herded by hunters with boats into Kasegaluk Lagoon and harvested in shallow waters. Point Hope hunters primarily harvest beluga in conjunction with spring bowhead hunts in late March and early June, but continue to hunt them in open water along the coast from late July through early September.

According to the MMS (2008a), sound energy from vessel traffic could cause brief disruption to beluga whale harvest but does not make the resource unavailable to subsistence users. Beluga whales respond differentially to vessel sound energy, but temporary and localized sound energy from vessels should cause only brief disturbances to the whales. These disturbance effects have a duration of one day or less (MMS 2008a). While vessel traffic may impact beluga whale as a subsistence resource in a limited manner, it could potentially impact the related subsistence activities to a greater extent. Subsistence hunters may view increased vessel traffic from Shell's activities and associated sound as disruptive and the vessels as imposing on their traditional subsistence areas. They may avoid areas in which they can see and hear vessel traffic.

Vessel traffic associated with Shell's exploration program includes an increase in re-supply trips, contingency vessel crew changes between the prospect and Barrow, and a general increase in vessel traffic associated with the increase in number of support vessels. The additional re-supply trips will occur between the prospect and Dutch Harbor and will therefore be located more than 60 mi (97 km) west and more than 30 mi (48 km) offshore of areas known to be used for the beluga hunts. Additionally, the drillship and support vessels will not enter the Chukchi Sea until on or about 1 July, which is after much of the beluga harvests in Point Hope and Wainwright takes place. The contingency vessel crew change will occur in or near areas where some hunting for belugas by Barrow residents may occur. Shell's mitigation measures include a system of SAs, Community Liaisons, and Com Centers that will be established and utilized on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on beluga hunting. Implementation of Shell's Marine Mammal Monitoring and Mitigation Plan (4MP) and Plan of Cooperation (POC) is expected to further minimize or avoid impacts of vessel traffic on marine mammals, including belugas; thus vessel traffic associated with the exploration drilling program as described in EP Revision 2 will have little effect on the availability of beluga to subsistence hunters (MMS 2008a) or on the hunt. With these mitigation measures in place, the impact of vessel traffic associated the exploration drilling program on beluga hunting remains as described in the EIA for EP Revision 1.

Polar Bear Hunting

Polar bear are hunted for their meat and pelts. Polar bear subsistence hunts occur in the fall and winter anywhere between September and April depending on the region. In general, polar bear are hunted along the coast, rarely more than two miles offshore. Shell anticipates minimal to no impact to subsistence polar bear hunting. Polar bears react little to vessels because they do not stay long in the open water (MMS 2008a). When they do react, polar bears show a range of behavior responses to vessel traffic from curiosity to avoidance. MMS (2008a) has concluded that vessel traffic associated with oil and gas exploration would not change the availability of polar bears as a subsistence resource. Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities. With these mitigation measures in place, the impact of vessel traffic associated the exploration drilling program as described in EP Revisions 2 on polar bear hunting remains as described in the EIA for EP Revision 1.

Seal Hunting

Seals are an important subsistence resource. Ringed seals make up the bulk of the seal harvest. Most ringed and bearded seals are harvested in the winter or in the spring before Shell's exploration drilling program would commence, but some harvest continues into the open water period and could possibly be affected by Shell's planned activities. Spotted seals are also harvested during the summer.

Potential effects of Shell's planned exploration drilling program as described in EP Revision 2 on bearded, ringed, and spotted seals are discussed above. Ringed seals in particular appear to be relatively tolerant of vessels and ice-breaking. For example, Brewer et al. (1993) and Hall et al. (1994) reported that ringed seals were often observed apparently feeding in the wake of icebreakers associated with exploration drilling in the Beaufort. Kanik et al. 1980 as cited in Richardson et al. 1995a reported that ringed seals remained on the ice unless icebreakers approached within 0.6 mi (1.0 km) of the seals. Brueggeman et al. 1992a as cited in Richardson et al. 1995a similarly noted that ringed and bearded seals tended to remain on the ice until the vessel came within 0.58 mi (0.93 km) when they would dive into the water. Any such effects from the planned activities would be minor behavioral effects and temporary lasting only minutes or hours after the activity ceased. Alliston (1980, 1981 as cited in Richardson et al. 1995a) found the distribution and density of ringed seals was the same in the year following icebreaking activities in study sites in the Beaufort and off the coast of Labrador. According to BOEM, vessel traffic should not cause long term effects to seal distribution or availability for subsistence use (MMS 2008a).

Vessel traffic may cause temporary displacement of bearded, ringed, and spotted seals hauled out on the ice or on beaches, as wells as those feeding and swimming in the water (MMS 2008a). However, most vessel traffic associated with the exploration program will take place offshore of areas where seal hunting takes place. The increase in re-supply trips will take place along corridors that are more than 30 mi (48 km) offshore of areas known to be used when hunting seals. The contingency vessel crew change through Barrow will occur in or near areas where some hunting for seals by Barrow residents occurs. Vessels may be moored in Kotzebue Sound near Goodhope Bay, an area where seal hunting takes place, and crew changes may be conducted between that location and the Port of Kotzebue. Bearded seal hunting in the area is generally over by July 10 (W. Goodwin pers. comm. 2013) so there is little opportunity for effect on that hunt from vessel traffic. As part of its mitigation plan, Shell will establish and utilize a system of SA, Community Liaisons, and Com Centers on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on subsistence including seal hunting. The implementation of Shell's 4MP and POC is expected to further minimize or avoid impacts on seal species; thus, vessel traffic associated with the exploration drilling program as described in EP Revision 2 will have little effect on the availability of seals to subsistence hunters or the hunt. With these mitigation measures in place, vessel traffic associated the exploration drilling program on seal hunting will be negligible.

Walrus Hunting

The walrus is an important subsistence resource, and is especially significant to residents of Wainwright, as evidenced by harvest data. Walrus are harvested by Barrow residents in conjunction with the spring bowhead hunt in the Chukchi from Point Barrow to Peard Bay, but the primary effort occurs from late June to mid-September with a peak in August. Wainwright residents hunt walrus in July to August along the retreating ice pack but occasionally harvest walrus that are hauled out on the beaches in late August and September. Point Lay residents harvest most of their walrus from the end of June through July, but continue to harvest them into August north of the village. Point Hope residents harvest walrus primarily along the ice in June but also hunt walrus that are hauled out along the shore from boats throughout the summer.

Although a portion of the walrus harvest occurs in the spring prior to Shell’s planned exploration drilling operations, some walrus hunting is conducted throughout the summer and could potentially be impacted by vessel traffic associated with the exploration drilling program as described in EP Revision 2. The increase in re-supply trips will take place along corridors that are more than 30 mi (48 km) offshore of areas known to be used when hunting walruses. The contingency vessel crew change will occur in or near areas where some hunting for walruses by Barrow residents likely occurs. However, Shell will establish and utilize a system of SAs, Community Liaisons, and Com Centers on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on subsistence including walrus hunting. With implementation of Shell’s mitigation measures, the impact of vessel traffic associated with the exploration drilling program on walrus or walrus hunting will be negligible.

Bird Hunting and Egg Collection

Coastal and marine birds are harvested by residents of all four villages. They compose a small (2-5 percent) but important part of the total subsistence harvest (ACI et al. 1984). Harvests occur throughout the spring, summer, and fall, both inland and in or adjacent to coastal waters, and often in conjunction with hunts for marine mammals.

Vessel traffic associated with Shell’s exploration drilling program as described in EP Revision 2 will have no or only a negligible effect on birds, and therefore negligible impacts of bird hunting. Vessel and traffic has the potential to disturb (flush) birds, but the effects on the birds would be minor and temporary. The increase in re-supply trips will take place along corridors that are more than 30 mi (48 km) offshore of areas known to be used when hunting waterfowl and seabirds. The contingency vessel crew change will occur in or near areas where some hunting for birds by Barrow residents occurs, but much of the spring waterfowl hunting by Barrow is conducted in conjunction with spring marine mammal hunts would take place before exploration activities commence, and therefore could not be affected. As part of its mitigation plan, Shell will establish and utilize a system of Subsistence Advisors, Community Liaisons, and Com Centers on a daily basis to coordinate and modify vessel traffic based on current or anticipated subsistence activities to avoid any effects on subsistence including bird hunting. With these mitigation measures in place, the impact of vessel traffic on birds or bird hunting remains negligible as described in the EIA for EP Revision 1.

Fishing

Fish play an important dietary role in the North Slope subsistence system. Fish generally represent the second or third most important subsistence resource depending on the community (MMS 1991 citing ACI and SRBA 1984). Marine and diadromous fish commonly harvested for subsistence in the villages include pink and coho salmon, char, Bering cisco, humpback whitefish, broad whitefish, rainbow smelt, capelin, Pacific cod, saffron cod, Arctic cod, Bering flounder and Arctic flounder.

Subsistence fishing is not known to be carried out in the offshore waters where most vessel traffic associated with Shell's exploration drilling program will occur. Most fishing by Barrow residents is conducted at inland fish camps and would be unaffected by the exploration drilling program, but coastal fishing can be important and takes place in three areas near Barrow, along the Chukchi Sea coast from Barrow south to Walikpa Bay, inside Elson Lagoon on the Beaufort coast, and along the barrier islands of Elson Lagoon (Craig 1989). Marine fishing occurs along the Chukchi Sea shoreline just west of Barrow. Marine fishing is conducted with gill nets and by jigging, with the primary species harvested including whitefishes and least cisco. Other species include capelin, char, salmon, and cod. Fishing along the Chukchi Sea coast takes place mostly in the spring and summer in conjunction with hunts for waterfowl and marine mammals.

The increase in re-supply trips as described in EP Revision 2 will take place along corridors that are more than 30 mi (97 km) offshore of areas known to be used for fishing. The contingency vessel crew change will occur in or near coastal areas where some fishing by Barrow residents occurs. Potential effects will be negligible, as these vessel trips are for contingencies only, and would therefore be limited in frequency; little if any vessel traffic would be expected to occur in these fishing areas. Effects on fish and subsistence fishing associated with the Shell's exploration drilling program as described in EP Revision 2 will be negligible.

Effects of Vessel Moorings in Kotzebue Sound on Subsistence

As part of exploration program as described in EP Revision 2, several vessels, including the resupply tug and barge, nearshore OSR barge and tug, the ACS, and a shallow water landing craft may be moored as a group in a coastal location for extended periods during the open water season. Two or more mooring buoys may be installed at the location. These vessels may leave the area occasionally, and other vessels may join these vessels on occasion. Crew changes may be conducted between the moored vessels and the Port of Kotzebue using the shallow water landing craft. As envisioned these crew changes would require one round trip between the moored vessels and the Port of Kotzebue per week during the drilling season. The presence of the moorings and vessels, and the associated vessel traffic, could potentially affect subsistence activities.

A tentatively identified area for the moorings is within Kotzebue Sound offshore of an area known as Goodhope Bay in water depths of 36-48 ft (11-15 m), with muddy seafloor sediments. Residents of Deering and Buckland (BLM 2007) and possibly Kotzebue use the general area for the harvest of marine mammals including beluga, walrus; bearded, ringed, and spotted seals. Waterfowl and seabirds are harvested in coastal waters. Subsistence fishing is also conducted in the area for salmon, saffron and arctic cod, smelt, capelin, and herring. There is also a small commercial fishery for chum salmon in Kotzebue Sound; 30-40 small boats with set nets primarily at river mouths.

Shell held a meeting in Kotzebue on 29 July 2013 and discussed the proposition of mooring vessels in the Sound, including the tentatively identified location with borough, village, and tribal leaders. Shell will utilize a system of Com Centers and SAs to avoid or minimize any effects on subsistence. With these mitigation measures in place, and the limited associated vessel traffic, the mooring of the vessels in Kotzebue Sound, and associated vessel traffic is expected to have negligible impacts on subsistence.

4.2 Changes to the Aircraft and Flights

4.2.1 Impact of Aircraft Emissions on Air Quality

Shell's exploration drilling program as described in EP Revision 2 includes the addition of a helicopter, shuttling of helicopters between Barrow and Deadhorse, and an increase in expected helicopter trips from 12 to 40 per week. These changes will result in an increase in emissions in the form of NO_x, CO, SO_2, and VOCs (Air Sciences, Inc. 2013, Appendix O); however, they represent a very small portion of total emissions from the exploration drilling program. A summary of the calculated emission rates for helicopter operations at the Barrow Airport associated with the exploration drilling program are presented in Appendix O. Dispersion of emissions associated with the helicopters was modeled along with the emissions from expansion and use of the Barrow man camp and operation of the hangar at the Barrow Airport.

The methods and results of the modeling effort are described in Section 4.3.1. As discussed in Section 4.1.1, the impacts of aircraft emissions remain associated with the exploration drilling program on overall air quality remains as described in the EIA for EP Revision 1.

4.2.2 Impact of Aircraft Traffic on Birds, Including Birds Designated as Threatened or Endangered

Helicopter flights can disturb birds, with the potential to flush the birds, and create increased movement (Derksen et al. 1992) with potential effects on energetics and body weight (Ward and Stehn 1989), alter habitat use (Belanger and Bedard 1989), or decrease productivity at nesting sites. These effects are thought to be of greatest impact at nesting colonies, or areas where the birds congregate for molting or staging before migration.

Disturbance of Staging and Molting Birds

Owens (1977) found that wintering brant were disturbed by fixed-wing aircraft flights at altitudes of less than 1,640 ft (500 m) and lateral distances of less than 1.0 mi (1.4 km). Barry and Spencer (1976) reported that molting snow geese and white-fronted geese run from approaching helicopters, and that geese within 1.5 mi (2.5 km) of the aircraft were disturbed. Mosbech and Glahder (1991) reported that larger Bell 212 model helicopters caused reactions by molting emperor and pink-footed geese at distances possibly as great as 5.6 mi (9.0 km).

Ward and Stehn (1989) observed the responses of staging black brant, Canada geese, and emperor geese in Izembek Lagoon in western Alaska to incidental and experimental flights. Results of the study are summarized in Tables 4.2.2-1 and 4.2.2-2. These data indicate that responses of geese to aircraft are very brief, that geese within a distance of 1.2 mi (1.9 km) or more may be disturbed by helicopter traffic, and that the number of geese that respond generally decreases as altitude increases from 500-1,000 ft (152-305 m). Their analysis of disturbance patterns indicated that 45-50 disturbances per day would be required to prevent weight gain by the brant. Brant exhibited three general levels of response. When brant reacted to the stimulus, their initial response was a raised head and alert posture, followed by flight if stimulus continued. The flocks often returned to the same location if the stimulus passed rapidly. Bird flight responses to aircraft were observed in three increasing levels of flight duration; rise flights lasting an average of 21 sec, circle flights lasting an average of 90 sec, and departure flights lasting about 126 sec. Aircraft caused less response than other stimuli such as people on foot or vessels. The authors suggested that staging and wintering birds might be more tolerant of disturbance than flightless molting birds.

Table 4.2.2-1 Bird Responses to Aircraft Overflights, Izembek Lagoon, Alaska

Bird Species	Aircraft	Birds Responding [1] (percent)	Duration of Response [1] (seconds)	Birds in Flight [1] (percentage)	Flight Duration [1] (seconds)
Black Brant	Single engine	52	131	38	82
	Twin engine	25	99	14	92
	Helicopter	57	266	39	93
Canada Geese	Single engine	29	108	9	68
	Twin engine	15	80	4	-
	Helicopter	31	93	8	92

[1] Source: Ward and Stehn 1989

Table 4.2.2-2 Birds Responding to and Flying in Response to Aircraft in Izembek Lagoon

Aircraft Type	Aircraft Flight		Canada Geese [1]		Emperor Geese [1]		Black Brant [1]	
	LD [2]	ALT [2]	Response	Flight	Response	Flight	Response	Flight
Single engine	0-0.2	500	80	40	-	-	96	76
	0-0.2	1,000	39	1	75	63	72	41
	0.3-0.7	1,000	8	1	100	0	44	15
	0.8-1.2	1,000	11	11	100	0	25	3
Twin engine	0-0.2	500	31	0	73	0	79	32
	0-0.2	1,000	18	0	27	0	64	14
	0.3-0.7	1,000	22	12	100	0	39	6
	0.8-1.2	1,000	0	0	-	-	1	0
Helicopter	0-0.2	500	57	24	83	83	92	84
	0-0.2	1,000	31	4	83	37	90	74
	0.3-0.7	1,000	24	7	69	18	72	47
	0.8-1.2	1,000	7	5	98	50	38	15

[1] Source: Ward and Stehn 1989
[2] LD = lateral distance to aircraft in miles
[3] ALT = aircraft altitude in feet

Derksen et al. (1992) studied the responses of molting black brant on the Alaska North Slope to 140 experimental overflights with a Bell 206 helicopter at altitudes of 500-5,000 ft (150-1,525 m). Responses of the flightless brant primarily included increased movement, with monitored birds in overflight areas moving at more than five times the rate of birds in control areas. Some response was noted as far as 2.1-2.5 mi (3.5-4.0 km) laterally from the aircraft. The duration of responses to the helicopter overflight varied with altitude (Table 4.2.2-3) but was generally less than six minutes. There was no evidence of injury or mortality to the birds. The brant did not appear to habituate to the daily experimental flights. Owens (1977) and Madsen (1985) found the same to be true for helicopter disturbance of the pink-footed goose. Modeling and extrapolation of the study results led the authors to believe that helicopter flights in excess of 50/day could result in weight loss to the birds that could affect their ability to successfully molt and migrate to a staging area.

Table 4.2.2-3 Response Time of Molting Brant to Helicopter Overflights

Altitude		Number of Overflights [1]	Average Duration of Response (sec) [1]
760 m	2,500 ft	131	325.4
455 m	1,500 ft	28	316.5
Landing	-	40	300.6
Take-off	-	54	204.4
610 m	2,000 ft	18	164.3
150 m	500 ft	22	157.5
305 m	1,000 ft	59	144.6
1,070 m	3,500 ft	3	100.7
915 m	3,000 ft	10	100.4
1,525 m	5,000 ft	6	10.7
1,220 m	4,000 ft	2	0.0

[1] Source: Derksen et al. 1992
[2] Observations recorded near Teshekpuk Lake, Alaska

These studies indicate that the effects of helicopter flights associated with Shell's exploration drilling program would result in only negligible disturbance effects on a portion of the population of staging and molting waterbirds. EP Revision 2 will result in an increase in the number of round trip crew change helicopter flights from 12 to 40 per week, and will add flights of helicopters being shuttled between the Barrow and Deadhorse airports. The potential effects of helicopter flights associated with the exploration drilling program on staging and molting birds will increase slightly with the increase in number of flights, but overall the impact of such flights on staging and molting birds will consist of negligible, brief behavioral responses and short term, with no population effects. The number of flights is still much lower than what research has indicated would be required to result in long term physiological effects on the birds. The planned crew change flights would be at an altitude of 1,500 ft (457 m) or more along a direct route between Barrow and the Burger Prospect (Figure 2.2-1) that avoids areas noted as especially important for staging and molting, such as Peard Bay, Kasegaluk Lagoon, and Ledyard Bay (Table 4.2.2-4). The helicopter shuttle flights may be over land or the Beaufort Sea, depending on communications with SAs and subsequent route selection. Again some molting or staging birds may be disturbed by these flights but the effects would be temporary lasting only minutes, and minimized by Shell's mitigation measure of requiring a minimum altitude of 1,500 ft (457 m) for helicopter flights.

Table 4.2.2-4 Distances Aircraft Flight Corridors to Colonies and Staging/Molting Areas

Cape Lisburne		Nearest Nesting Colony		Kasegaluk Lagoon		Peard Bay		Ledyard Bay	
mi	km	mi	km	mi	Km	mi	km	mi	km
184	296	29	47	67	107	27	44	64	103

[1] Based on flight corridor in Figure 2.2-1 and nesting colonies and other resources in Figure 3.6-1

Disturbance of Bird Nesting Colonies

Bird nesting colonies can sometimes be disturbed by aircraft resulting in a loss of productivity (Carney and Sydeman 1999); adult birds flushed from nests can cause displacement of eggs and young from the nest and/or render eggs and young more vulnerable to predation and exposure to weather. However, studies indicate that these types of effects can be avoided if certain altitudes and distances are maintained.

Rojek et al. (2007) observed a relatively low level of disturbance from helicopters at a murre cliff colony and concluded aircraft at altitudes of >1,000 ft (>305 m) would not cause disturbance to breeding sea birds. Fjeld et al. (1988) reported that most aircraft flushing responses at murre colonies was limited to flights within 1.5 mi (2.5 km).

Gollop et al. (1974) studied the reaction of similar small colonies of arctic terns, glaucous gulls, on spits in the Beaufort Sea and found these colonies / species resistant to displacement from helicopters, especially common eiders. Nesting common eiders exhibited no response to helicopters. The arctic tern was the most sensitive with 100 percent of nesting and non-nesting birds flushing in response to helicopters at altitudes of up to 1,000 ft (305 m), but no response to flights at 1,500 ft (455 m). A few non-nesting gulls flushed from overflights at 1,000 ft (305 m) but the number was not substantial. All observed flushing responses were brief with the birds returning within minutes. The helicopter flights were found to have no apparent effect on reproductive success.

The nearest large cliff-nesting bird colonies are located more than 184 mi (296 km) south of the flight corridors and will therefore not be affected by flights associated with the exploration drilling program. Four small coastal bird colonies of common eiders, arctic terns, and horned puffins are located between Icy Cape and Barrow shoreward of the prospect area; however, these colonies are located more than 29 mi (47 km) from any planned aircraft corridor for the crew changes (Table 4.2.2-4). Identified helicopter shuttle routes between Barrow and Deadhorse are no closer than 0.9 miles from any known seabird colony along the Beaufort Sea (Table 4.2.2-5). These flights would there for have no effect on nesting colonies. Shell's minimum altitude requirement of 1,500 ft (457 m) would likely avoid all responses from nesting common eiders and most if not all responses from other species. Any responses that might occur would likely consist of alert postures, head bobbing, increased movement, and/or flushing, but any flushed birds would be expected to return to the nest within seconds or a few minutes. Any such effects would be brief and negligible

Table 4.2.2-5 Distances from Helicopter Shuttle Routes to Bird Colonies

Flight Path	Colony Name	Distance to Nearest Bird Nesting Colony [1]	
		(km)	(mi)
Barrow-Deadhorse offshore	Igalik Island	6.3	3.9
Barrow-Deadhorse coastal	Point Barrow Spit	15.8	9.8
Barrow-Deadhorse onshore	Spy Island	1.4	0.9

[1] Colonies are those described in the Beringia Seabird Catalog (USFWS 2000) ; distances are from routes on Figure 2.3-1

The increase in the number of helicopter flights and adding flights to shuttle helicopters between Barrow and Deadhorse incrementally increases the potential for disturbance of birds. However, implementation of Shell's mitigation measures, which include maintaining a minimum altitude of 1,500 ft (457 m), will ensure that any such effects will be negligible. The effects of helicopter traffic associated with the exploration drilling program as described in EP Revision 2 on birds remains as described in the EIA for EP Revision 1.

Disturbance of Threatened or Endangered Birds

Disturbances to threatened or endangered birds would be similar to other birds as described above. All of these species are found in low densities in offshore waters so aircraft would result in no more than brief disturbance of a few if any birds offshore. Shell's minimum altitude requirement of 1,500 ft (457 m) would likely avoid all responses from threatened endangered birds in offshore waters.

Kittlitz's murrelet does not nest along the Chukchi Sea or the Beaufort Sea; therefore, there would be no effect on nesting Kittlitz's murrelets. Yellow-billed loons and spectacled and Steller's eiders (Rojek and Martin 2003, Rojek 2005, 2006, 2007, 2008) nest inland in areas that would not normally be traversed by crew change helicopters, but may be traversed by crew change helicopters if the Barrow-Wainwright alternative corridor were to be utilized. As with other eiders (Gollop et al. 1974), nesting spectacled eiders have been observed to exhibit some tolerance to aircraft by nesting within 820-2,460 ft (250-750 m) of the Deadhorse airport (TERA 1996, Martin 1997). With Shell's minimum altitude requirement of 1,500 ft (457 m) would likely avoid all responses from nesting yellow-billed loons and nesting and molting spectacled eiders. Areas such as the Ledyard Bay Critical Habitat Unit (LBCHU), Kasegaluk Lagoon and Peard Bay where Steller's or spectacled eiders congregate in large numbers to molt or stage, would not be traversed (Table 4.2.2-4). No operational flights would occur in critical habitat (LBCHU). Any impacts to threatened or endangered birds would be negligible.

The Barrow-Deadhorse helicopter shuttle routes are outside of the known range of the Kittlitz's murrelet and therefore would have no impact on this species. The shuttle flights between Barrow and Deadhorse could potentially occur near nesting, staging, or feeding of yellow-billed loons, Steller's eiders or spectacled eiders. Again, Shell's minimum altitude requirement of 1,500 ft (457 m) would likely avoid or minimize behavioral responses from nesting and molting/staging spectacled eiders, Steller's eiders, and yellow-billed loons. Given these mitigation measures, any effects from aircraft associated with the exploration drilling program on these species would be negligible.

4.2.3 Impact of Aircraft Traffic on Marine Mammals, Including Marine Mammals Designated as Threatened or Endangered

Helicopter overflights may disturb marine mammals as sound sources or visual cues. Levels and duration of sounds received by marine mammals underwater from a passing helicopter or fixed-wing aircraft are a function of the type of aircraft, orientation of the aircraft, depth of the animal, and water depth. Aircraft sounds are detectable underwater at greater distances when the receiver is in shallow rather than deep water. Generally, sound levels received underwater decrease as the altitude of the aircraft increases (Richardson et al. 1995a). Aircraft sounds are audible for much greater distances in air than in water.

Helicopters will be used for personnel and equipment transport to and from the drillship. Under calm conditions, rotor and engine sounds are coupled into the water within a 26-degree cone beneath the aircraft. Some of the sound will transmit beyond the immediate area, and some sound will enter the water outside the 26º area when the sea surface is rough. However, scattering and absorption will limit lateral propagation in shallow water. Dominant tones in noise spectra from helicopters are generally below 500 Hz (Greene and Moore 1995). Because of Doppler shift effects, the frequencies of tones received at a stationary site diminish when an aircraft passes overhead. The apparent frequency is increased while the aircraft approaches and is reduced while it moves away.

Aircraft flyovers are not heard underwater for very long, especially when compared to how long they are heard in air as the aircraft approaches an observer. Helicopters flying to and from the drillship will generally maintain straight-line routes at altitudes of 1,500 ft (457 m) ASL or greater, thereby limiting the received levels at and below the surface.

The nature of sounds produced by aircraft activities above the surface of the water does not pose a direct threat to the hearing of marine mammals that are in the water; however minor and short term behavioral responses of cetaceans to aircraft have been documented in several locations, including Arctic waters (Richardson et al. 1985a,b Patenaude et al. 2002). Cetacean reactions to aircraft depend on several variables including the animal's behavioral state, activity, group size, habitat, and the helicopter flight pattern, among other variables (Richardson et al. 1995a).

Cetaceans

Aircraft traffic associated with the exploration program could result in some disturbance of marine mammals. Gray whales may show avoidance behavior in response to air traffic sound energy. The Scientific Research Association (1988) reported that gray whales usually exhibit avoidance behavior when helicopters flew lower than 1,198 ft (365 m). Mothers with calves appear to be more sensitive to air traffic (Clarke et al. 1989). 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 and landings and when weather conditions force an altitude reduction for safety reasons. Shell helicopter flights should therefore have little or no effect on gray whales. Any changes in gray whale behavior due to aircraft traffic will therefore be minor and temporary lasting only minutes or hours at the most. Given these findings, aircraft traffic associated with Shell's exploration drilling program as described in EP Revision 2 will have little or no impact on gray whales and will not have any effect on gray whale populations.

Richardson et al. (1995b) observed some belugas exhibiting avoidance behaviors in reaction to aircraft flying at altitudes less than or equal to 820 ft (250 m), most, however, showed no reaction to aircraft flying at altitudes greater than or equal 492 ft (150 m). The amount of time that belugas may be affected by low-flying aircraft is usually only seconds (Stewart et al. 1982). In one study, most reactions of beluga whales have been observed (Patenaude et al. 2002) reacting to helicopter sound via deflection when exposed to helicopters occurred when the helicopter approached within 820 ft (250 m). These brief encounters with aircraft are not expected to have any more than a brief effect on belugas (Richardson et al. 1991; Richard 1998), and any potential deflection or displacement would likely be temporary. Shell's mitigation measure of requiring an altitude of 1,500 ft (457 m) or more for all helicopter flights will therefore avoid most or all effect on belugas. Given these findings, aircraft traffic associated with Shell's exploration drilling program as described in EP Revision 2 will have little or no impact on belugas and will not have any effect on the beluga populations.

Threatened and Endangered Cetaceans

The most common reaction of bowhead whales to aircraft traffic is avoidance behavior, such as diving. Richardson et al. (1985b) 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 that 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, but changes in orientation, dispersal or movement out of the area, and change in activity were sometimes noted. Bowheads that were engaged in social activities or feeding or 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 et al. 1995a) 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). Given these findings, aircraft traffic associated with the exploration program will have little or no impact on bowhead whales. Aircraft may momentarily alter the behavior of bowheads in the form of hasty dives and changes in respiration rates. These impacts will not have any effect on the bowhead or bowhead populations. As a mitigation measure, aircraft will fly at a minimum altitude of 1,500 ft (460 m), which should avoid or minimize most such impacts. Any reactions to aircraft that must fly at altitudes below 500 ft (150 m) for safety concerns will be temporary, negligible, behavioral impacts, and not expected to harm the health or safety of threatened or endangered whales (Richardson et al. 1995b). Impacts on fin whales and humpback whales would be similar.

No significant impacts on cetaceans will occur as a result of sound energy generated from aircraft associated with the exploration drilling program described in EP Revision 2. The exploration drilling program as described in EP Revision 2 will have negligible impact on threatened and endangered cetaceans.

Pinnipeds, Including Pinnipeds Designated as Threatened or Endangered

Few systematic studies of pinniped reactions to aircraft overflights have been conducted. Documented reactions range from simply becoming alert and raising the head, to escape behavior such as hauled out animals rushing to the water. Brueggeman et al. (1992a) reported that about 6.6 percent of 552 seals (ringed, bearded, and spotted seals but primarily ringed seals) observed while monitoring previous exploration drilling efforts in the Chukchi Sea reacted to a twin otter airplane flown at an altitude of 1,000 ft (305 m). Reactions included diving in the water resulting in a splash, or escaping from ice into the water. Ringed seals hauled out on the surface of the ice have shown behavioral responses to helicopter overflights with escape responses most probable at lateral distances <656 ft (<200 m) and overhead distances <492 ft (<150 m; Born et al. 1999). Spotted seals showed immediate reaction to the presence of aircraft during surveys by Rugh et al. (1997). They observed disturbances of spotted seals at altitudes up to 4,500 ft (1,370 m). Concentrations of animals hauled out on land seem to react more severely than the scattered small groups found on the sea ice in spring. Disturbances of seals by Shell's aircraft will be temporary and localized. Shell's identified flight corridors (Figure 2.3-1) where both the increased crew change flights and the helicopter shuttle flights would take place avoid all known spotted seal haulouts and minimizes the portion of flights that would be over coastal waters. Known spotted seal haulout locations in Kasegaluk Lagoon are more than 70 mi (113 km) from the identified flight corridors. Shell's mitigation measures require a minimum altitude of 1,500 ft (457 m), which should reduce the disturbance to ringed seals, bearded seals, and spotted seals.

Brueggeman et al. (1991a) evaluated walrus reactions to survey aircraft flying at an altitude of 305 m (1,000 ft) over the pack ice and 152 m (500 ft) in water. They observed that 17 percent of the walrus groups on ice and none in water reacted to the aircraft. Walrus reacted to flights between 197 and 492 ft (60 and 150 m) above sea level within 0.62 mi (1 km) lateral distance by either orienting towards the aircraft or escaping into the water (Brueggeman et al. 1990). It appeared that walrus that had hauled out on land or ice were more sensitive to overflights (Brueggeman et al. 1990). In recent years, walrus have moved to terrestrial haulout sites along the Chukchi Sea coast when ice has retreated far offshore beyond the continental shelf break and preferred feeding areas. Stampedes at these large haulouts can result in deaths of animals, particularly smaller juveniles and calves as happened in 2009. Shell will use its aerial monitoring capability and communications with the various agencies and villages to monitor the locations of terrestrial haulouts that may occur along the Chukchi Sea coast during the duration of the exploration drilling program. Flight paths to and from the drillship will be altered if necessary to avoid areas with large numbers of hauled out walrus. Helicopters will maintain a 1,500 ft (450 m) minimum altitude unless weather does not permit this altitude, and aircraft will not operate within 0.5 mi (800 m) of walrus hauled out onto ice or 1.0 mi (1.6 km) of walrus hauled out on land.

Given the mitigation measures Shell has in place, any disturbance effects on any of the pinniped species from the increased helicopter traffic associated with Shell's exploration drilling program as described in EP Revision 2 will be negligible and temporary.

Polar Bears

The USFWS (2008) concluded in its Programmatic BO that routine aircraft has little to no effect on individual polar bears or the population. It was noted that any reactions of non-denning bears should be limited to short term changes in behavior before bears resumed their normal activity. In their BO for issuance of Incidental Take Regulations in the Beaufort Sea, USFWS (2011) concluded that any disturbance due to infrequent aircraft overflights is likely to be temporary, lasting a few moments to about five minutes. Denning does not occur during the time period when the flights would be conducted, and flights would not prohibit polar bear movements along the coast. Overflights could potentially result in some human disturbance of polar bears but any such impacts would be minor, brief, and would affect few polar bears. Shell will also implement measures designed to mitigate potential effects of aircraft traffic on polar bears. Helicopters on operations flights will fly along direct pre-determined flight corridor (Figure 2.2-1), which will reduce the spatial area potentially disturbed. Polar bears on ice or in the water are not stationary and are very mobile, thus the same bears would not be disturbed by flights along the corridor. The flight corridors identified for the helicopter shuttle flights between Barrow and Deadhorse avoid barrier islands which polar bears frequent in the fall. Helicopters will maintain a 1,500 ft (450 m) minimum altitude unless weather does not permit this altitude, and aircraft will not operate within 0.5 mi (800 m) of bears hauled out onto land or ice. The Barrow-Deadhorse helicopter shuttle routes transit polar bear denning and barrier island habitat; however, given the infrequency of trips and minimum altitude requirements, effects on polar bears would be negligible and there would be no known physical impacts on habitat. Although the potential for disturbance of polar bears will increase commensurately with the increase in helicopter flights supporting the exploration drilling program as described in EP Revision 2, any actual disturbances will have only negligible effects on polar bears and no effect on the polar bear population.

4.2.4 Impact of Aircraft Traffic on Sensitive Areas

Aircraft traffic will have little or no effect on the identified sensitive resources. Regular aircraft traffic will consist of helicopter traffic between the drillship and shorebase facilities flown along the corridor identified in Figure 2.2-1 and PSO overflights with a fixed wing aircraft. This corridor traverses the polynya zone, but is located no closer than 18 mi (29 km) to LBCHU, Kasegaluk Lagoon, Peard Bay, and the Alaska Maritime National Wildlife Refuge (NWR) (Table 4.2.4-1). At these distances the aircraft traffic associated with the exploration drilling program, as described in EP Revision 2 will have no discernible effect on the identified sensitive resources.

Table 4.2.4-1 Distances from Flight Corridor to Sensitive Resources and Habitats

Vessel Corridor Section	Polynya Zone	Ledyard Bay LBCHU	Kasegaluk Lagoon SA	Alaska Maritime NWR	Peard Bay SA
Wainwright-Burger	traverses	41 mi (65 km)	18 mi (29 km)	40 mi (65 km)	17 mi (28km)
Barrow-Burger Alt1	traverses	62 mi (99 km)	60 mi (96 km)	66 mi (106 km)	27 mi (44 km)
Barrow-Burger Alt2	traverses	64 mi (103 km)	52 mi (84 km)	64 mi (103 km)	13 mi (21 km)

[1] Based on minimum distances from flight corridors on Figure 2.2-1

Aerial surveys for marine mammals will be conducted along a standardized route, two times per week, for the duration of the exploration drilling program (see EP Revision 2 Appendix D). A portion of these surveys will be conducted over the LBCHU, where a minimum flight altitude of 1,500 ft (457 m) will be maintained. Given their low frequency and minimum altitudes the flights are expected to have no or only a negligible effect on molting or staging spectacled eiders in the LBCHU. USFWS (2009c) came to a similar conclusion in their BO for oil and gas exploration in the Beaufort and Chukchi Sea, in which they stated that marine mammal survey flights in the LBCHU with a fixed-wing plane at an altitude of 1,500 ft (457 m) are unlikely to disturb or adversely affect spectacled or Steller's eiders.

4.2.5 Impact of Aircraft Traffic on Subsistence

Aircraft traffic associated with the exploration drilling program as described in EP Revision 2, which include an increase in crew change helicopter flights between the prospect and Barrow and helicopter shuttle flights between Barrow and Deadhorse, could potentially affect subsistence by interrupting hunts or by displacing, deflecting, or otherwise affecting the behavior of subsistence resources. The effects of aircraft traffic on subsistence resources such as fish, marine birds, and marine mammals, as described above, are temporary and restricted to areas very near the aircraft, consisting of temporary displacement or deflection of their path of movement. Most potential effects on subsistence resources and therefore subsistence activities will be avoided or greatly reduced by implementation of a number of mitigation measures that have previously been successfully implemented by Shell, including:

- Vessels will not enter the Chukchi Sea until after July 1
- All aircraft traffic will be communicated to and coordinated with subsistence users through a system of Com Centers, SAs, and Community Liaisons
- Other procedures in Shell's Communication Plan and Conflict Avoidance Agreement with the Alaska Eskimo Whaling Commission
- Aircraft will not operate below and altitude of 1,500 ft (457 m) unless the aircraft is engaged in marine mammal monitoring, approaching, landing or taking off, in poor weather, or in an emergency situation

The most important of these mitigation measures is the coordination of aircraft traffic through the system of Com Centers and SAs. Operational calls are held each morning that are attended by the SAs, Com

Center staff, and Shell operational and logistical staff. Current and expected subsistence activity types and locations are described by the SAs during these calls, and planned operational activities such as helicopter traffic are described by Shell staff. Adjustments to the timing and route of any pending aircraft traffic are made at this time to avoid any conflict with subsistence users to the extent practicable. With these measures, most potential effects of aircraft traffic on subsistence will be avoided; those that are not avoided will be minimized, short term, and negligible. Effects on specific subsistence hunts are discussed below.

Bowhead Whale Hunting

According to BOEM sound energy from aircraft could potentially cause some disruption to bowhead whale harvest, but would not make the bowhead as a subsistence resource unavailable to subsistence users (MMS 2008).

Scientific evidence shows that bowhead whales may respond to low-flying aircraft, but generally exhibit no response to aircraft flying above 500 ft (150 m) (MMS 1987a, 1987b, 2008a). Bowhead whales may temporarily deflect from the sound source. Section 4.2.3 discusses these impacts.

Information from Traditional Knowledge (TK) and statements from traditional subsistence users indicated the belief that whales can hear sounds at much greater distances and will modify their behavior for longer periods of time (MMS 2008a), resulting in potentially greater effects to the subsistence hunters.

Many Iñupiat hunters maintain that the bowhead whale is more sensitive than scientific equipment and thus can pick up sounds much farther away, and that they can hear sounds in the air as well as in the water. They state that bowhead whales flee loud sounds. For example, Barrow residents ask pilots not to fly over open leads and disturb the whales (MMS 2008a). Iñupiat hunters are concerned that increased oil and gas industry activity will disrupt current whale migration routes. They fear the bowhead may change their route to one much farther from shore (MMS 2008a).

Spring whaling is concluded prior to the dates when Shell's exploration drilling program would commence (Tables 4.1.13-1, 4.1.13-2). Barrow residents also hunt bowheads in the fall (August-October). Since 1994, Barrow fall bowhead harvests have taken place between 4 September and 23 October (Table 4.1.13-2). Most fall whaling by Barrow crews is conducted east of Barrow; however, whaling is conducted in the Chukchi Sea west of Barrow in some years (Suydam et al. 2008). Helicopters servicing offshore operations could traverse areas utilized by Barrow whalers for fall whaling if the whaling were to be conducted in the Chukchi Sea (to the west of Barrow) rather than the Beaufort Sea (to the east of Barrow). Crews from the village of Wainwright conducted fall whaling in 2010 and harvested the first whale in over 90 years in October 2010 and continued to hunt in 2011-2013. Wainwright whalers indicate they plan to continue fall whaling in the future. If fall whaling were to be conducted by Wainwright it would likely be during the exploration drilling program (Table 4.1.13-1), and helicopter flights could traverse areas where whaling might be conducted. However, the primary aircraft corridor (Barrow to Burger) does not traverse these areas, and the secondary corridors (Wainwright to Burger, Barrow to Burger Alt2) would only be used occasionally as required due to weather (Figure 2.2-1). Helicopter traffic often evokes no response from bowheads, but the whales sometimes engage in hasty dives or abrupt turns (Richardson et al. 1985b, 1995a). Bowhead whales tend to be more sensitive in shallow water (Richardson et al 1985b). Any such behavioral responses would be momentary and have only a negligible effect on the subsistence resource and no effect on the subsistence activity. Flight path and altitude restrictions of 1,500 ft (457 m) would avoid or greatly minimize such potential impacts. Implementation of Shell's POC and 4MP (see, e.g., Section 4.1.10), which includes the use of SAs and operation of Com Centers, is expected to further minimize or avoid impacts of aircraft traffic on marine mammals, particularly bowhead whale and their subsistence harvest.

Beluga Hunting

Helicopter and vessel traffic between the shorebase and offshore drill sites have the potential to cause some disruption of communal hunts for belugas by disturbing and altering the course of the whales, possibly rendering them more difficult to herd or harvest. Most of the beluga harvest by these villages occurs during spring whaling and in the first two weeks of July in Kasegaluk Lagoon, but some hunting continues through the summer in coastal lagoons. The spring hunt occurs before Shell's planned exploration drilling program would commence, but Shell's operations would be on-going in July.

Helicopter traffic will be primarily between Barrow and the Burger Prospect along a prescribed direct route. This does not traverse areas where belugas are commonly hunted so little or no effect on this subsistence activity would be expected. Alternatively, some helicopter flights between Barrow and the prospect could follow an onshore corridor to Wainwright and then offshore to the drill sites, a route that would traverse some areas where belugas are hunted by residents of Wainwright, Point Lay and Point Hope. There is therefore some potential for disturbance of summer beluga hunts from associated helicopter traffic. However, flights between Wainwright and the drill sites would be only occasional.

Observed reactions of spring-migrating belugas have been variable. Belugas have been observed to react to helicopter overflights, but all of these effects would be temporary behavioral changes, occurring during the actual flight, and would not have any effect on the beluga population as a subsistence resource. Richardson et al. (1991, 1995b) reported that most spring-migrating belugas exhibited no overt response to helicopter overflights at altitudes of more than 500 ft (150 m), but some belugas exhibited responses such as turning or diving to helicopter flights as high as 1,500 ft (460 m) and within a distance of 700 ft (250 m) laterally. These studies indicate that any effects would be temporary and limited to a very small area along the helicopter flight path (Figure 2.2-1), and would be negligible, as the most important beluga hunts would be conducted prior to the drilling season. Such potential impacts are expected to be minimized or avoided due to flight path and altitude restrictions on aircraft and through implementation of Shell's POC, 4MP (see, e.g., Section 4.1.10) and other subsistence mitigation measures.

Aircraft will follow defined flight paths and maintain a regulated altitude, and all operations will be carried out consistent with Shell's POC and 4MP. These measures are expected to minimize or avoid impacts to beluga whales and their subsistence harvest from Shell's aircraft traffic. Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Polar Bear Hunting

Shell anticipates minimal impact to subsistence polar bears or polar bear hunting from aircraft traffic associated with the exploration drilling program as described in EP Revision 2. Polar bears exposed to aircraft may move away, show curiosity, or show no effect. Polar bears may exhibit avoidance behavior resulting in short term and localized effects. This may disrupt some polar bear harvest activities, but will not likely affect annual harvest levels (MMS 2008a). Implementation of Shell's POC will minimize or avoid the potential for aircraft traffic to impact polar bear or interfere with their subsistence harvest.

While sound energy from aircraft may impact this subsistence resource in a limited manner, it may impact the related subsistence activities to a greater extent. Subsistence hunters may view increased air traffic from Shell's activities and associated sound as disruptive and as imposing on their traditional subsistence areas.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Aircraft will follow a defined flight path and maintain a regulated altitude. Shell will implement its POC. Shell will also implement a polar bear avoidance and interaction plan to prevent problems with human-bear interactions. These measures will minimize or avoid impacts on polar bears from Shell's air traffic. Aircraft already occupy the airspace throughout the North Slope for personal and commercial uses. The small scope of Shell's program and related air traffic will be a minimal addition to the existing conditions.

Seal Hunting

Impacts to seals and seal hunting activities from aircraft traffic will be negligible, temporary and localized. Sound energy from aircraft can disturb bearded, ringed, and spotted seals haul out on the ice and along the coast on beaches. Low-flying helicopters and fixed wing aircraft have often been observed to cause ringed and bearded seals to dive into the water, but this is not always the case (Burns and Harbo 1972, Burns and Frost 1979, Alliston 1981). Spotted seals hauled out on beaches have been observed to leave the beach and enter the water when survey aircraft flew at altitudes of 1,000-2,500 ft (305-760 m) or more came within 0.6 mi (1 km) (Frost and Lowry 1990, Frost et al. 1993, Rugh et al. 1993, Richardson et al. 1995a).

Subsistence hunters may view increased air traffic from Shell's activities and associated sound as disruptive and as imposing on their traditional subsistence areas. TK explain that intense sound startles, annoys, and can cause flight of seals.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities.

Aircraft will follow defined flight paths and maintain a regulated altitude, and all operations will be carried out consistent with Shell's POC. These restrictions will minimize or avoid impacts to seals and the subsistence harvest of seals from Shell's aircraft traffic. Aircraft already occupy the airspace throughout the North Slope for personal and commercial uses. Helicopter traffic between the shorebase and the offshore drill sites would be minor due to the small number of flights and the altitude at which flights occur. Further, most seal hunting is done during the winter and spring, not during the exploration drilling season when Shell will be active. Any effects on seals and subsistence hunts for seals will be negligible and temporary, lasting only minutes after the flight has passed.

Walrus Hunting

Helicopter and vessel traffic between the Burger Prospect and the shorebase could potentially disturb walrus or the walrus hunt. Fay et al. (1984) reported that walrus hauled out on the pack ice left the ice when helicopters approached within 1,300-2,000 ft (400-600 m) upwind or 3,300-5,900 ft (1,000-1,800 m) downwind of the animals. Brueggeman et al. (1990) reported on the reactions of walrus to overflights of a fixed-wing survey aircraft at an altitude of 1,000 ft (305 m) in the Chukchi Sea. Twelve percent of 34 walrus groups in the open ocean and 38 percent of the walrus groups observed on the pack ice reacted to the aircraft by diving or escaping into the water.

The primary aircraft corridor for helicopters servicing Shell's exploration drilling operations traverses some areas where Barrow residents hunt walrus. The secondary aircraft travel corridor traverses areas utilized by Wainwright residents to hunt walrus, but the frequency of travel along this route would be very low. Although a portion of the walrus harvest occurs in the spring prior to Shell's planned exploration drilling operations, some walrus hunting is conducted throughout the summer and could potentially be impacted by vessel and helicopter traffic servicing the offshore operations. All helicopter flights would be required to maintain an altitude of 1,500 ft (457 m) or more on these flights, which will minimize potential disturbance of walrus and any effects on walrus hunting. All operations will be conducted consistent with Shell's POC and 4MP. These measures will minimize or avoid impacts to walrus and subsistence walrus hunting. Any such effects would be temporary and negligible due to the small number of vessel and helicopter trips that would be undertaken.

Bird Hunting

Helicopter traffic between the shorebase and offshore drill sites, and fixed wing aircraft traffic between the shorebase and regional hub airports, could potentially disturb birds and therefore subsistence hunts for birds during the summer and fall, but these effects are anticipated to be minor due to the small number of flights and the altitude at which flights typically occur.

As discussed in Section 4.2.2, aircraft traffic may cause some disturbance to both onshore and offshore birds, resulting in displacement of small numbers of birds from preferred habitat and induced stress to birds, potentially resulting in impacts to subsistence bird hunting and egg collection. Any such impacts would be negligible and temporary. Shell does not anticipate long term impacts to subsistence bird hunting and egg collection due to aircraft associated with this program. Aircraft traffic may cause short term impacts to subsistence hunting and egg collecting.

Stress from aircraft overflights on molting birds can make it difficult for birds to maintain or acquire sufficient nutrients for subsequent migration to staging areas (Taylor 1993). Aircraft, especially helicopters, may cause the most intense responses (Bélanger and Bédard 1989 cited in Miller 1994), and birds do not habituate well to small low-flying aircraft (Owens 1977). Aircraft may disturb birds, but are not anticipated to directly lead to mortality. However, loss of eggs and young from predators may occur when parent birds are displaced (MMS 2008a). Therefore, aircraft may impact bird resources during exploration activities, but impacts should not extend to following years.

Because birds are important food sources, Iñupiat interpret harm to birds as a threat to subsistence and their livelihood (MMS 2008a). While aircraft sound may impact this subsistence resource in a limited manner, it may impact the related subsistence activities to a greater extent. Subsistence hunters may view increased air traffic from Shell’s activities and associated sounds as disruptive and as imposing on their traditional subsistence areas.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell’s effort to identify and address the perceived impacts to subsistence activities.

Land Mammal Hunting

Aircraft traffic associated with Shell’s exploration drilling program would be expected to have little to no impact on land mammals or the subsistence hunting of land mammals. Caribou is the most important land mammal subsistence resource in the coastal Chukchi Sea villages. Caribou are found in coastal habitats in the summer, and are known to utilize beach habitats to minimize harassment by insects, and caribou hunting is conducted in coastal areas. Helicopter traffic could therefore potentially disturb caribou in these areas and therefore subsistence hunts for caribou. Observed caribou responses to helicopter overflights have varied from no response to running away.

The BOEM states subsistence hunters could experience short term, localized effects on subsistence hunting (MMS 2008a). Subsistence hunters may view increased aircraft traffic as disruptive and the aircraft as imposing on their traditional subsistence areas. They may avoid areas in which they can see and hear aircraft traffic. Planned helicopter flights will be conducted along a direct route from the Barrow airport to the drill sites and would therefore not traverse any areas utilized for caribou hunting. However, helicopter flights along the secondary flight corridor from Barrow to the prospect (Barrow-Prospect Alt2, Figure 2.2-1) overland does traverse areas used by caribou and caribou hunters. Helicopter shuttle transits between Deadhorse and Barrow (Figure 2.2-1) have the most potential to disturb caribou hunts. Alternate routes located offshore have been designated and will be used to avoid such impacts. Routes will be considered and selected on a daily basis after conference with SAs. Shell's mitigation measures require a minimum altitude of 1,500 ft (457 m), which should minimize any potential effects. Any effect on caribou and caribou hunting would be temporary, lasting only minutes after the helicopter flight.

Shell will take all reasonable steps to minimize conflicts with subsistence hunting activities of the local residents. Part of this effort is addressed through the POC and the outreach and consultation actions Shell implements. This is a major component of Shell's effort to identify and address the perceived impacts to subsistence activities. With these mitigation measures any effects from aircraft associated with the exploration drilling program will be minor.

Fishing

Aircraft traffic will have no impact on the availability of subsistence fish resources or subsistence fishing (see also EIA for EP Revision 1).

4.3 Changes to Shorebases

EP Revision 2 includes construction of new onshore buildings and other infrastructure improvements. Activities would include expansion of a 75 person camp facility to support up to 200 persons in Barrow, and use of a larger facility in Wainwright. Direct and indirect effects of the increased shorebase presence are described below.

4.3.1 Impact of Shorebase Air Pollutant Emissions on Air Quality

Changes to shorebase activities associated with Shell's exploration drilling program will result in increases of air emissions. Onshore Activities associated with the exploration drilling program as described in EP Revision 2 could result in temporary, localized increases in dust due to construction. For example, dust from construction activities such as excavation, grading, sloping and filling would contribute to ambient concentrations of suspended particulate matter. Construction contractor(s) would be required to comply with ADEC regulations requiring that reasonable precautions be taken to minimize dust emissions.

Construction may require the use of heavy trucks, excavators, graders, work vessels, and a range of smaller equipment such as generators, pumps, and compressors. Emissions from diesel-powered construction equipment will be minimized to the extent practicable. Construction-related diesel emissions would not affect air quality in the project vicinity, particularly when taking into account appropriate emissions controls.

In addition to construction and operation of the man-camp, shorebase activities will include helicopter flights (crew change flights and helicopter shuttle flights) and operation of a hangar. EP Revision 2, Appendix O, provides a listing of calculated emissions for these shorebase activities.

The onshore activities were modeled separately from the *Discoverer* and support vessel emissions using EPA's AERMOD model. AERMOD is recommended by EPA and other regulatory agencies as the appropriate model for industrial facilities where the distance between the emission sources and the receptor is less than 50 km (37 mi). The air quality modeling for the onshore activities was conducted using separate modeling from the *Discoverer* and support vessel emissions because:

- the distance between the *Discoverer* and the onshore facilities is over 135 mi, so no significant overlap in the impact areas of the two operations is expected; and
- the areas of potential impact for the onshore facilities are very close to those facilities, on the order of a mile or less, while the nearest point of land to the *Discoverer* is more than 60 mi away

Meteorological data from 2008-2012 at the Barrow Airport were used in the modeling analysis. Receptors were placed along the fence line of the proposed man camp and in two grids of receptors, with a spacing of 25 to 50 m, over the entire area of potential impact. In all, a total of 7,720 receptors were used in the analysis. Maximum concentrations, background concentration, and design concentrations for each pollutant are summarized in Table 4.3.1-1.

Table 4.3.1-1 Maximum Predicted Concentrations for Shore-Based Operations (µg/m3)

Pollutant	Averaging Time	Peak Concentration	Background Concentration[1]	Design Concentration	NAAQS
NO_2	1-hour	60.92	53	114	188
	Annual	2.25	2	4	100
SO_2	1-hour	5.50	16	22	196
	3-hour	9.25	13	22	1300
	24-hour	5.76	5	11	365
	Annual	0.20	2	2	80
PM_{10}	24-hour	3.33	57	60	150
$PM_{2\ 5}$	24-hour	3.33	18	21	35
	Annual	0.12	2	2	12
CO	1-hour	478.69	1,145	1,624	40,000
	8-hour	143.27	1,145	1,288	10,000

[1] See Table 3.1.3-1

Based on this analysis, emissions of air pollutants associated with the shorebase activities for the exploration drilling program will have a negligible impact on air quality at coastal villages or elsewhere on the North Slope.

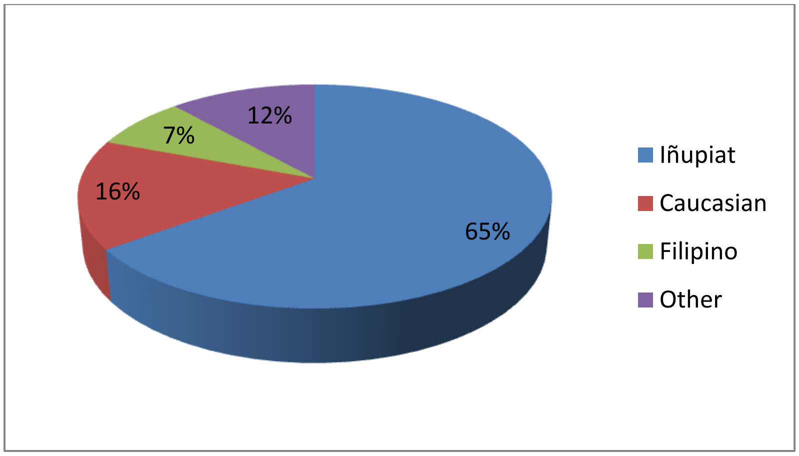
4.3.2 Impact of Shorebase Increases on Socioeconomic/Socio-cultural Resources

Shorebase Expansion at Barrow

As part of this EP Revision 2, the Barrow man camp will be expanded from 75 to 200 beds and a kitchen will be added. The camp may also be moved to a location near the Barrow airport. Some of the shorebase increase is to accommodate the increase in offshore crews associated with the vessels added as a part of EP Revision 2. However, some of the increase in accommodations is to reduce the number of hotel rooms and rental properties used by Shell in Barrow during the 2012 exploration drilling season.

With their subsistence lifestyle and culture, the Inupiat residents of the North Slope are considered a minority/Native American community under the Presidential Order on Environmental Justice. The Inupiat are a minority population in the State of Alaska and are indigenous inhabitants of Alaska. The State of Alaska estimate of Barrow's population is 4,380 (ADCA 2013), the U.S. Census Bureau 2010 estimate is 4,212 (U.S. Census Bureau 2010), and the NSB census for 2010 placed the Barrow population at 4,719 (NSB 2010). Approximately 65 percent of the Barrow population is Inupiat (Figure 4.3.2-1). A man camp of 200 represents a potential influx of non-NSB residents equaling about 5.0 percent of the total Barrow population, and therefore holds potential for some socio-cultural effects.

Figure 4.3.2-1 Barrow Ethnic Makeup in 2010



(Source: Data used to generate the pie chart came from NSB 2010)

Shell's management of the camp will minimize the potential for any socio-cultural effects. The proposed location for the possible camp move is very near the airport, where crew members would enter or exit Barrow. Crew members are brought to and from the camp via vans. If Shell decides to re-locate the camp to the proposed location near the airport, that move would minimize vehicular traffic in Barrow associated with the operation of the camp. Crews are generally restricted to the camp, but with permission are permitted to visit the cultural center or the AC store. With these restrictions, socio-cultural impacts are expected to be negligible.

Negative socioeconomic effects of work camps in relatively small communities are generally associated with effects on goods and services. Shell's Barrow man camp is largely self-contained with little potential for effects on goods and services. Power and heat (electricity) are provided by the camp's generators, and will therefore not place a load on municipal utilities. Diesel fuel would be purchased locally. Expansion of the accommodations and adding the kitchen will minimize the need for hotel rooms and rental properties. This will reduce revenues of local business but avoid any substantial reductions in the availability of such services for local residents and other visitors. The camp will be managed by one of the village native corporations, resulting in revenues for the business and shareholders.

With these policies and management strategies in place, the expansion of the Barrow man camp associated with the exploration program is expected to have negligible effects on socio-cultural or socioeconomic resources. Socio-cultural and socioeconomic impacts of Shell's exploration drilling program as described in EP Revision 2 will remain as described in the EIA for EP Revision 1; the influx of people into the community will be temporary and have negligible effects on the local population or the availability of goods and services.

Crew Changes at Kotzebue

Associated with the changes in the number of support vessels, a number of vessels may be moored in Kotzebue Sound. Crew changes for these vessels would likely be completed with the shallow water landing craft transporting the crews between the vessels and the Port of Kotzebue; however, crew changes may also be undertaken at Nome. The frequency for the crew changes is expected to be once per week. As planned, the crews would rotate through Kotzebue in a single day. Crews would arrive in Kotzebue via commercial airlines and be transported the same day to the moored vessel; crews arriving via the landing craft would similarly leave Kotzebue on the commercial airlines the same day they arrived at the Port. As a contingency, Shell may book approximately 15 hotel rooms in Kotzebue for occasions when the same day connections cannot be made. Currently there are approximately 70 hotel rooms available in the village. A staff of 2-3 persons may be housed at existing facilities in Kotzebue for the duration of the drilling season. These crew changes are expected to have only temporary, negligible effects on the local population or the availability of goods and services in Kotzebue.

4.4 Changes to Drilling Sound

4.4.1 Impact of Drilling Sound on Marine Mammals, Including Marine Mammals Designated as Threatened or Endangered

Prior to 2012, sounds from the *Discoverer* and a number of the support vessels had not been measured in the Arctic, and analogs or modeling based on sound measurements outside the Arctic were used to estimate the distances from the various sound sources at which the generated sound would attenuate to levels below thresholds and at which incidental takes under the MMPA may occur according to NMFS and USFWS policies. As described in the EIA for EP Revision 1, potential impacts associated with the generation of sound energy by the drillship *Discoverer* were based on measurements recorded near the *Discoverer* in the China Sea in 2009 (Austin and Warner 2010), which were then modeled under Chukchi Sea conditions to provide estimated radial distances to various sound energy levels as the sound energy dissipated with distance. The distance from the sound energy source (drillship) at which drilling sounds would likely fall below 120 dB because of transmission loss was estimated in this manner to be 0.814 mi (1.31 km).

During its 2012 exploration drilling activities, Shell measured the sounds produced by the *Discoverer* while drilling on the Burger Prospect. A broadband (10 Hz – 32 kHz) source level of 182 dB was calculated for the *Discoverer* based on the measurements recorded when drilling the 26-inch hole interval. Radii to other received sound energy levels for the *Discoverer* while drilling and constructing an MLC, as well as support vessels conducting ice management and anchor handling are provided in Table 2.5-1. It was found that sound energy generated by drilling operations varied with the specific activity, sound energy from vessels supporting the drilling in dynamic positioning (DP) mode or performing anchor handling was greater than that generated by the drillship, and that areas ensonified by ice management were greater than previously predicted.

Table 4.4.1-1 Areas Potentially Ensonified by Sound Sources to >120 dB or >160 dB rms

Sound Source	Threshold	Distance to Threshold[1,2]	Area Ensonified at Single Site	Sites / Season		Total Area Potentially Ensonified	
				Summer	Fall	Summer	Fall
Drillship	120 dB	1.5	7.1	2	2	14.1	14.1
Supply vessel DP [3]	120 dB	4.0	50.3	2	2	100.5	100.5
MLC	120 dB	8.1	206.1	1	1	206.1	206.1
Anchor handling	120 dB	20.0	1,256.6	2	1	2,513.3	1,256.6
Icebreaking	120 dB	9.6	661.6	1	1	661.6	661.6
ZVSP [4]	160 dB	6.5	132.7	2	2	265.5	265.5

[1] Source: Unpublished Data from LGL
[2] Distances in Tables 2.5-1 and 2.5-2
[3] Distance in Table 2.6-1 as drilling with support vessel (anchor handler) in DP mode
[4] Modeled VSP radius from Warner 2012 is 4.3 km; this was multiplied by 1.5 to be conservative

Potential exposures based on the estimated areas that might be ensonified (Table 4.4.1-1) and calculated densities of marine mammals in the northeastern Chukchi Sea were therefore recalculated for future drilling seasons and are provided in Table 4.4.1-2. Two estimates are provided, one in which the population is presumed to remain static for the duration of the activity, and another in which the population is moving such that there is a complete turnover of the animals within the ensonified area each day.

Table 4.4.1-2 Potential Marine Mammal Exposures to Sound Levels >120 or >160 dB rms

Species	Number of Exposures to Sound Levels > 120 dB or ≥160 dB [2,3]			
	Considering a Static Distribution		Considering a Complete Population Turnover Daily	
	Avg	Max[1]	Avg	Max[1]
Beluga	28	52	221	423
Narwhal	0	5	0	5
Killer whale	1	5	4	10
Harbor porpoise	11	18	87	152
Bowhead whale	171	415	1,376	3,338
Fin whale	1	5	4	10
Gray whale	93	130	749	1,046
Humpback whale	1	5	4	10
Minke whale	1	5	4	10
Bearded seal	60	114	480	917
Ribbon seal	4	14	28	114
Ringed seal	1,734	2,872	13,394	23,076
Spotted seal	35	57	278	465

[1] Arbitrary estimates have been included in the maximum columns to account for chance encounters or where greater numbers may be encountered than calculations suggested. Not all marine mammals will change their behavior when exposed to these sound levels
[2] Assumes activity levels identified in Table 4.4-1
[3] Source: Unpublished Data from LGL

The effect on mammals of sound generated by drilling is described in the EIA for EP Revision 1. The exploration drilling program, as described in EP Revision 2, results in no change to the effects described in the EIA for EP Revision 1; estimates of the number of mammals that may be exposed to sound levels great enough to result in Level B takes have changed but not substantially. Effects of the sound generated by exploration drilling and ice management associated with Shell's exploration drilling program as described in EP Revision 2 remain as described in the EIA for EP Revision 1. None of the equipment planned for use will produce continuous sounds loud enough to cause detrimental physical effects in marine mammals unless the animals enter the area immediately adjacent to the drillship during operations and remain there for an extended period of time, which is unlikely given their tendency to avoid such areas. Sound energy from drilling and ice management associated with Shell's exploration drilling program as described in EP Revision 2 could result in behavioral disturbance of marine mammals and may mask marine mammal communication and other sounds in the natural environment; however, the sound energy is expected to result in only negligible short term behavioral disturbance as described in the EIA for EP Revision 1.

4.5 Changes to Drilling Fluids and Drilling Wastes

EP Revision 2 includes changes in drilling fluid components and changes in drilling waste discharge volumes. The changes in volumes are due to a refinement of the estimates based on results of the 2012 exploration drilling program, and the finding that it is not practicable in most cases to recycle the drilling fluids from one drill site to the next. The design of the wells has six intervals from the MLC to the bottom hole; each of these is a discrete drilling interval (Table 4.5-1). The upper intervals, drilled prior to the marine riser being installed, will be discharged at the seafloor; the lower intervals will be discharged through the disposal caisson approximately 22-25 ft (6.7-7.6 m) below the sea surface. The total volumes of drilling wastes to be discharged at the Burger drill sites are provided in Tables 2.4-5 and 2.4-6. Volumes and rates of the expected drilling waste discharges for Burger J drill site are provided in Table 4.5-2 by interval. Discharges at the other Burger drill sites would be similar.

Table 4.5-1 Drilling Fluids in the Six Well Intervals Described in EP Revision 2

Well Interval	Drilling Fluids [1,2]	Discharge Location
1 MLC	Riserless Gel / Polymer Sweeps & Weighted Gel / Polymer Fluid	Seafloor
2	Riserless Gel / Polymer Sweeps & Weighted Gel / Polymer Fluid	Seafloor
3	Riserless Gel / Polymer Sweeps & Weighted Gel / Polymer Fluid	Seafloor
4	KLA-SHIELD –Inhibitive WBM	Sea surface
5	KLA-SHIELD –Inhibitive WBM	Sea surface
6	KLA-SHIELD –Inhibitive WBM	Sea surface

[1] KLA-SHIELD abandonment fluid will be used throughout the wellbore at the end of drilling
[2] Source: M-I SWACO 2013

Table 4.5-2 Discharge Scenario for the Burger J Well

Discharge Location	Drilling Interval	Total Cuttings (bbl)	Total Drilling Fluids (bbl)	Seawater (bbl)	Effluent Discharge Rate (bbl/hr)
Seafloor	1	9,185	25,335	1,687,868	25,714
Seafloor	2	316	983	132,722	25,714
Seafloor	3	1,070	3,694	879,807	25,714
Sea surface	4	349	1,904	13,980	697
Sea surface	5	452	2,464	17,400	701
Sea surface	6	115	625	22,320	620
Sea surface	rig pit	-	1,500	-	1,000
Total	--	11,487	36,505	2,754,092	--

[1] Source: Fluid Dynamix 2013b

A MLC will be constructed at each drill site. The MLCs will be constructed in the seafloor using a large diameter bit operated by hydraulic motors and suspended from the *Discoverer*. During the 2012 drilling season Shell used a bit that was 20 ft (6.1 m) in diameter and constructed MLCs to a depth of about 40 ft (12.2 m). In future drilling seasons, Shell may use a larger bit and the MLC may be excavated to a greater depth to accommodate larger BOPs. Maximum dimensions of MLCs that may be constructed in future drilling seasons are presented in Table 4.5-3. The purpose of the MLC is to ensure that the top of any portion of the wellhead and BOP is located below the maximum ice keel gouge depth. Shallow hazards surveys (GEMS 2009; Fugro GeoConsulting, Inc. 2010a,b,c,d,e,f; 2011a,b) conducted in the area of the planned exploration and historical drill sites in the area indicate that ice gouge ranges from infrequent to pervasive, with a maximum observed depth of about 5.0 ft (1.5 m).

Table 4.5-3 Maximum Dimensions of MLCs for Burger Drill Sites

Diameter [1]	Surface Area	Depth [1]	Volume [2]
30 ft (9.0 m)	1,018 ft^2 (95 m^2)	50 ft (15.2 m)	9,186 bbl (619 yd^3) (473 m^3)

[1] Maximum dimensions, actual dimensions may be less
[2] Volume assumes maximum dimensions and includes 50% washout of the MLC

Estimates of the total area of seafloor that would be directly disturbed and the total volume of sediments that would be displaced by drillship mooring and MLC construction are presented in Table 4.5-4. Exploration drilling program totals are based on a total of nine anchor settings to conservatively account for one re-positioning over a drill site once per season, and six MLCs for the six Burger drill sites.

Table 4.5-4 Seafloor Area that may be Disturbed by Mooring and MLC Construction

Time Period	Activity	Total Sediment Volume Displaced			Total Seafloor Directly Disturbed	
Drilling Program	Mooring	135,124 bbl	28,098 yd^3	21,483m^3	3.4 ac	13,554 m^2
Drilling Program	MLC	55,116 bbl	11,461 yd^3	8,763 m^3	0.1 ac	382 m^2
Drilling Program	All	190,240 bbl	44,591 yd^3	30,246 m^3	3.4 ac	153,936 m^2

[1] Based upon ten moorings for seven wells
[2] Based on MLCs for six wells as

4.5.1 Impact of Drilling Waste Discharges on Water Quality

Drilling wastes will be discharged as authorized through EPA NPDES General Permit AKG-28-8100, which places limits and conditions on discharge content, volume, and rate to ensure they do not result in serious impacts to water quality (Table 4.5.1-1). The EPA has conducted a mandatory evaluation of the potential effects of the discharges that would be authorized by the General Permit and concluded that the discharges would not result in an unreasonable degradation of the marine environment or exceed marine water quality criteria developed pursuant to Section 304(a)(I) of the CWA (EPA 2012).

Table 4.5.1-1 Limitations on Water-Based Drilling Fluids and Drill Cuttings Discharge 001

Discharge Parameter	Limitation / Condition [1]			
Free oil	No discharge			
Metal Concentrations	Mercury 1 mg/kg		Cadmium 3 mg/kg	
Toxicity	Minimum 96-hr LC_{50} of 30,000 ppm			
Maximum Discharge Rate	Water Depth 0-5 m	Water Depth 5-20 m	Water Depth 20-40 m	Water Depth >40 m
	No discharge	500 bbl/hr	750 bbl/hr	1,000 bbl/hr

[1] Source: EPA NPDES General Permit AKG-28-8100

The discharges will create a plume of suspended solids. Shell conducted dispersion modeling of the drilling waste discharges with the new volumes and rates (Tables 2.4-5, 2.4-6, 4.5.1-2) as detailed in EP Revision 2 using the Offshore Operators Committee Mud and Produced Water Discharge (OOC) model (Fluid Dynamix 2013b). Simulations were performed for each of the six discrete drilling intervals with two discharge locations: seafloor and sea surface. Cement is discharged only under the sea floor discharge scenarios and is included in the volume of drill cuttings. Discharges for each of the Burger wells include the discharge of 1,500 bbl of drilling fluids at the end of drilling operations. Results of the dispersion simulations for the Burger J well are summarized below in Table 4.5.1-2. The six Burger Prospect wells are all very similar in well design and site conditions, so the information presented below for the Burger J drill site also approximates the results for the other five Burger wells.

Table 4.5.1-2 Expected TSS Concentrations from Drilling Waste Discharges at Burger J

Discharge Location	Drilling Interval	TSS in Water Column (mg/l) [1]		
		328 ft (100 m)	984 ft (300 m)	0.62 mi (1 km)
Seafloor	1	212.06	48.48	8.03
Seafloor	2	90.29	20.,72	3.34
Seafloor	3	46.56	10.72	1.77
Sea surface	4	17.94	4.14	0.70
Sea surface	5	21.82	5.02	0.87
Sea surface	6	7.04	1.58	0.23
Sea surface	Rig pit	241.40	103.80	-

[1] Source: Fluid Dynamix 2013b

The predicted TSS concentrations are very similar to projections provided in the EIA for EP Revision 1. Therefore, the evaluation of impacts to water quality from the discharge of drilling wastes remains the same as described in the EIA for EP Revision 1. The primary effect of the discharges will be increased TSS, with most of this effect ameliorated within 984 ft (300 m) of the discharge locations through settling and dispersion. Impacts to water quality would cease when the discharge is concluded. Impacts to water quality from the discharge of drilling wastes and cement will be negligible, localized, and will occur over a short period of time (weeks to months during exploration drilling at an individual drill site).

4.5.2 Impact of Drilling Waste Discharges on Lower Trophic Organisms

Discharges of water based drilling fluids and drill cuttings produce effects similar to seafloor disturbances, although bentonite clays in drilling fluids flocculate upon mixing with seawater and settle more quickly than disturbed seafloor sediments (Neff 2005). Drilling fluids and cuttings discharges generally disperse in water into an upper plume and a lower plume. The upper plume contains about 10 percent of the mass of drilling fluid solids (Neff 2005); consists of very fine particles and soluble material; and is important in contributing to water quality impacts. Dispersion of particles in the upper plume is influenced by particle size, ambient current velocities, and release depth. The lower plume contains the majority (90 percent) of discharged material and is considered to be the more important regarding possible impacts on the benthos.

Effects on Benthic Organisms

Most benthic invertebrates are sedentary or are relatively non-mobile. Benthic organisms near the discharge locations will therefore be exposed to suspended sediments in the water column temporarily, but to the cuttings and drilling fluids that are deposited on the seafloor for a number of years depending on the depth of deposition. The primary effects of exploration drilling waste discharges on benthic organisms will be smothering by the deposition of these materials, change in predator/prey relationships within benthic communities (habitat modification), and the possibility of long term biological effects caused by toxicity of the drilling fluids and/or cuttings constituents (EPA 2006b). Additional effects include redistribution of seafloor materials and increased particulate matter suspended in the water. The suspended particles would be carried by currents away from the site, and be greatly diluted in the down current waters.

There is relatively little information on the effects of various deposition depths on arctic biota (Dunton et al. 2003, Hurley and Ellis 2004); most such studies have investigated the effects of deposition of dredged materials (Wilbur 1992). Burial depths as low as 1.0 in (2.54 cm) have been found to be lethal for some benthic organisms (Wilbur 1992, EPA 2006). The seafloor areas predicted by the OOC model to experience accumulations of deposited drill cuttings, drilling fluids, and cement, to various thicknesses, at a single well, are presented in Table 4.5.2-1. Discharges for each of the Burger wells, includes the discharge of 1,500 bbl of drilling fluids at end of well. The maximum deposition thickness of 162 in (412 cm) occurs close to the discharge location. Deposition thickness is < 0.4 in (1.0 cm) beyond 460 ft (140 m) from the discharge location.

Table 4.5.2-1 Predicted Seafloor Accumulations of Discharged Cuttings and Drilling Fluids

Thickness (in)	Thickness (cm)	Area with Accumulation to Thickness			
		ha	m^2	ft^2	Ac
78.7	200	0.102	1,020	10,979	0.3
39.4	100	0.112	1,120	12,056	0.3
3.9	10	0.652	2,720	29,278	0.7
0.4	1	0.272	6,520	70,181	1.6

[1] Source: Fluid Dynamix 2013b

Accumulations of cuttings and drilling fluids on the seafloor from the other Burger wells would be similar as the wells are of similar depth and design. A total of about 9.7 ac (3.9 ha) of seafloor within the Chukchi Sea would be expected to experience accumulations of >0.4 in (> 1.0 cm) when all six wells in the EP are drilled. This represents < 0.000028 percent of the Lease Sale 193 Area and 0.000007 percent of the Chukchi Sea.

The effects will be minor given the small area affected, but longer term, with re-colonization occurring over a time period of a few years. A 2008 investigation (Trefry and Trocine 2009) of the drill site for the historic Hammerhead well, which was drilled in the U.S. Beaufort Sea in 1985, revealed no substantive differences between the benthic community found at the site and benthic communities at other locations in that area of the Beaufort Sea. This time period represents a known maximum. Re-colonization in the Chukchi Sea will probably occur in a similar or shorter time period.

Neff et al. (2010) determined the concentrations of metals and various hydrocarbons in sediments at the historic Burger and Klondike wells in the Chukchi Sea, which were drilled in 1989-1990. Surface and subsurface sediments collected in 2008 at the historic drill sites contained higher concentrations of all types of analyzed hydrocarbon in comparison to the surrounding area. The same pattern was found for the metal barium, with concentrations 2-3 times greater at the historic drill sites (means = 1,410 µ/g and 1,300 µ/g) than in the surrounding areas (639 µ/g and 595 µ/g). Concentrations of copper, mercury, and lead, were elevated in a few samples from the historic drill sites where barium was also elevated. All observed concentrations of hydrocarbons or metals in the sediment samples from the historic drill sites were below levels (Effects Range Low) of Long (1995) believed to have adverse ecological effects (Neff et al. 2010). Similar results were reported by Trefry and Trocine (2009) for the historic Hammerhead drill sites in the Beaufort Sea.

These data show that the potential accumulation of heavy metals in discharged drilling fluids accumulations on the Chukchi seafloor associated with drilling exploration wells is very limited and does not pose a threat. Impacts to seafloor sediments from the discharge of drill cuttings and drilling fluids will be minor, as they would be restricted to a very small area in the Lease Sale 193 Area and will not result in contamination. The predicted minor increases in concentrations of metals will likely be evident for a number of years until gouged by ice, redistributed by currents, or buried under natural sedimentation.

The NPDES General Permit limits discharges offshore Alaska to a low level of toxicity. The EPA has determined that exploration drilling discharges are expected to comply with marine water quality criteria outside of a 330 ft (100 m) area around an exploration drilling discharge point in the Chukchi Sea (EPA 1985, EPA 2006). Despite this zone of potential water quality impacts from discharges, there is no evidence of the effects on lower trophic-level organisms. Studies by Neff (1991 in MMS 2003) indicated drilling fluid had no effect on plankton, and studies in the 1980s, 1999, 2000, and 2002. MMS (2003a) also found that benthic organisms near historical drill sites in the Beaufort Sea have accumulated neither petroleum hydrocarbon nor heavy metals, except for barium.

Effects on Planktonic Organisms

As discussed and analyzed in the context of the EIA for EP Revision 1, discharge could potentially impact phytoplankton by increasing TSS loads in the water column and increasing turbidity. Blockage of sunlight to lower depths could then reduce photosynthesis resulting in lower growth rates in phytoplankton. Any such effects will be restricted to a small area forming an extremely small portion of the Chukchi Sea. Modeling of similar discharges indicates that TSS concentrations will be reduced to <100 ppm within about 328 ft (100 m) or less from the discharge (Shell Global Solutions 2009). Plankton will not remain in this plume area for more than minutes or hours as the ocean currents will move them out of the plumes (Aldredge et al. 1986). Aldredge et al. (1986) studied the effects of drill cuttings and drilling fluids discharges on phytoplankton and found no reduction in photosynthesis. Reviews of existing information indicate little if any effect on phytoplankton (NRC 1983 in Neff 2005). Based on these studies it is concluded that discharges of drill cuttings and fluids associated with Shell's exploration drilling program will have negligible effects on phytoplankton. Any reduction in photosynthesis or other effects on phytoplankton will be restricted to the area within 328 ft (100 m) of the discharge and will be temporary, lasting only minutes or hours after the discharge is complete.

Fine-grained particulates and other solids in drilling fluids and cuttings could cause sublethal effects to organisms in the water column. The responses observed following exposure to drilling fluids include alteration of respiration and filtration rates, and altered behavior. Zooplankton in the immediate area of discharge from exploration drilling operations could be adversely impacted by sediments in the water column, which could clog respiratory and feeding structures. Additionally, the zooplankton could suffer abrasions. Fine grained particles and other solids from drilling fluids and cuttings would likely result in short term impacts and not likely affect population levels of zooplankton.

Toxicity of drilling fluids may also potentially impact zooplankton. In a study of crab and mysid larvae subjected to lignosulfonate drilling fluids, Neff (2005) observed that the larvae stopped swimming at low levels of toxicity; however, Shell will not be using lignosulfonate muds. Planktonic and larval forms are generally the most sensitive of organisms found in Alaska that have had acute lethal bioassays done following exposure to water based drilling fluid. Not all of these organisms have shown sensitivity to short term exposure to drilling fluid (Tornberg et al. 1980), and potential impacts to zooplankton are expected to be negligible and short term. EP Revision 2 includes the addition of 28 drilling fluid components. Some of these are base fluid additives and others are contingency products that may be used depending of conditions encountered. Measured toxicity of these components is provided in Table 4.5.2-2; by international standards (Table 4.5.2-3) these components are non-toxic with lethal concentration 50 (LC_{50}'s) of over 100,000 ppm. Whole drilling fluids of various formulations of the drilling fluids to be used by Shell in the Chukchi Sea have also been texted for toxicity (MI-SWACO 2013). The KLA-SHIELD basic formula with various additives had acute 96 hr LC_{50}'s of 302,000-500,000 ppm. A formulation of the abandonment fluid was found to have a 96-hr LC_{50} of 142,000 ppm (MI-SWACO 2013).

Table 4.5.2-2 Toxicity of New Drilling Fluid Components

Generic Description	Product Name	96 hr LC_{50}
Acrylic polymer	IDCAP D	>500,000
Shale/clay inhibitor	EMI-2009	>500,000
Biopolymer	Flowzan	>500,000
Zinc oxide	Sulf-X	117,275
Shale/clay inhibitor	KLA-STOP	345,008
Copolymeric shale stabilizer	POROSEAL	>500,000
Biocide	Busan 1060	>500,000
Vegetable, polymer fiber blend	MI SEAL	206,000
Cellulose fiber	MIX II Fine	>500,000
Cellulose fiber	MIX II MED	>500,000
Graphite	G-SEAL	>1,000,000
Calcium carbonate	SAFECARB-20	>1,000,000
Calcium carbonate	SAFECARB-40	>1,000,000
Calcium carbonate	SAFECARB-250	>1,000,000
Sodium chloride	stock product	178,000
Resinated lignite	RESINEX	>518,766
Sulfonated asphalt	ASPHASOL SUPREME	557,538
Mixture	FORM-A-BLOK	>500,000
Cellulose	FORM-A-SET AK	148,000
Mixture	Pipelax ENV WH	293,000
Mixture	LUBE 945	462,937
Mixture	CLEAN SPOT	161,600
Surfactant	SCREENKLEEN	>500,000
Mixture	SAFE-SCAV HS	>500,000
Hydrogen sulfide scavenger	SAFE-SCAV HS	>500,000
Oxygen scavenger	Sodium Metabisulfite	142,000

[1] Source: M-I SWACO 2013
[2] Method # 2 testing of maximum concentrations

Table 4.5.2-3 Toxicity Rating System (GESAMP 1997 as cited in Patin 1999)

Acute Toxicity [1]	
Rating	**48 to 96-hr LC_{50} / EC_{50} (mg/L)**
(0) Non-toxic	> 1,000
(1) Practically non-toxic	100-1,000
(2) Slightly toxic	10-100
(3) Moderately toxic	1-10
(4) Highly toxic	0.1-1.0
(5) Very highly toxic	0.01-0.1
(6) Extremely toxic	<0.01

[1]GESAMP 1997 as cited in Patin 1999, based on system originally developed by International Maritime Consultative Organization (IMO / FAO / UNESCO / WMO / WHO / IAEA / UN / UNEP 1969). The system was recently updated by GESAMP.

Modeling (Shell Global Solutions 2009) of discharges associated with Shell's exploration drilling program as described indicate that any increases in metal concentrations in the sediments will be minor and below levels that cause environmental effects (EIA EP Revision 1 Table 4.1.3-4).

Studies by the National Research Council (NRC 1983), EPA (2006), and Neff (2005) indicated that although planktonic organisms are extremely sensitive to environmental conditions, such as temperature, light, availability of nutrients, and water quality, there is little or no evidence of effects from exploration drilling fluid discharges.

4.5.3 Impact of Drilling Waste Discharges on Fish and EFH

Discharges of drill cuttings and drilling fluids could potentially impact fish through chemical or physical toxicological effects or through the alteration fish habitats; however, any such impacts will be minimal in nature and short term. The primary effect on fish habitat will be the deposition of drill cuttings and drilling fluids on the seafloor. This will occur at each well site, all of which are located within areas of the Chukchi Sea designated as EFH for arctic cod, saffron cod, and salmon. Deposition of these materials on the seafloor will:

- alter seafloor relief;
- change sediment consistency and grain size;
- increase concentrations of some metals in the sediment;
- decrease oxygen in the sediments (anoxia); or
- lower abundance or diversity of benthic organisms some of which may be fish prey.

These types of habitat effects may lower the value of the affected area as fish spawning or feeding habitat. The effects will largely be limited to the area where accumulations of the discharged materials are expected to exceed 0.4 in (1.0 cm). Modeling of the discharges indicates that accumulations of 0.4 in (1.0 cm) or more will be limited to the area within about 460 ft (140 m) down current of the discharge location, an area of approximately 1.6 ac (0.6 ha) for each well, and about 9.7 ac (3.9 ha) for all six wells in the EP (Fluid Dynamix 2013b). This represents less than 0.000028 percent of the Lease Sale 193 Area and 0.000007 percent of the Chukchi Sea.

These areas of potential impact are within EFH for arctic cod. Impacts on fish habitat would however, be minor because: 1) a very small area would be impacted, 2) existing seafloor sediments are generally small-grained clays and silts, and 3) no especially productive fish habitats are known to be in the vicinity of the Burger Prospect. There are no substantial differences in the fish resources in the Burger Prospect area. Important spawning areas have not been identified in the Chukchi Sea, although gravelly areas along the coast are thought to be herring spawning areas. The only kelp beds identified in the northeastern Chukchi Sea are located along Peard Bay more than 100 mi (161 km) from Shell's drill sites. Drill sites in the Burger Prospect are located more than 90 mi (145 km) from the nearest anadromous stream. Shallow hazards surveys (Fugro 1989, 1990; GEMS 2009) indicate that surficial sediments at the drill sites range from mud to clay to gravelly clay. These negligible impacts to the fish habitat would be restricted to very small areas of the Chukchi Sea seafloor but may be long term due to the low energy of the system and few ice keel scours in the 143-150 ft (43.7-45.8 m) water depths found at Shell's drill sites.

The NPDES General Permit under which the discharges will be authorized limits the toxicity of drilling fluids (at end of discharge pipe) to a minimum 96-hr LC50 of 30,000 ppm. Recent toxicity testing of the drilling fluid system planned for the revised Chukchi Sea EP shows a 96-hr LC50 of >500,000 ppm (M-I Swaco 2013). Both modeling and field studies have shown that discharged drilling fluids dilute, disperse and/or diffuse rapidly in receiving waters (Ayers et al. 1980a, 1980b, Brandsma et al. 1980, NRC 1983, O'Reilly et al. 1989; Nedwed et al. 2004, Smith et al. 2004, Neff 2005). Dilution rate is strongly affected by discharge rate; EPA's NPDES General Permit limits the discharge of cuttings and fluids to 1,000 bbl/hr or less in water depths of 130 ft (40 m) or more. The EPA (2006a) modeled hypothetical 1,000 bbl/hr discharges of drilling fluids in water depths of 130 ft (40 m) in the Chukchi Sea and predicted a minimum dilution of 1,173:1 at 33 ft (100 m) from the discharge point. Modeling of similar discharges offshore of Sakhalin Island predicted a 1,000-fold dilution within ten minutes and 328 ft (100 m) of the discharge point. EPA (2011) modeled similar discharges in the Chukchi Sea and predicted a 25-385-fold dilution within 328 ft (100 m) of the discharge point. Drilling fluid discharges at Shell's drill sites will be pre-diluted with seawater at a rate of 10 bbl / minute.

In a field study (O'Reilly et al. 1989) of a drilling waste discharge offshore of California, a 56 yd^3 (43 m^3) discharged drilling fluids were found to be diluted 183-fold at 33 ft (10 m) and 1,049-fold at a distance of

328 ft (100 m) from the discharge point. Neff (2005) concluded that concentrations of discharged drilling fluids drop to levels that would have no effect within about two minutes of discharge and within 16 ft (5 m) of the discharge location. Any toxic effects on fish and fish larvae present within a few feet of the discharge point would be expected to be due solely to the physical effects of suspended solids, and would be negligible and ephemeral. Modeling of the cuttings and adhered drilling fluid discharges associated with Shell's exploration drilling program indicates that suspended solids would be less than 100 ppm within 110 yd (100 m) of the discharge location, and that the end of season mud discharges would be less than 46 ppm at a distance of 0.6 mi (1.0 km). As discussed above regarding the effects of MLC construction, these suspended sediment loads are much lower than those reported to be harmful to fish.

Demersal fish eggs could potentially be smothered if discharges occur in, and the discharged materials are deposited on a spawning area during the spawning period. Shallow hazards surveys conducted at the drill sites indicate that the seafloor is relatively level and featureless with sediments consisting primarily of silts and clays. No special spawning areas were noted. Many of the most abundant marine fish species in the northeastern Chukchi Sea spawn under the ice during the winter and diadromous fish spawn in freshwater or brackish water near the shoreline. Therefore little or no effect on fish eggs would be expected.

4.5.4 Impact of Drilling Waste Discharges on Birds, Including Birds Designated as Threatened or Endangered

The discharge of drill cuttings and drilling fluids will have no direct effect on birds. All drill cuttings and drilling fluids will be discharged to the Chukchi Sea under the conditions and limitations of the required NPDES General Permit AKG-28-8100 (Table 4.5.1-1). Under this permit there can be no discharge of oil, which could impact birds. The EPA (2006) in their required assessment of the effects of discharges associated with the permit similarly concluded that such discharges would not have noteworthy effects on birds either through direct contact or indirectly by affecting prey species availability.

The discharge of drill cutting and drilling fluids will affect water quality parameters, primarily increasing TSS. Most of these effects will be limited to the area within 328 ft (100 m) of the discharge location and would last only a few minutes to a few hours after the discharge is stopped. These water quality effects would have no direct effect on birds, and little or no indirect effect on birds through effects on prey species such as zooplankton and fish.

Drill cuttings and drilling fluids will settle rapidly onto the seafloor, and within areas of heavy seafloor accumulation there will some temporary diminution of the density and abundance of benthic invertebrates, and therefore potential for indirect impact to benthic feeding seabirds such as eiders and long-tailed ducks. However, the Burger Prospect area is not heavily utilized by these species due to water depths and distance from shore and the area that would affected is small. Modeling of these discharges indicates that these discharged materials may settle to a thickness of 0.4 in. (1.0 cm) or more over a total of approximately 9.7 ac (3.9 ha) for all six wells, which represents less than 0.000028 percent of the Lease Sale 193 Area. Indirect effects on seabirds from the smothering of benthic invertebrates by drilling waste discharges will therefore be negligible.

Concentrations of heavy metals may be slightly elevated within this area, but these effects will be minimized by NPDES General Permit restrictions on metal concentrations in barite used in the drilling fluids. Metal concentrations would not be elevated to levels that would have ecological effects (Shell Global Solutions 2009). Research has shown that these metals have low bio-availability and that there is little bio-accumulation of the metals (Neff et al. 1989a, 1989b, and 1989c; Leuterman et al. 1997; Neff 2010). Drilling waste discharges will have at most only a negligible impact on marine birds.

4.5.5 Impact of Drilling Discharges on Marine Mammals, Including Marine Mammals Designated as Threatened or Endangered

Drill cuttings and drilling fluid discharges are regulated by the EPA's NPDES General Permit. The NPDES General Permit establishes discharge limits for drilling fluids (at the end of a discharge pipe) to a maximum of 1,000 bbl/hr (159 m^3/hr) in receiving waters with a depth of 130 ft (40 m) or more. Actual discharge rates during Shell's exploration drilling operations are expected to be less than 30 bbl/hr (5.0 m^3/hr). All discharged fluids are required to meet strict toxicity limits with a minimum 96-hr LC_{50} of 30,000 ppm. The most recent toxicity testing on the drilling fluid planned for use in Shell's exploration drilling program indicated the fluid has a 96-hr LC50 of >500,000 ppm. Both modeling and field studies have shown that discharged drilling fluids are diluted rapidly in receiving waters (Ayers et al. 1980a, 1980b; Brandsma et al. 1980; NRC 1983; O'Reilly et al. 1989; Nedwed et al. 2004; Smith et al. 2004; Neff 2005). The EPA modeled a hypothetical 1,000 bbl/hr discharge of drilling fluids in 130 ft (40 m) of water in the Chukchi Sea and predicted a minimum dilution of 1,173:1 at 330 ft (100 m) down-current from the discharge point. The impact of drill cuttings and drilling fluid discharges on marine mammals, including marine mammals designated as threatened or endangered, remains as described in the EIA for EP Revision 1.

Gray whales will more than likely avoid exploration drilling activities and not come into close contact with drilling fluid and cuttings. However, gray whales are benthic feeders and the area of seafloor that will be covered by discharge will be unavailable to the whales for foraging purposes. This is not expected to impact individual whales or the gray whale population, because the areas of disturbance on the seafloor covered with drill cuttings, calculated to be an ellipse some 328 ft (100 m) long, are unimportant compared to the area available to the whales for foraging. Dunton et al. (2009) investigated the benthic communities at the historic Hammerhead exploration wells in the Beaufort Sea, and concluded that they could not discern any measureable changes in benthic community structure at Hammerhead as a result of drilling activities that took place over 20 years ago. They further stated that if the benthic community was impacted during drilling operation for the Hammerhead well, it had progressed well towards recovery. Any effect of drilling discharges associated with the exploration drilling program as described in EP Revision 2 on foraging areas for benthic feeding marine mammals, such as gray whales, would be negligible.

Impacts on beluga whales, killer whales, minke whales, and harbor porpoise, as well as fin, humpback, and bowhead whales, due to the discharge of drilling fluid and cuttings are not likely. It is anticipated that drilling fluid and cuttings will only dispense up to 330 ft (100 m) from the discharge location at the drill site in beluga feeding areas. It is therefore unlikely that these marine mammal species will come into contact with any exploration drilling discharge or that the discharges will have any adverse impact.

Seals would not be expected to be impacted by drilling fluid or cuttings. It is unlikely that seals would remain within 330 ft (100 m) of the discharge point for an extended time period, so exposure to discharged fluid and cuttings would limit any impacts to this highly mobile species. Discharge of drilling fluid and cuttings would likely result in some loss of benthic invertebrates on and in the seafloor due to the smothering. This loss would have negligible effects on pinniped species, even those that feed primarily on benthic organisms, such as bearded seals and walrus, because of the small area likely to be affected. Results of discharge modeling indicate that a relatively small area would be impacted by drill cuttings settling out on the seafloor (Tables 4.1.3-2 and 4.1.3-3). This area, compared with the total area of feeding habitat available to seals, is very small. Any direct effects from the discharge on seal prey would have a negligible effect on the seals.

4.5.6 Impact of Drilling Discharges on Sensitive Areas

Discharges of drill cuttings and drilling fluids will take place at the drill sites located more than 54 mi (87 km) offshore of LBCHU, Kasegaluk Lagoon, Peard Bay, and the Alaska Maritime NWR and 31 mi (50 km) seaward of the polynya zone (EIA EP Revision 1 Table 4.1.9-1). The discharges will have negligible effects on water quality near the drillship, consisting primarily of increases in TSS concentrations, which will be limited primarily to the area within about 328-656 ft (100-200 m) of the drill site. Most seafloor effects due to deposition of drill cuttings and drilling fluids will be restricted to the area within about 394 ft (120 m) of the drill site, although some negligible amounts of deposition will occur at greater distances. As described in the EIA for EP Revision 1, these discharges should have no effect on the identified sensitive areas due to the distance between the areas and the drill sites.

4.5.7 Impact of Drilling Waste Discharges on Subsistence

Shell's planned drill sites where exploration drilling and drilling waste discharges will occur are located over 78 mi (126 km) from the nearest village, 64 mi (103 km) offshore of the coastline (EIA EP Revision 1 Table 3.0-1) and more than 30 mi (48 km) from areas known to be used for subsistence (EIA EP Revision 1 Figure 3.11.7-11)

Drilling waste discharges will have minor effects on water quality near the drillship, consisting primarily of increases in TSS concentrations, which will be limited primarily to the area within about 328-984 ft (100-300 m) of the drill site. These water quality effects will have no effect on subsistence because of the distance to subsistence use areas, or to subsistence resources such as fish, birds, or marine mammals.

Most seafloor effects due to deposition of drill cuttings and drilling fluids will be restricted to the area within about 460 ft (140 m) of the drill site, although some negligible amounts of deposition will occur at greater distances. Deposition of these materials will have no direct effect on subsistence due to the distances from the drill sites to the nearest subsistence use areas. Deposition will smother some benthic organisms and result in long term changes to the benthic community. Some subsistence species, such as eiders and other sea ducks, bearded seals, walrus, and gray and to a lesser degree bowhead whales are benthic feeders. Loss of feeding habitat for these subsistence resource could be considered an indirect effect on subsistence; however, use of the area by sea ducks is very low due to water depths, and the area of effect is so small (approximately 0.4 ac / 1,460-1,500 m^2 for each well, and about 9.7 ac (3.9 ha) for all six wells in the EP) representing < 0.000028 percent of the Lease Sale 193 Area and 0.000007 percent of the Chukchi Sea, that any such effects on sea ducks or other benthic feeding species are negligible.

The deposition will result in nominal increases in the concentrations of some metals. Past modeling of similar discharges in the Chukchi Sea (Shell Global Solutions 2009) indicates that increases in mercury, cadmium, and chromium, if any, would be minimal, below concentrations found to have ecological effects (Long et al. 1995). Laboratory studies of bioaccumulation of drilling fluids have found only a small degree of barium and chromium uptake, and little or no uptake of other metals (Neff 1989a, 1989b). When bioaccumulation has been observed it has not been high enough to be harmful to the accumulating animals (Melton et al. 2000). Studies of bioaccumulation of mercury, cadmium, copper, lead, and arsenic have found that these metals are virtually non-available for bio-accumulation due to their chemical form (Neff 1989b). Studies have also shown that these heavy metals do not bio-magnify in marine food webs (Neff 1989a, 1989b). Therefore the discharges will not impact subsistence.

EP Revision 2 includes adjustments in drilling waste discharge volume estimates, and additional drilling fluid components. Modeling indicates that the area of effect of these discharges is substantially the same or less than described in the EIA. Toxicity of the added drilling fluid components (Table 4.5.2-2) and the whole fluid are low and similar to that described in the EIA for EP Revision 1. Impacts to subsistence will be the same as described in the EIA for EP Revision 1, drilling waste discharges will have no direct effect on subsistence due to the distance between the drill sites and areas used for subsistence, and only negligible or minor effects on subsistence resources or their habitats and food resources.

4.6 Cumulative Impacts

This section identifies and evaluates potential cumulative impacts of Shell's exploration drilling program as described in EP Revision 2 in combination with other past, present, and reasonably foreseeable activities. Cumulative impacts can result from individually minor, but collectively significant, actions taking place simultaneously and over time. This cumulative impacts analysis characterizes the cumulative impacts of Shell's exploration drilling program under EP Revision 2, when added to the aggregate effects of past actions, together with other current and reasonably foreseeable future actions in the Lease Sale 193 Area of the Chukchi Sea. Cumulative impacts may arise from single or multiple actions and may result in additive or interactive effects. Interactive effects may be countervailing, where the net adverse cumulative effect is less than the sum of the individual effects, or synergistic, where the net adverse cumulative effect is greater than the sum of the individual effects.

4.6.1 Previous Cumulative Impact Analyses

Potential cumulative impacts associated with Shell's exploration drilling program were evaluated in detailed in Section 4.2 of the EIA for EP Revision 1. This revised analysis builds on prior information in a number of cumulative impact analyses of proposed oil and gas activities that have been prepared in recent years, including NEPA EISs and EAs, and ESA Biological Opinions (BOs), as well as draft and final cumulative impact analyses that have been completed since 2011, including the following:

- Effects of Oil and Gas in the Arctic SDEIS (NOAA 2013b) (*new*)
- EA for incidental take regulations for walruses and polar bears in the Chukchi Sea (USFWS 2013) (*new*)
- EA for Shell's EP Revision 1 (2012 Exploration Drilling Program in the Chukchi Sea) (BOEM 2012) (*new*)
- Draft EIS on the effects of oil and gas activities in the Arctic Ocean (NMFS 2011) (*new*)
- EA for ancillary activities (Statoil shallow hazards surveys) in the Chukchi Sea (BOEM 2011) (*new*)
- Cumulative impact section of the EIA for EP Revision 1
- Final Supplemental EIS for Lease Sale 193 in the Chukchi Sea (BOEMRE 2011)
- Draft Programmatic EIS for seismic surveys in the Beaufort and Chukchi Seas (MMS 2007a)
- EIS for Lease Sale 193 and seismic surveys in the Chukchi Sea (MMS 2007b)
- Programmatic EA for seismic surveys in Chukchi and Beaufort Seas (MMS 2006b)

The reader is referred to the above-referenced larger documents for detailed analyses of past, present, and reasonably foreseeable activities in the Chukchi Sea and their potential effects on the environment. These documents cover periods of time ranging from one to 20 years. The level and types of activities planned in Shell's EP Revision 2 are within the range of past, present, and reasonably foreseeable activities identified in the cumulative impacts scenario and evaluated in these documents.

Shell's exploration drilling program, as outlined in EP Revision 1 and altered here by EP Revision 2, is expected to be conducted over a period of approximately three years, with all exploration drilling likely concluded in approximately three drilling seasons. No identified potential impacts associated with EP Revision 2, with the exception of negligible impacts to seafloor sediments, are anticipated to last beyond that time period.

The time frame of a cumulative impacts analysis "extends as long as the effects may singly, or in combination with other anticipated effects, be significant on the resources of concern. At the point where the contribution of effects of the action, or combination of all actions, to the cumulative impact is no longer significant the analysis should stop." (EPA 1999, *Consideration of Cumulative Impacts in EPA Review of NEPA Documents*; CEQ 1997, *Considering Cumulative Effects Under the National Environmental Policy Act* at 16 ("time frame for the project-specific analysis usually does not extend beyond the time when project-specific effects drop below a level determined to be significant" or beyond when the project-specific effects combined with other actions result in significantly cumulative effects)).

The time frame for a cumulative impacts analysis must be defined on a case-by-case basis, and depends on the characteristics of the resources affected and the magnitude and scale of a project's impacts (EPA 1999). In regard to Shell's EP Revision 2, the only impacts anticipated to remain after the exploration drilling program has been concluded will be negligible or minor as described in Section 4; therefore, the time frame for the cumulative effects analysis is not extended into the future beyond the conclusion of the drilling program. For example, some effects of seafloor disturbance associated with the exploration drilling program may be demonstrable for 10 or more years after drilling, but any such effects would be minor. Present and future activities considered in the cumulative effects analysis are therefore limited to activities that are reasonably foreseeable in the next three years. The cumulative impacts analysis also considers past activities that have resulted in impacts that are expected to still be evident in the next drilling season; therefore, the time frame of the analysis extends into the past to the time when those earliest past activities were conducted. For this analysis, the historic exploration drilling programs of 1989-1992 represent the earliest activities and the start of the cumulative impacts analysis time frame. The effects of some past activities that occurred at an earlier time are considered in the analysis of effects on certain resources specifically the effects of commercial whaling on marine mammals but little effect of these activities remain.

This section provides an analysis of Shell's exploration drilling program as described in EP Revision 2, when added to the effects of other past, present, and reasonably foreseeable activities. As required under 30 CFR 550.285(b), the section avoids repeating the analysis of the EIA for EP Revision 1 and discusses those portions of the cumulative impacts analysis that have changed as a result of new activities and new information since the prior EIA was completed.

4.6.2 Past, Present, and Reasonably Foreseeable Activities

Section 4.2.2 of the EIA for EP Revision 1 identified past, present, and reasonably foreseeable future activities for consideration in the cumulative impacts analysis. The following sections update that information.

<u>Past, Present, and Future Oil and Gas Exploration</u>

Past Exploration Drilling Programs

Operators have drilled five exploration wells in the U.S. waters of the Chukchi Sea to date (Table 1.2-1 in the EIA for EP Revision 1). The only change in past exploration drilling programs since the EIA for EP Revision 1 is that Shell constructed the MLC and drilled the upper sections of the Burger A well in 2012.

Investigations of well sites, where drilling was conducted in the 1980s and 1990s in the Chukchi and Beaufort Seas, indicate that little impact remains to date. For example, Neff et al. (2010) evaluated concentrations of metals and various hydrocarbons in sediments at the historic Burger and Klondike wells drilled in the Chukchi Sea in 1989-1990. Surface and subsurface sediments collected in 2008 at the historic drill sites contained higher concentrations of all types of analyzed hydrocarbon in comparison to the surrounding area. The same pattern was found for the metal barium, with concentrations 2-3 times greater at the historic drill sites (mean = 1,410 µ/g and 1,300 µ/g) than in the surrounding areas (639 µ/g and 595 µ/g). Concentrations of copper, mercury, and lead, were elevated in a few samples from the historic drill sites where barium was also elevated. All observed concentrations of hydrocarbons or metals in the sediment samples from the historic drill sites were below levels (below ERL or Effects Range Low of Long 1995) believed to have adverse ecological effects (Neff et al. 2010).

Similar results were reported by Trefry and Trocine (2009) for the historic Hammerhead drill sites in the Beaufort Sea, where elevated levels of barium, silver, chromium, lead, selenium were found within 328 ft (100 m) of the Hammerhead drill site. Some changes in relief are still evident such as MLC excavations.

All of the effects associated with past drilling are negligible but some effects are long term and will overlap in time with any similar effects associated with Shell's EP Revision 2.

Present and Future Offshore Oil and Gas Exploration Drilling

Shell's approved EP Revision 1 includes six drill sites (Table 2.1-1 in the EIA for EP Revision 1). This exploration drilling program will use a drillship and a number of associated support vessels as described in Section 2.2 of the EIA for EP Revision 1 and revised in Section 2 above in this document. Potential environmental impacts associated with these planned activities are detailed in Section 4 of the EIA for EP Revision 1; changes in the evaluation of these effects due to EP Revision 2 are discussed in Section 4. EP Revision 2 results in no substantial increases or changes in potential environmental impacts associated with the exploration drilling program.

The only other appreciable change in reasonably foreseeable exploration drilling since the EIA for EP Revision 1 is the treatment of exploration drilling by other operators within the next few years in the Chukchi Sea as speculative, as described below.

Speculative Offshore Oil and Gas Exploration Drilling

A cumulative impacts analysis must consider "reasonably foreseeable future actions" per 40 CFR § 1508.7. While some "reasonable forecasting" is required under NEPA and a project sometimes must be considered in a cumulative impacts analysis even if a specific proposal is not available, a cumulative impacts analysis need not include projects that are "speculative" (EPA 1999). Although "speculative" is not defined in NEPA or the Council on Environmental Quality's (CEQ's) regulations, case law interpreting the term "speculative" holds that whether a future project is to be considered speculative depends upon: (1) the likelihood the future project will occur and (2) whether there is sufficient information available for a meaningful analysis. *Environmental Protection Information Center v. U.S. Forest Serv.*, 451 F.3d 1005, 1014 (9th Cir. 2006) ("*EPIC*"); *Habitat Education Ctr. v. U.S. Forest Serv.*, 609 F.3d 897 (7th Cir. 2010) (reasonably foreseeable future projects that do not have enough information for a meaningful analysis do not need to be included in a cumulative analysis); EPA 1999 *Consideration of Cumulative Impacts in EPA Review of NEPA Documents* (identifying actions the cumulative impacts analysis should consider, including the likelihood the project will occur and the imminence of the project).

When courts have found that future projects were inappropriately excluded from an agency's cumulative impacts analysis, the cases involved future projects which, at the time of the NEPA analysis, were likely, imminent, and had sufficient project detail available to allow for a meaningful analysis of both the activity anticipated and the associated environment impacts. *Muckleshoot Indian Tribe v. U.S. Forest Serv.*, 177 F.3d 800, 812 (9th Cir. 1990) (court held that a future land exchange should have been included in the cumulative impacts analysis when there was a summary document describing the future land exchange one year before the final NEPA document was issued, and a press release five months before, finding the "virtual certainty of the transaction and its scope" required agency to evaluate the future land exchange under NEPA); *Blue Mountain Biodiversity Project v. Blackwood*, 161 F.3d 1208 (9th Cir. 1998) (the court found that five future timber sales should have been included in the cumulative impacts analysis because they were disclosed by name, and estimated sale quantities and timelines were known before the NEPA document was completed). While it is not appropriate to defer the cumulative impacts analysis to a future date when a meaningful analysis can occur now, when not enough information is available to allow for meaningful consideration it is impractical to include a vague proposal in the analysis. *EPIC*, 451 F.3d at 1014 (citing *Kern v. BLM*, 284 F.3d 1062, 1075 (9th Cir. 2002) and *Blue Mountains Biodiversity*, 16 F.3d at 1215).

Two other operators have indicated their intent to drill exploration wells in the Chukchi Sea. Statoil holds an interest in, and is designated the operator at, 16 leases at prospects named Amundsen and Augustine in the Chukchi Sea; 14 of these leases are in collaboration with Eni. Statoil is also a partner in the Devils Paw prospect where ConocoPhillips is the operator. Statoil originally indicated its intent to drill at Amundsen and Augustine as early as 2014, but in July 2013 it publically announced that it would not make a decision on future drilling in the Chukchi until 2015, at the earliest.

ConocoPhillips acquired 98 Chukchi Sea leases in 2008 at Lease Sale 193. The company submitted draft EPs to BOEM in 2011 and again in 2013, proposing to drill up to two exploration wells at the Devils Paw Prospect in 2014. ConocoPhillips' 2013 draft EP was never made public and was never "deemed submitted" by the BOEM. ConocoPhillips subsequently announced in April 2013 that it put plans for exploration drilling in the Chukchi Sea in 2014 on hold, citing uncertainty created by evolving federal regulatory requirements and operational permitting standards. See ConocoPhillips News Release, *Regulatory Uncertainty Leads ConocoPhillips to Put 2014 Chukchi Sea Exploration Drilling Plans on Hold* (Apr. 10, 2013), at http://alaska.conocophillips.com/EN/news/newsreleases/Documents/NR-AK-Chukchi%20Sea-FINAL%204-9-2013.pdf.

Importantly, despite multiple, active oil and gas leases in the Chukchi and Beaufort Seas, and the government's projections of more significant exploration and development in the area, the Arctic Ocean, generally, and the Chukchi Sea, specifically, remain a frontier. In light of the demanding and changing regulatory and permitting hurdles required to proceed with exploratory drilling in the Arctic, other companies' plans are uncertain and predicting such activity over the next three years is difficult.

At this time, exploration drilling by Statoil or ConocoPhillips is not imminent, and it is unclear whether or when any projects might move forward. Numerous state and federal permits and approvals are required before Statoil or ConocoPhillips could conduct exploratory drilling. There are no proposals, permits, or applications pending that provide current information or timing regarding either company's future plans. Specifically, it does not appear likely that an exploratory drilling program in the Chukchi Sea from Statoil, ConocoPhillips, or another company, is likely within the next three years.

Even if such a project were likely in the next three years, which Shell concludes it is not, Shell cannot make reasonable forecasts as to how these companies would conduct any future operations. There is no public information about: (1) when any future drilling would occur, (2) what drillship, support vessels and infrastructure would be used, (3) the air emissions and NPDES and other water discharges associated with any future operations, (4) which and how many specific prospects and locations would be drilled, (5) the site-specific biological, physical, and socioeconomic characteristics of the prospect(s), (6) what distinct oil spill concerns would be posed by the locations and the OSR vessels to be employed, and, most importantly (7) the anticipated environmental impacts of such a project. Without any of this basic operational information and site characterization, Shell cannot forecast what environmental impacts would be associated with any future, hypothetical drilling program and what mitigation measures would be adopted. Shell cannot conduct a meaningful analysis of the cumulative impacts associated with such activity.

Shell used the legal standard for determining when future projects should be considered reasonably foreseeable when determining the status of other potential exploration activities in the Chukchi Sea. For purposes of this cumulative impacts analysis, Shell considers any Exploration Plan (or Development Plan) that has been "deemed submitted" by BOEM and is publicly available, to be "reasonably foreseeable" and appropriate for inclusion in a cumulative impacts analysis. By the same token, Shell considers any discussions of possible activity without the submission of an Exploration Plan (or Development Plan) and completeness determination by BOEM to indicate a project is not likely in the short-run. Without sufficient information and detail regarding the parameters of another project and its potential effects, a meaningful analysis is impractical and Shell considers any such activity "speculative" and inappropriate for inclusion in a cumulative impacts analysis. Based on this definition of speculative, Shell has not considered any potential exploration activity in the Chukchi Sea by Statoil, ConocoPhillips, or other companies in this cumulative impacts analysis. BOEM (2011) used this same criterion for determining when offshore exploration drilling programs are reasonably foreseeable in the NEPA EA for Shell's EP Revision 1.

Shell notes that if an EP is submitted by another company in the future, any subsequent review and NEPA approval by BOEM would be in a better position to consider the cumulative impacts of those programs in conjunction with previously-approved EPs in the Arctic. *See Kleppe v. Sierra Club,* 427 U.S. 390, 410 n.20 (1976) (noting that once contemplated actions become more formal proposals, later impact statements on those projects will take into account the effect of the earlier proposed actions); *EPIC* 451 F.3d at 1014 & n.5.

Past Seismic Surveys and Shallow Hazards Surveys

Offshore oil and gas exploration programs have operated in the Alaskan Chukchi Sea since the 1950s, although the extent of these activities has varied significantly over the years. Since 2006, seismic and shallow hazards surveys have been conducted by industry in the Alaskan Chukchi Sea. The levels of survey activity, as represented by survey trackline distances per year in the Chukchi Sea were presented in Table 4.2-1 in the EIA for EP Revision 1; that information is updated below as Table 4.6-1 with survey miles in 2011 and 2012. Survey activity levels were greatest in 2006 and lowest in 2012. Similar survey activity levels occurred in the Chukchi Sea in 2007-2011.

Table 4.6-1 Seismic & Shallow Hazards Survey Source Vessel Miles in the Chukchi Sea 2006-2012

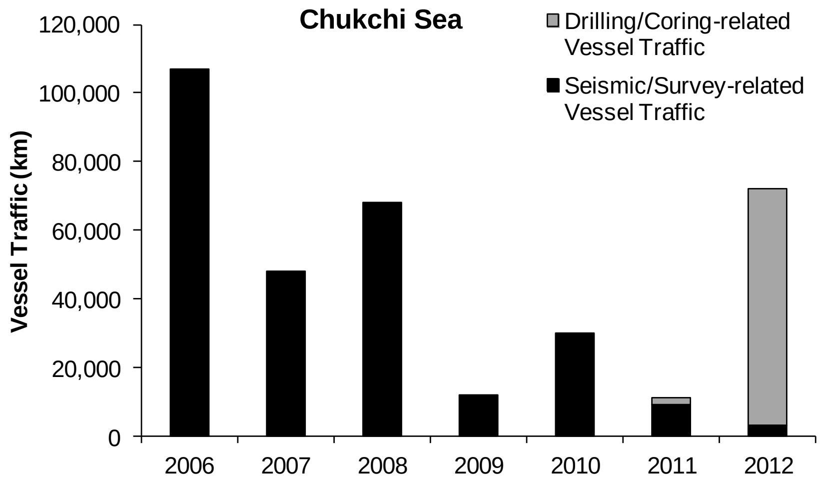
Survey Type	Source Vessel Trackline by Year [1]						
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Shallow Hazards	0 mi	0 mi	1,365 mi	1,107 mi	0 mi	2,785 mi	0 mi
	0 km	0 km	2,196 km	1,781 km	0 km	4,482 km	0 km
Deep Seismic	11,359 mi	1,812 mi	905 mi	0 mi	2,785 mi	329 mi	115 mi
	18,280 km	2,916 km	1,457 km	0 km	4,482 km	530 km	185 km
Total Survey	11,359 mi	1,812 mi	2,270 mi	1,107 mi	2,785 mi	3,114 mi	115 mi
	18,280 km	2,916 km	3,653 km	1,781 km	4,482 km	5,012 km	185 km
All Vessel Traffic	66,386 mi	25,743 mi	27,642 mi	7,618 mi	30,035 mi	ND	ND
	106,838 km	41,430 km	44,485 km	12,260 km	48,336 km	ND	ND

[1] Source: Funk et al. 2011 for 2006-2010, Hartin et al. 2011 and RPS 2011 for 2011, and Beland et al. 2013 for 2012

Environmental effects of seismic surveys and shallow hazard surveys are largely restricted to ensonification (increases in ambient sound levels) by the vessels and operating geophysical equipment, vessel presence, and vessel discharges. All of these effects are transient lasting only as long as the specific activity is on-going, and therefore provide no opportunity for additive or synergistic effects with Shell's exploration drilling program.

Seismic surveys, shallow hazards surveys, and exploration drilling require support vessels in addition to the survey source vessel or drilling unit. Vessel traffic experienced in the Chukchi Sea in 2006-2010 was presented in Figure 4.2-1 in the EIA for EP Revision 1; the figure is updated below as Figure 4.6-1 with levels of vessel traffic associated with oil and gas exploration through 2012.

Figure 4.6-1 Kilometers of vessel traffic, including support vessels, from offshore oil and gas exploration programs from drilling/coring versus seismic/marine survey in the Alaskan Chukchi Sea 2006–2012



Source: LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2013.

Present and Future Offshore Seismic Surveys and Shallow Hazards Surveys

Shell has no current plans to conduct large-scale three-dimensional (3D) or two-dimensional (2D) seismic surveys in the Chukchi Sea during the same time frame covered by EP Revision 2. Shell may conduct shallow hazards surveys during the time period covered by EP Revision 2. A typical shallow hazards site survey is conducted by a single survey vessel. If conducted, shallow hazards surveys would be only on Shell leases. Shallow hazards survey vessels may require one or two crew changes in a season; these crew changes may be in Nome, Kotzebue, Wainwright, or Barrow. The anticipated equipment to be used for any shallow hazards surveys would include: dual-frequency, side-scan sonar; single-beam, bathymetric sonar; multi-beam, bathymetric sonar; shallow sub-bottom profiler; deep penetration profiler 40 in^3 airgun array; medium penetration profiler 40 in^3 airgun array; ultra short baseline acoustic positioning; navigation instrumentation; and magnetometer. These types of surveys using the identified equipment have been conducted in the recent past, and the environmental effects associated with the reasonably foreseeable future surveys would be expected to mirror those identified for past surveys. Some of the proposed equipment (multi-beam sonars, side-scan sonars, and most single beam sonars) are operated at frequencies that are above what is thought to be the hearing range of most marine mammal species and are expected to have no effect on marine mammals. Other proposed equipment could have transient effects (i.e., lasting only as long as the activity), restricted to ensonification by the vessels and operating equipment, vessel presence, and vessel discharges, and do not result in additive or synergistic effects with Shell’s exploration drilling program.

Shell’s shallow hazards survey activities are considered reasonably foreseeable and included in this cumulative impact analysis. Shell is not aware of any proposed seismic surveys or shallow hazards surveys in 2014 or beyond by other oil and gas operators. No applications for permits with BOEM or NMFS for such surveys are presently found on line.

Present and Future Geophysical, Geotechnical, and Environmental Surveys

The Office of Coast Survey, National Oceanic and Atmospheric Administration (NOAA) have filed an application with NMFS for a Letter of Authorization (LOA) to conduct hydrographic surveys in coastal waters of the U.S., including the Chukchi Sea in 2013-2018. The application is not specific as to which years the Alaskan surveys would be conducted or the specific locations of the surveys. Geophysical equipment operated during these hydrographic surveys includes single-bean and multi-beam echosounders and side-scan sonars. Potential environmental effects of hydrographic surveys include vessel discharges and operation of geophysical equipment. Multi-beam sonars, side-scan sonars, and most single beam sonars used in the Chukchi Sea are operated at frequencies that are above what is thought to be the hearing range of most marine mammal species. Sound energy from these types of equipment would therefore be expected to have no effect on marine mammals.

Shell may conduct ice gouge and strudel scour surveys, geotechnical surveys, or environmental surveys of various types in the Chukchi Sea during the time period covered in EP Revision 2. While Shell has not determined if and when any of these surveys will take place, Shell has determined that they are "reasonably foreseeable" in one or more of the years covered and has conservatively included them in its cumulative impacts analysis. The types of geophysical equipment typically utilized in these surveys are indicated in the new Table 4.6.2-1 provided below.

Table 4.6.2-1 Equipment Use for Possible Offshore Surveys by Shell in the Chukchi Sea

Equipment Type [1]	Ice Gouge	Strudel Scour	Geotechnical	Environmental
Dual-frequency, side-scan sonar	●	●	--	--
Single-beam, bathymetric sonar	●	●	●	--
Multi-beam, bathymetric sonar	●	●	--	--
Shallow sub-bottom profiler	●	--	--	--
Deep Penetration Profiler 40 in^3 airgun	--	--	--	--
Medium Penetration Profiler 40 in^3 airgun	--	--	--	--
Ultra Short Baseline Acoustic Positioning	●	--	●	--
Navigation Instrumentation	●	●	●	●
Magnetometer	●	--	●	--
Rotary drilling	--	--	●	--
Cone penetrometer	--	--	●	--

[1] Equipment types may vary slightly from that proposed, thus all equipment types are qualified with, "or similar"
[2] Key: ● = Possible use for this survey type during the cumulative impacts analysis time frame; -- = Not intended for this survey type

A total of about six vessels may be used to conduct all these different types of surveys across broad areas of the Chukchi Sea in a given open water season. Ice gouge, geotechnical, and environmental surveys would be conducted in and around Shell OCS leases as well as coastal waters between the OCS leases and the shoreline. Periodic crew changes would be conducted for these vessels. The crew changes would likely to be staggered on a weekly basis, but would vary depending on weather and other considerations. Approximately 8-24 crew personnel would be rotated off the vessel to shore by a shallow water landing craft each week, and exit the shore location on the same day via commercial airlines. At this time Kotzebue is a likely shore location but Nome may also be used for part or all of these crew changes. A block of hotel rooms may be booked in Kotzebue as a contingency when timing or weather prevents same-day departure.

Geotechnical surveys, if conducted by Shell during the time period covered in this cumulative effects analysis, would consist of the collection of soil borings to assess the index and engineering properties of the soils encountered. The borings would range in depth and generally fall into three categories: shallow pipeline borings generally no deeper than 50 ft (15 m); deep assessment borings drilled no deeper than 450 ft (137 m) and typically range between 200-300 ft (61-91 m); and deep platform borings no deeper than 500 ft (152 m). All boreholes would likely be conducted using a rotary drilling type system, with either conventional (on the vessel) equipment or the newer seabed-based technology. These activities would be conducted from the deck of a single vessel in either DP mode or utilizing an anchoring system. The vessel is expected to be a DP vessel with a length of about 261 ft (79.6 m). The number of borings to be drilled would depend on the speed with which the drilling effort proceeds; Shell estimates that approximately 22 shallow pipeline borings, two deeper assessment borings, and four deep platform borings may be drilled in an open water season. Drilling fluids consisting primarily of a viscosifier such as bentonite or attapulgite clay and a weighting agent such as barite would be used when drilling the deeper boreholes; in general, the shallow pipeline boreholes would not require drilling fluid. Other discharges from the survey vessel would likely include those that are normal parts of vessel activity, including: non-contact cooling water, bilge, ballast, gray water, and black water. The geotechnical work is expected to take about 40 days (excluding any downtime) per year and would be conducted during an open water season, most likely in August-September. The borehole locations would be located within Shell leases and along prospective pipeline routes between Shell OCS leases and the Chukchi Sea shoreline.

Ice gouge and strudel scour surveys may be conducted during the time period covered by the cumulative effects analysis. These surveys would likely be carried out by two survey vessels; one (a larger vessel with a length of about 230 ft / 70 m) would conduct the offshore ice gouge surveys in water depths of 66-166 ft (20-50 m), and the other would conduct the nearshore ice gouge surveys and strudel scour surveys in water depths of less than 98 ft (30 m). The survey work would take about 48 days per year and would be conducted during an open water season, most likely in June-July. Ice gouge surveys would likely be conducted along about 650 mi (1,050 km) of tracklines per year between Shell OCS leases and the Chukchi Sea shoreline. The strudel scour survey also entails the use of a helicopter for an aerial reconnaissance during break-up (mid-May to early June) to locate strudel holes in the ice. The vessel-based geophysical surveys associated with the strudel scour survey would take place subsequently in the open water season at locations identified in the aerial reconnaissance.

Shell may also conduct vessel-based fish and bird surveys in coastal waters of the Chukchi Sea during the time period covered by the cumulative effects analysis. A single vessel with a minimum length of about 50 ft (15m) would be used to conduct the fish and bird surveys. The fish surveys would consist of towing beam and pelagic trawls behind the vessel in nearshore waters in June-August, as well as setting fyke nets and using beach seines near the shoreline. Bird surveys would be conducted along transects within 6 mi (9 km) off the coast in a series of cruises in June-September.

Shell may also conduct various environmental surveys onshore on the North Slope during the time period covered by the cumulative effects analysis. These surveys could include cultural resource surveys, shore-based radar studies of bird movements, meteorological monitoring, permafrost characterization (geotechnical), wildlife habitat assessments, and hydrology studies (e.g. spring break-up, surface hydrology). Staff utilized in some of these surveys may potentially utilize shorebases established for the exploration drilling program. The onshore program would also use two helicopters to transport crews between field sites and shorebase facilities at Wainwright, Atqasuk, Umiat, Inigok and potentially another remote camp.

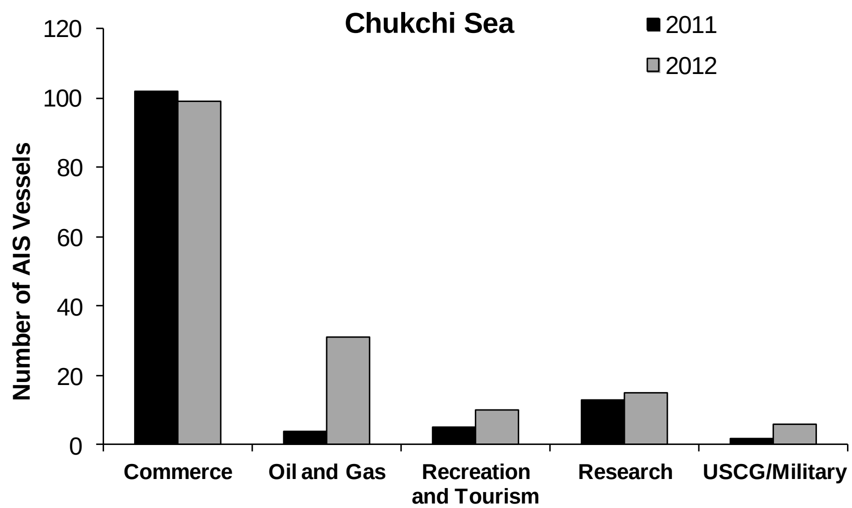
Past, Present, and Future Vessel Traffic

Various types of barge traffic unrelated to Shell's exploration drilling or seismic surveying occur in the Chukchi Sea. Chukchi Sea barge traffic is generally coastal, with the traffic occurring landward of Shell's Burger Prospect. Estimates of barge traffic (distances traveled by barges) in the Chukchi Sea in 2006-2010 based in some cases on actual schedules of barge trips supplied by barge operators and estimated length of barge routes, were provided in Table 4.2-2 of the EIA for EP Revision 1. Barge traffic levels in 2011 and 2012 are thought to have been similar to those presented in the EIA for 2006-2010.

Information on the total number of vessels that operated in the Chukchi Sea with an operating Automatic Identifications System (AIS) in 2011 and 2012 is provided in the new Figure 4.6.2-1. The AIS data does not capture all vessels present; for example, USCG requires on passenger vessels, tankers, and commercial vessels of > 300 gross tons have AISs onboard. Therefore these data should be considered minimums.

Environmental effects of vessel traffic are largely restricted to ensonification of waters by the operation of the vessels, vessel presence, and vessel discharges. All of these effects are transient lasting only as long as the specific activity is ongoing. Therefore, past barge traffic provides no opportunity for additive or synergistic effects with Shell's exploration drilling program as described in EP Revision 2. Future vessel traffic during the time period of the cumulative effects analysis is expected to occur at similar levels to those presented in Table 4.2-2 in the EIA for EP Revision 1 and Figure 4.6.2-1 below.

Figure 4.6.2-1 AIS-equipped Vessels in the Chukchi Sea 2011-2012



Source: LGL Alaska Research Associates, Inc., JASCO Applied Sciences, Inc., and Greeneridge Sciences, Inc. 2013.

Past, Present, and Future Effects of Subsistence and Commercial Whaling

Past, present, and future effects of the subsistence harvest of marine mammals and commercial whaling are described in Section 4.2.4 of the EIA for EP Revision 1. There are no substantial changes to that description of effects or activity levels. Givens et al (2013) published a revised estimate of the Bering-Chukchi-Beaufort (BCB or Western Arctic Stock) bowhead whale population: as of 2011, there were an estimated 16,892 whales in the stock with an estimated annual rate of increase of 3.7%. These new data indicate that the bowhead whale population continues to increase, and that the past effects of historical commercial whaling, and present subsistence and oil and gas activities are currently having little or no effect on the bowhead whale population.

4.6.3 Cumulative Impacts on the Physical Environment

Potential Cumulative Impacts on Air Quality

Air quality in the Chukchi Sea and onshore areas adjacent to the Chukchi Sea is considered to be good. Additional years of air quality monitoring data from a station in Wainwright since the EIA for EP Revision 1 (as provided in updated Table 3.1.3-1) indicate no change or diminution in regional air quality.

Emissions in the region come primarily from vessels and from electrical power generation in the villages of Barrow, Wainwright, Point Lay, and Point Hope, with smaller amounts from the operation of heavy equipment, vessels, and vehicles such as cars, trucks, and all-terrain vehicles. These would be expected to continue at the present levels during the time period of the cumulative effects analysis. Other reasonably foreseeable activities that would also potentially affect air quality include the general vessel traffic, shallow hazards, hydrographic, geophysical, geotechnical, and environmental surveys described above. Various engines on the vessels used for these purposes will emit pollutants of the same type and similar quantities as vessels used for Shell's exploration drilling program.

The exploration drilling program will emit air pollutants, largely through the use of combustion engines. EP Revision 2 effects on air pollutants include an increase in the number and size of support vessels, increased vessel and aircraft traffic, and construction and use of an expanded shorebase in Barrow. Emissions of primary interest include NO_2, CO, SO_2, $PM_{2.5}$, and VOC. As indicated in Table 4.1.1-1 above, modeled cumulative pollutant concentrations resulting from the *Discoverer* and its support vessels plus existing background concentrations at the shoreline are less than 50 percent of the NAAQS. The NAAQS primary and secondary standards are designed to protect human health and all aspects of the public welfare, including flora and fauna. Modeling also indicates that any effects on air quality in offshore areas will be similarly negligible. Predicted cumulative concentrations of air pollutants in offshore areas used for subsistence are far below the impact criteria thresholds developed, as indicated in Table 4.1.1-2 above. Because actual emissions are expected to be less than the estimated maximum emissions evaluated in the modeling effort, actual cumulative concentrations are expected to be even lower than those presented in Tables 4.1.1-1 and 4.1.1-2.

The air quality modeling utilized background concentrations from baseline air quality data collected at Wainwright in 2009-2011. These baseline data were collected during years and times when the other offshore activities described above, such as aforementioned surveys, barge traffic, and onshore power generation, were ongoing. Because these other activities are expected to occur in the future at the range of activity levels experienced during collection of the baseline data, the modeling results represent an assessment of the cumulative impacts on air quality given the above identified reasonably foreseeable activities.

Cumulative impacts on air quality from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered to be minor.

Potential Cumulative Impacts on Water Quality

Water quality is considered to be good in the Chukchi Sea, with few if any effects of past human activities. Potential water quality impacts of EP Revision 2 include those associated with vessel and drillship discharges of graywater, treated blackwater, deck drainage, cooling water, ballast water, and bilge water from the additional vessels. These discharges will result in negligible effects on water quality (e.g. increases in turbidity, BOD, temperature) that are restricted to the area within about 328 ft (100 m) of the vessel and ephemeral lasting only minutes longer than the discharge. The results of revised thermal modeling of the drillship cooling water discharges indicate that thermal effects from such discharges would be limited to the area within 11-273 yd (10-250 m) of the discharge outfall (new Table 4.6.3-1).

Table 4.6.3-1 Predicted Water Quality Impacts of Discoverer Cooling Water Discharges

Discharge	Effluent Sources and Characteristics [1]			Impact on the Ambient Water Quality [1]					
	Volume (bbl/day)	Temp (°C)	Salinity (psu)	Excess Temp (°C)	Plume Depth (m)	Plume width (m)	Distance Source (m)	Duration (minutes)	Affected Area (m^2)
1	4,165	5.1	31	0.05	2.5	10	250	20	25.0
2	4,760	4.2	31	0.05	3.0	10	150	10	12.5
3	610	16.1	31	0.05	0.5	10	110	15	25.0
4	610	16.1	31	0.05	0.5	10	110	15	25.0
5	2,200	14.0	31	0.05	1.0	15	140	30	45.0
6	70	4.2	31	0.05	0.5	2	10	1	2.0
7	1,115	12.0	31	0.05	0.7	12	110	20	17.0

[1] Source: Fluid Dynamix 2013a

In addition to normal vessel discharges, the drilling unit will discharge drilling wastes with resulting negligible water quality effects. EP Revision 2 includes the addition of a number of new drilling fluid components and increases in estimated drill waste discharge volumes. The drilling fluids have been shown to have low toxicity. The primary water quality effect of the discharges will be temporary increases in TSS, which would largely be limited to the area within 328-984 ft (100-300 m) of the discharge.

Other reasonably foreseeable activities that would also potentially affect water quality include vessel discharges associated with the general vessel (barge) traffic, and shallow hazards, hydrographic, geophysical, geotechnical, and environmental surveys described above. Vessels used for these purposes will necessarily discharge the same types of effluents due to normal vessel activity. Quantities of the discharges will also be similar to those from vessels associated with Shell's exploration drilling program, depending on vessel size and crew numbers. Geotechnical surveys will also discharge drill cuttings and potentially drilling fluids, at each borehole. Volumes of these discharges will be much less than those associated with the drilling of exploration wells at the Burger Prospect, due to the smaller diameter and shallower depth of the boreholes.

Water quality effects of vessel discharges of deck drainage, cooling water, ballast water, and bilge water, associated with the Shell's EP Revision 2 and the other identified reasonably foreseeable activities, will be negligible, lasting only minutes longer than the actual discharge, and not causing unreasonable degradation of water quality. The effects from these discharges will be limited to the immediate vicinity of the vessels and the drillship, as indicated by modeling and published findings. Although these activities would occur in the same sea and are therefore technically additive, there would be little or no opportunity for overlapping or synergistic effects. The vessels will be at various scattered locations across the Chukchi Sea when in transit or on standby, while the ephemeral impacts associated vessel discharges will be generally limited to the area within 330 ft (100 m) of the vessel. The Chukchi Sea is a very large open water body of more than 230,000 mi^2 (595,697 km^2) and the Lease Sale 193 Area is 53,125 mi^2 (137,593 km^2). Additive effects on water quality would be negligible given the immense size of the Chukchi Sea.

The EPA has evaluated the cumulative environmental impact of these types and quantities of vessel discharges in territorial seas as part of their NPDES program prior to issuing their general permits for vessels (VGP) and oil and gas exploration (EPA 2006, 2008, 2012), and drilling discharges under the general permit for oil and gas exploration facilities (AKG-28-8100). EPA has concluded repeatedly that these discharges would not result in "unreasonable degradation" (as defined in 40 CFR 125.122) of ocean waters of the Chukchi Sea, which means they will not result in:

- Major adverse changes in the ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological communities

- Threat to human health through direct exposure to pollutants or through consumption of exposed aquatic organisms
- Loss of aesthetic, recreational, scientific, or economic values

Cumulative impacts on water quality of the Chukchi Sea from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered negligible. This finding is generally consistent with the BOEM's conclusion in its Lease Sale 193 FEIS, where the BOEM concluded that sustained effects on water quality resulting from any post lease activities would be low, represent only a small percentage of the foreseeable cumulative effects, and would not contribute significantly to cumulative effects on water quality (MMS 2007b). BOEM further stated that degradation of local and regional water quality from discharges and offshore construction activities was unlikely (MMS 2007b).

4.6.4 Cumulative Impacts on the Biological Resources

Potential Cumulative Impacts on Lower Trophic Organisms

Potential effects from Shell's exploration drilling program on lower trophic organisms could potentially occur from changes to water quality associated with disturbance caused by sediment plumes from MLC construction and vessel mooring, and various permitted discharges that may change the temperature or chemical properties of the water column. Additionally, benthic organisms will be impacted by destruction of habitat associated with vessel mooring, MLC construction, and drilling waste discharges. Changes for EP Revision 2 include additional support vessels, changes in drilling fluids, and increased estimates of the volume of drilling wastes to be discharged at each drill site.

Other reasonably foreseeable activities potentially affecting lower trophic organism include discharges from barges and other vessels in the Chukchi Sea, including the described geophysical and geotechnical surveys to be conducted by Shell and NOAA, and seafloor impacts from past exploration drilling and present and future geotechnical surveys.

Water quality effects from discharges associated with vessels and drilling are ephemeral and unlikely to have any more than a negligible impact on plankton and other lower trophic organisms and would be unnoticeable at the population level. The effects are limited to the immediate vicinity of the discharge so no overlapping or synergistic effects will occur between discharges from the various identified present or reasonably foreseeable activities. Most of these effects due to water quality would end as soon as the discharge is discontinued.

A small amount of seafloor habitat will be altered from construction of MLCs, mooring and anchoring of vessels, and accumulation of drill cuttings and drilling fluids on the seafloor. This will result in localized effects to lower trophic organisms through direct destruction of benthic organisms and the loss of available habitat. The seafloor would be re-colonized by benthic organisms over the course of a year or more. Habitat effects due to mooring, MLC construction, and drilling waste discharges may remain longer, but would be minor given the small area affected and the enormity of available habitat in the Chukchi Sea.

The habitat loss associated with EP Revision 2 will be additive to the seafloor impacts remaining from the five historical wells in the Chukchi Sea and future seafloor disturbances from geotechnical surveys. Monitoring studies indicate that little environmental effect remains at the historical well sites. Geotechnical surveys will disturb very little seafloor due to the small number, small diameter, and shallow depth of the boreholes. Together, the area of impact represents an extremely small portion of the available similar habitat in the Chukchi Sea. Cumulative impacts on lower trophic organisms from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered minor.

Potential Cumulative Impacts on Fish and EFH

Potential effects from Shell's exploration drilling program on fish and EFH are described in the EIA for EP Revision 1 and could potentially occur from changes to water quality associated with disturbance caused by sediment plumes from MLC construction, vessel mooring and anchoring, various permitted discharges that may change the temperature or chemical properties of the water column, and small releases of liquid hydrocarbons. Sound energy generated by vessels, ice management, drilling, and the operation of ZVSPs could also affect fish. Aspects of EP Revision 2 that could potentially impact fish or EFH include additional support vessels, changes in drilling fluids, and increases in drilling waste discharges.

Overall, the cumulative impacts on fish and EFH from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered negligible. Details of the cumulative effects for each impact factor are discussed below.

Cumulative Effects of Marine Sounds on Fish

Shell's proposed activities will introduce industrial sounds into the environment from drilling operations, anchor handling, ice management, ZVSP airgun surveys, and vessel and aircraft traffic. EP Revision 2 would result in additional vessels and therefore vessel sound. New measurements of the sound energy generated by vessel traffic and drilling are provided in Sections 2.5 and 4.4 of this document.

Reasonably foreseeable activities that would result in sound generation include the identified hydrographic, geophysical, geotechnical and environmental surveys. Sound would be generated by vessel engines and movement as well as geophysical equipment. Shallow hazards surveys would involve the use of airguns. Geotechnical surveys would result in some sound generation in conjunction with conducting the borings. Current levels of marine sound are not great enough to cause abandonment of habitat at a level that has affected fish populations of any species present in the project area. While it is theoretically possible that impacts could accumulate to that level in the future it would require much greater impacts than those expected from Shell's exploration drilling program and the other identified reasonably foreseeable activities.

Potential cumulative effects from the proposed project on marine fish could occur from increased in-water sound from numerous industrial sources including aircraft. Fish are unlikely to be directly affected by increases in vessel traffic in the Chukchi Sea but may be affected by indirect impacts from increases in noise or pollutant emissions associated from vessel traffic. The cumulative impacts on fish from sound generation associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Cumulative Effects of Water Quality Impacts on Fish

Potential effects on water quality from Shell's drilling program as described in EP Revision 2 include increased TSS, BOD, and water temperature associated with vessel and drilling waste discharges and potentially the introduction of petroleum through small spills. These types of impacts will be short term and limited to very small areas near the point of discharge.

Other reasonably foreseeable activities that would have similar water quality impacts due to vessel discharges include general vessel and barge traffic, NOAA's proposed hydrographic surveys, and Shell's potential geophysical and geotechnical surveys. Geotechnical surveys would also discharge drill cuttings and possibly drilling fluids. Although these activities would occur in the same sea, they would be separated in time and space and would be unlikely to have any additive or synergistic effects, particularly given the size of the Chukchi Sea. The cumulative impacts of water quality on fish associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be nonexistent or negligible.

Cumulative Effects of Seafloor Habitat Impacts on Fish

Shell's exploration drilling program as described in EP Revision 2 will have localized impacts on seafloor sediments associated with mooring of the drillship and vessels, MLC construction, and the discharge of drilling wastes. These types of impacts will be long term but limited to a very small portion of the available habitat in the Chukchi Sea.

Other reasonably foreseeable activities that would have similar seafloor habitat impacts include past exploration drilling and present or future geotechnical surveys. Monitoring studies indicate that little effect due to past exploration drilling programs remains. Were Shell to conduct geotechnical surveys, they would result in very little seafloor disturbance due to the number, diameter, and depth of the boreholes. The cumulative impacts on fish from seafloor habitat impacts associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible given the size of the Chukchi Sea.

Potential Cumulative Impacts on Birds, Including Birds Designated as Threatened or Endangered

Potential effects from Shell's exploration drilling program as described in EP Revision 2 on birds and threatened and endangered birds are described in detail in the EIA for EP Revision 1 and include: disturbance and/or collisions by vessel and aircraft traffic; effects from sound energy generated by vessels, drilling, and ZVSPs; water quality effects from vessel discharges, drilling waste discharges, and small petroleum spills; and air quality effects due to vessel and drillship emissions. The changes associated with EP Revision 2 include increases in the number of vessels and aircraft, increased vessel and aircraft traffic along revised corridors, increased air emissions, and changes in drilling fluids and volumes of drilling waste discharges.

Other reasonably foreseeable activities potentially affecting birds include: disturbance associated with barges and other vessel traffic in the Chukchi Sea, including the described geophysical, shallow hazards, geotechnical, and environmental surveys to be conducted by Shell and NOAA; discharges associated with vessel traffic and survey vessels for these activities; seafloor impacts from past exploration drilling and geotechnical surveys; and air quality impacts from other emission sources in the region including vessels and village power generation.

Overall, the cumulative impacts on birds and threatened and endangered birds from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered minor. Details of the cumulative effects for each impact factor are discussed below.

Cumulative Effects of Vessel Traffic on Birds

Shell's exploration drilling program as described in EP Revision 2 will contribute to an increase in vessel traffic in the northeastern Chukchi Sea where the project is located and throughout the Chukchi Sea in general. Vessels associated with Shell's exploration drilling program in 2012 resulted in temporary avian disturbances and a small number of bird mortalities due to vessel collisions. The identified reasonably foreseeable barge and general vessel traffic and surveys vessels would be expected to have similar effects. Disturbance effects are likely not additive as they would not occur in the same time and space often enough to result in any cumulative effects such as area abandonment. Mortalities due to vessel-avian collisions would be additive if they occurred in the same season, but the sum total would be an extremely small portion of the bird populations and would therefore have only minor and temporary effects.

Oil and gas exploration is expected to increase the number and extent of scientific studies in the Chukchi Sea, but such studies generally have little impact except for temporary behavioral disturbance of fish, birds, and marine mammals (EIA for EP Revision 1 at 4-165).

Current levels of vessel traffic as identified in Table 4.6-1 and Figures 4.6-1 and 4.6.2-1 above are not great enough to cause abandonment of coastal or marine bird habitat of the Chukchi Sea or North Slope, or to result in more than small number of avian collisions. Levels of vessel traffic expected to occur during the time period of the cumulative effects analysis, including Shell's EP Revision 2 and other identified present and reasonably foreseeable activities, are not expected to vary greatly from the range of these previous annual vessel traffic levels.

Most bird species using offshore habitats in the project area are migratory and are exposed to greater levels of vessel traffic in other portions of their range than they are exposed to on the North Slope. The cumulative impacts on marine and coastal birds due to vessel traffic associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be minor and temporary.

Cumulative Effects of Air Quality on Birds

Ambient air quality modeling conducted for Shell's exploration drilling program under EP Revision 2 was based on emission estimates that are considered to be maximums. Primary and secondary NAAQS standards will be met seaward of the shoreline, with the projected impact values at the shoreline being less than 50 percent of NAAQS (Table 4.1.1-1 above). Actual emissions are expected to be less than these calculated emissions. The NAAQS primary and secondary standards are designed to protect human health and all aspects of the public welfare, including flora and fauna. The modeling also indicated little effect on air quality in offshore waters (Table 4.1.1-2 above). The modeling effort included background concentrations collected during years when emissions are similar to that expected in the future. The cumulative impacts on marine and coastal birds from air quality impacts associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Cumulative Effects of Sound on Birds

Shell's exploration drilling program will introduce industrial sounds into the environment from drilling operations, anchor handling, ice management, ZVSP airgun surveys, and vessel and aircraft traffic. Sound energy would be emitted into the air and water. These sounds contribute additively to other industrial and non-industrial sounds when they are contemporaneous. Shell's exploration drilling program as described in EP Revision 2 may result in additional sound generation due to the increased number of vessels, vessel trips, and aircraft flights. Current levels of underwater and in-air sound are not great enough to cause abandonment of coastal or marine bird habitat on the North Slope (EIA for EP Revision 1 at 4-166).

Reasonably foreseeable activities that would also contribute to the sound budget include barge and vessel traffic, NOAA's proposed hydrographic surveys, and Shell's potential geophysical and geotechnical surveys. Marine and coastal bird species with the potential to be impacted by the EP revisions are migratory. Potential impacts from activities and events outside the Burger Prospect include past, present, and reasonable foreseeable activities, as well as inland development, competition with invasive species, and military operations. Table 4.2.4-1 of Shell's EIA for EP Revision 1 detailed the types of impacts the migratory bird species most likely to be encountered in the Chukchi Sea would experience outside of the Chukchi Sea during migration, and identified potential cumulative impacts that might be experienced over the course of a year as a function of seasonal timing and location. The cumulative impacts on marine and coastal birds due to underwater and in-air sound associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Potential Cumulative Impacts on Marine Mammals, Including Marine Mammals Designated as Threatened or Endangered

Potential effects from Shell's exploration drilling program on mammals and threatened and endangered mammals are described in detail in the EIA for EP Revision 1 and include: disturbance by vessel and aircraft traffic; effects from sound energy generated by vessels, drilling, and ZVSPs; water quality effects from vessel discharges, drilling waste discharges, and small petroleum spills; and air quality effects due to vessel and drillship emissions. EP Revision 2 relevant activities include increases in the number of vessels and aircraft, increased vessel and aircraft traffic along revised corridors, increased air emissions, and changes in drilling fluids and volumes of drilling waste discharges.

Past, present, and potential future actions that have impacted, or have the potential to impact marine mammals in the Chukchi Sea include: historic commercial whaling; past, current, and future subsistence hunting; previous and past oil and exploration; the aforementioned reasonably foreseeable geophysical, shallow hazards, hydrographic, geotechnical, and environmental surveys that may be conducted by Shell and NOAA; present and future research activities; and climate change. The cumulative effects of climate change on marine mammals are discussed in the EIA for EP Revision 1. There have been no important changes to that analysis; however, Rode et al. (2013) recently reported that climate change is having little or no effect on polar bears in the Chukchi Sea.

Most of the marine mammal species within the Lease Sale 193 Area are migratory; therefore, activities and events outside the area considered for most of this cumulative effects analysis affect marine mammals that use the Chukchi Sea. These activities include marine traffic, commercial fisheries, offshore and near shore development (related to oil and gas operations, tidal power generation, and marine construction projects), mining, subsistence hunting, invasive species, and military exercises. Table 4.2.4-2 in the EIA for EP Revision 1 provided detailed information on the marine mammals most likely to be encountered during the exploration drilling program, summarized their feeding/summering grounds, migration routes, and their breeding/wintering grounds. There are no substantial changes to the activities and effects identified in the table.

Overall, the cumulative impacts on marine mammals and threatened and endangered marine mammals from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered negligible. Details of the cumulative effects for each impact factor are discussed below.

Cumulative Effects of Industrial Whaling on Marine Mammals

Industrial whaling was responsible for the depletion of stocks of a number of baleen whales including the two common whales in the Lease Sale 193 Area, the gray whale and the bowhead whale. Stocks have rebounded with the elimination of commercial whaling for these species.

The population size of the Eastern North Pacific gray whale stock has been increasing since cessation of whaling and was removed from the threatened and endangered species list in 1994. The population has continued to increase over the past several decades with an estimated annual rate of increase of about 3.3% (Buckland et al. 1993) and a population of about 19,126 animals. The stock may be reaching carrying capacity; therefore, remaining effects of industrial whaling are therefore negligible.

All stocks of bowhead whales were severely depleted during intensive commercial whaling. The pre-commercial-whaling population of the Western Arctic stock of bowhead whales has been estimated to be 10,400-23,000 whales (Woodby and Botkin 1993) dropping to less than 3,000 at the end of commercial whaling. The stock has rebounded substantially. The most recent population estimate for the stock is 16,892 for 2011 (Givens et al. 2013). Estimates of the annual increase rate were 3.4 percent in 2001 (Zeh and Punt 2005) and 3.7 percent in 2011 (Givens et al. 2013), as current population levels are in the range of pre-commercial whaling estimates and the population continues to grow. The cumulative impacts of industrial whaling on marine mammals associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible.

Effects of Subsistence Harvests on Marine Mammals

The activities associated with Shell's exploration drilling program as described in EP Revision 2 are not expected to impact marine mammal subsistence activities in any way as there are no known conflicts between Shell previous operations and subsistence activities and Shell's mitigation measures (including cessation of operations for whaling in important hunting areas, consistent communication between operators and Com Centers, and the 4MP) safeguard against future conflicts. The cumulative impacts on marine mammals from subsistence whaling does not appear to affect the species on a population level in light of the estimates that the Bering-Chukchi-Beaufort (BCB) bowhead whale population and the beluga whale population in the Chukchi Sea continue to grow (EIA for EP Revision 1 at 4-173 to 4-174). Similarly, the cumulative impacts from subsistence hunting on other marine mammals (including ringed, bearded, and spotted seals, the Pacific walrus, and polar bear) are not expected to affect these species at a population level (EIA for EP Revision 1 at 4-174 to 4-175).

Cumulative Effects of Vessel and Aircraft Traffic on Marine Mammals

Potential cumulative effects on marine mammals could occur due to vessel and aircraft traffic. Shell's exploration drilling program as described in EP Revision 2 will contribute to vessel and aircraft traffic in the northeastern Chukchi Sea. Impacts will consist only of brief behavioral disturbances. No vessel strikes of marine mammals are likely to occur.

Aircraft and vessel traffic associated with identified reasonably foreseeable activities such as barge and general vessel traffic, geophysical, geotechnical, shallow hazards, and environmental surveys would be expected to have similar effects. Oil and gas exploration may increase the number and extent of scientific studies in the Chukchi Sea, but such studies generally have little impact except for temporary behavioral disturbance of fish, birds, and marine mammals (EIA for EP Revision 1 at 4-165.)

The total annual vessel traffic in the Lease Sale 193 Area during the time frame of the cumulative effects analysis is not expected to vary greatly from the recent past levels indicated in Table 4.6-1 and Figures 4.6-1 and 4.6.2-1 above. Mortalities or injuries due to vessel-marine mammal collisions are not expected to occur given past experience. Brief behavioral disturbances will likely result from vessel traffic at these levels are likely not additive as they would not occur in the same time and space often enough to result in any cumulative effects such as area abandonment. Current levels of vessel traffic as identified in Table 4.6-1 and Figures 4.6-1 and 4.6.2-1 are not great enough to cause abandonment or alter migration routes. The cumulative impacts on marine mammals due to vessel traffic associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, will be negligible and temporary.

Cumulative Effects of Habitat Loss from MLCs and Mooring of Vessels on Marine Mammals

A small amount of seafloor habitat will be lost from construction of MLCs and mooring and anchoring of vessels. Shell's proposed future geotechnical surveys will add to the total impacts on the seafloor; however, given the distance of these proposed surveys from Shell's exploration activities, the additional impacts will not be additive or synergistic. Although benthic feeders (gray whales, bearded seals, and walrus) in the project and survey areas could also be affected by habitat loss, the loss will be small, localized and non-significant when compared to the amount of available similar habitat in the Chukchi Sea. No cumulative impacts are expected to marine mammals as a result of seafloor habitat loss associated with Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities.

4.6.5 Cumulative Impacts on Subsistence

Effects on subsistence activities from the Shell's exploration drilling program as described in EP Revision 2 are minimized by Shell's extensive mitigation measures (including its successful SA program, Com Centers and 4MP).

Other reasonably foreseeable activities that could potentially affect subsistence activities in the marine environment of the Chukchi Sea include: disturbance associated with barges and other vessel traffic in the Chukchi Sea, including the described geophysical, shallow hazards, geotechnical, and environmental surveys to be conducted by Shell and NOAA; and aircraft traffic associated with these types of activities. Geophysical, hydrographic, geotechnical, and shallow hazards surveys generally require incidental take authorizations under the MMPA from NMFS and USFWS. These authorizations require consultation with the potentially affected villages, and mitigation measures that will minimize subsistence impacts, similar to Shell's exploration drilling program. Additionally, much of the activity associated with these surveys occurs seaward of areas known to be used for subsistence.

Effects on subsistence from EP Revision 2 would be additive to the effects of the identified reasonably foreseeable activities. However, Shell's mitigation measures would apply to most of these activities, and any impacts would be dispersed given the size of the Chukchi Sea. Cumulative impacts on subsistence from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered to be minor.

4.6.6 Cumulative Impacts on Socioeconomic and Sociocultural Resources

Potential effects from Shell's exploration drilling program on socioeconomics are described in detail in the Sections 4.1.11 and 4.2.6 of the EIA for EP Revision 1 and include: effects on wages and employment, and on goods and services. Sociocultural impacts could potentially occur with the influx of workers in the villages.

Additional activities under EP Revision 2 could alter these impacts, including: changes in vessel routes (contingency crew change by vessel to Barrow, mooring of vessels near Kotzebue and vessel crew change through Kotzebue), changes in aircraft and flights (increase in number of helicopters and flights), changes in shorebases (expansion of the Barrow shorebase, increased utilization of Wainwright camps, and some presence in Kotzebue). As discussed above in Section 4.3.2, some increases in employment and wages will occur through hiring by Shell and Shell contractors for various positions. Additional employment and revenues will be generated by providers of the shorebase facilities (Section 4.1.11, EIA for EP Revision 1). These effects may increase slightly with the expansion of the Barrow man camp, the utilization of a large camp in Wainwright, and the small presence in Kotzebue.

Other identified reasonably foreseeable activities potentially affecting socioeconomic and sociocultural resources include: barge and vessel traffic that may access the villages or occur in coastal waters; and Shell's geophysical, geotechnical and environmental surveys, which include vessel traffic and possible crew changes through the Port of Kotzebue, Barrow, Wainwright, or Nome. Geophysical, shallow hazards, geotechnical, and environmental surveys and other reasonably foreseeable activities will likely add to the number of non-residents staying in or passing through these villages. These types of activities involve fewer vessels and typically smaller crew sizes, and would therefore result in less socioeconomic effect. Any increased shorebase presence may also exert some pressure on goods and services (including vehicular traffic). Cumulative impacts on socioeconomics from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered negligible and short term.

Sociocultural and population effects may also be experienced in Barrow, Nome, Wainwright, and Kotzebue where crews and other personnel from outside the region will reside or pass through. There will be no effects in Point Lay or Point Hope. Cumulative impacts on sociocultural resources from Shell's exploration drilling program as described in EP Revision 2, in conjunction with the identified past, present and reasonably foreseeable activities, are considered to be negligible.

4.6.7 Summary of Cumulative Impacts Analyses

Results of the above cumulative impacts analyses are summarized below in the new Table 4.6.7-1, and compared to the cumulative impacts analyses in the EIA for EP Revision 1 and BOEM's EA for EP Revision 1 (BOEM 2011). All assessed cumulative impacts were found to be negligible to minor. The conclusions are in general alignment with the findings of BOEM in its EA (BOEM 2011).

Table 4.6.7-1 Summary of the Results of the Cumulative Impacts Analyses

Resource	BOEM EA for EP Revision 1	Shell EIA for EP Revision 1	Shell EIA for EP Revision 1
Air quality	minor	minor	minor
Water quality	minor	negligible	negligible
Lower trophic	negligible	no effect	minor
Fish and fish habitat	minor	no effect	negligible
Marine mammals and T&E marine mammals	--	--	negligible
Birds and T&E birds	minor	not significant	minor
Socioeconomics/Sociocultural	negligible	minor	negligible
Subsistence	moderate	negligible	minor

[1] Cumulative effects on cultural resources and sensitive biological resources were not evaluated as the exploration drilling program with EP Revision 2 was found to have no effects on these resources

5.0 CONSULTATION

Shell's consultation with stakeholders such as the Chukchi Sea communities is summarized in Section 5.0 of the EIA for EP Revision 1 and detailed in the POC in EP Revision 1. Meetings held by Shell with communities and local governments regarding the exploration drilling program were listed in Table 5.1.1-1 in the EIA for EP Revision 1. Additional meetings that either have taken place since EP Revision 1 or are planned for 2013 are identified below in the new Table 5.1.1-2.

Table 5.1.1-2 Dates and Locations of Meetings Held in 2012-2013 Regarding Shell's Chukchi Sea Exploration Drilling Program for the Development of the POC

2012 Meetings	Meeting Location	Meeting Attendees
23 October	Point Lay	Plan of Cooperation Community Meeting
24 October	Wainwright	Plan of Cooperation Community Meeting
26 October	Kaktovik	Plan of Cooperation Community Meeting
29 October	Barrow	Plan of Cooperation Community Meeting
30 October	Nuiqsut	Plan of Cooperation Community Meeting
6 November	Barrow	NSB Assembly Workshop Meeting
2013 Meetings	**Meeting Location**	**Meeting Attendees**
29 July	Kotzebue	NWAB, City of Kotzebue, KIC and IRA representatives
5 November	Barrow	NSB Assembly
5 November	Wainwright	Plan of Cooperation Community Meeting
Upcoming Scheduled Meetings in 2013		
6 November	Point Lay	Plan of Cooperation Community Meeting
7 November	Point Hope	Plan of Cooperation Community Meeting
8 November	Barrow	Plan of Cooperation Community Meeting
13 November	Kotzebue	Plan of Cooperation Community Meeting
14 November	Deering	Plan of Cooperation Community Meeting

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Attachment A

Air Quality Impact Analysis Background, Modeling, and Impact Criteria

Arctic Offshore Air Quality Impacts
Recommendations for Appropriate Criteria
for Determining Significance Under NEPA

Executive Summary

The Bureau of Ocean Energy Management (BOEM) is charged with evaluating the impacts of air emissions associated with oil and gas exploration activities on the Outer Continental Shelf (OCS) under two different statutory/regulatory programs: (1) compliance with BOEM's Air Quality Regulatory Program (AQRP) (which addresses onshore impacts of emissions from OCS sources), and (2) the "hard look" at potential environmental impacts required for every major federal action under the National Environmental Policy Act (NEPA). Section 7.0 of the 2013 Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska (EP Revision 2) demonstrates that Shell's proposed operations are exempt under the terms of BOEM's AQRP because the relevant emissions impacts onshore are negligible, requiring no further analysis for purposes of agency review of EP Revision 2. In its NEPA analysis of Shell's prior exploration plans BOEM utilized the analyses of air quality impacts prepared in support of the Clean Air Act permits Shell obtained from the Environmental Protection Agency (EPA). Because Congress has now changed jurisdiction for air quality impacts in the OCS offshore of the North Slope Borough of Alaska from the EPA to BOEM and Shell will not have a Clean Air Act permit from EPA, air quality impacts will no longer be analyzed under EPA procedures and standards, and BOEM now has an opportunity to identify an appropriate methodology to evaluate air quality impacts for potential significance under NEPA.

In the past BOEM established NEPA significance thresholds for onshore air quality impacts based upon Clean Air Act standards, including the National Ambient Air Quality Standards (NAAQS) and the Prevention of Significant Deterioration (PSD) increments. These standards may continue to be applicable in the onshore environment as "significant impact" criteria under NEPA. But, while BOEM formerly used the NAAQS and PSD increments as default indicators of NEPA significance in the Arctic offshore environment, reference to those EPA standards is not necessary under NEPA because of the remoteness of the emissions source and the extreme improbability of exposure of humans to project emissions. Specifically, the NAAQS were established by the EPA to protect nationwide air quality in areas reasonably accessible to the general public, in order to protect the health of the most vulnerable population and to protect the quality of the environment generally.[a] Because emissions from Shell's project will impact only remote and inaccessible offshore areas, where comparatively healthy people are present, if at all, only for limited periods of time and receptors in the ecosystem are transient, the NAAQS are not appropriate benchmarks for use in BOEM's analysis of the offshore air quality impacts of Shell's proposed operations in the Chukchi Sea.

This document defines a set of more suitable offshore criteria to protect the health of the limited numbers of persons who work in offshore Arctic Ocean areas as well as subsistence hunters and fishermen in the Chukchi Sea, a few of whom may occasionally encounter some ancillary aspect of Shell's operations.[b]

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[a] 42 USC § 7409, U.S. Clean Air Act: national primary and secondary ambient air quality standards

[b] Subsistence hunting and fishing rarely, if ever, take place more than 30 miles offshore. The *Discoverer* will operate more than twice that far offshore. Any project-related emissions that persons may encounter will almost certainly be limited to emissions from supply boats transiting to or from the Discoverer. Shell accordingly believes that compliance with the proposed air quality limits should be evaluated only at points located within the subsistence areas designated under Figure 3.11.7-11 in the EIA for EP Revision 1.

Shell developed these criteria after reviewing scientific evidence and OSHA state and federal standards. The criteria adopted are more protective than OSHA's exposure standards, and thus have a built-in margin of safety. They represent proposed maximum concentration limits for Shell's operations. The criteria are set at levels adequate not only to ensure no significant impacts on the health of exposed workers and subsistence hunters and fishermen (if any), but also to avoid significant impacts to marine life and other environmental resources present in the offshore regions of the Arctic Ocean. These criteria for significant offshore air quality impacts are as follows:

- $PM_{2.5}$ and PM_{10}: 500 μg/m^3 (1-hour average concentration, not to be exceeded)
- NO_2: 3,760 μg/m^3 (2 ppm) (1- hour average concentration, not to be exceeded)
- CO: 55,000 μg/m^3 (50 ppm) (1-hour average concentration, not to be exceeded)
- SO_2: 5,200 μg/m^3 (2 ppm) (1-hour average concentration, not to be exceeded)

Assuming emissions from Shell's operations would not cause an exceedance of any of these criteria at offshore locations where third-party boats and vessels may experience emissions from the project, the emissions would be deemed not to have a significant impact requiring preparation of an Environmental Impact Statement.

Analysis

1. BOEM Needs to Determine Independent Criteria for NEPA Significance

Now that Congress has transferred from EPA to BOEM jurisdiction for air quality impacts on the OCS offshore of the North Slope Borough of Alaska, BOEM must develop an appropriate method for its NEPA analysis of those impacts. In the past, BOEM has used the analyses performed for EPA permits to inform its NEPA analysis of Shell's air quality impacts, but EPA analyses will no longer be available or appropriate for BOEM's use.

Going forward, the most significant change will be in how offshore air impacts are evaluated for significance under NEPA, *i.e.*, whether the emissions will have a "significant" impact such that an Environmental Impact Statement is required under NEPA or not. Shell expects that BOEM will continue to apply the Clean Air Act-based criteria it has developed in the past to determine whether and under what control scenarios Shell's air emissions will have a significant impact on onshore air quality for purposes of NEPA. Those criteria will remain keyed to the NAAQS that is applicable to the onshore area and the increment (or some fraction thereof) that would be applicable to the source if it were still regulated by EPA under its PSD rules.

BOEM's current approach to determining "significance" of onshore emissions is exemplified in the Environmental Assessment for Shell's 2011 Revised Chukchi Sea Exploration Plan (OCS EIS/EA BOEM 2011-061, Dec. 2011) (EP Revision 1). In that EIA, BOEM evaluated projected onshore and offshore air quality impacts from Shell's project against applicable NAAQS, while also examining whether in any case air quality impacts from Shell's emissions would exceed 50 percent of either the NAAQS or the "maximum allowable increase," i.e., the applicable PSD increment. EA at 67-68, Tables 28 and 29. BOEM concluded that the proposed action would 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. . . . As such, the level of effect on air quality caused by the Proposed Action is considered minor . . . ." Id. at 70-71.[c] BOEM has provided further clarification on determination of the significance levels of

[c] For air quality impacts, BOEM's NEPA "significance threshold" is that the project's emissions would cause at an onshore location (1) a violation of a NAAQS or (2) an increase in pollutant concentrations that would (a) exceed half of any NAAQS except for ozone, (b) exceed half of the maximum allowable increase (increment) under EPA's PSD rules, or (c) exceed half of

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onshore emissions for the Chukchi Lease Sale 193 area. Under the Supplemental Environmental Impact Statement for Lease Sale 193 (OCS EIS/EA BOEMRE 2011-041, Nov. 2011), BOEM determines a significant effect when the project-related emissions cause an increase in pollutant concentrations over the nearest onshore area of at least 20 square kilometers that exceed 50 percent of NAAQS and maximum allowable increases (MAIs).

While the significance levels BOEM developed for air quality impacts in the onshore environment may remain applicable to onshore impacts, Congress's decision to change jurisdiction for OCS air quality impacts offshore of the North Slope Borough from EPA to BOEM makes it necessary for BOEM to update its methodology for evaluating offshore air impacts. Clean Air Act Section 328(b) requires only that BOEM "coordinate" air pollution control regulations for OCS sources and adjacent onshore areas. In contrast, Section 328(a) requires EPA to regulate OCS sources specifically to "attain and maintain" the NAAQS and to comply with subchapter I of the Clean Air Act (stationary source requirements). Because Congress chose in Section 328(b) not to require that sources in areas of the OCS administered by BOEM meet the NAAQS and the CAA stationary source provisions, BOEM has both the discretion and obligation to thoughtfully regulate OCS sources within its jurisdiction, independent of these EPA standards. To assist BOEM with the NEPA analysis, Shell has developed proposed standards of NEPA significance that are more appropriate to the offshore environment and to the small population of workers in the region and subsistence hunters who might be briefly exposed at offshore locations to the air quality impacts from the project.

2. Clean Air Act Standards Are Not Appropriate As Offshore NEPA Significance Levels

The NEPA significance levels BOEM has used for onshore analysis are not appropriate for offshore analysis in the Arctic for several reasons. First, as discussed in detail below, the NAAQS, on which the significance levels rely, were designed for areas accessible to the public, and do not provide meaningful information on the significance of air quality impacts upon a remote and inaccessible region such as the Chukchi Sea OCS. Second, the impacts of offshore emissions to the human and natural environment offshore will be different from the impacts to the onshore environment because the affected environment is different. Third, information on background air quality is different onshore versus offshore. Finally, and most important, both the human and fauna populations offshore are transient, and thus are extremely unlikely to remain in a fixed location exposed to air pollution for the duration of a day, let alone a full drilling season.

A. NAAQS Are Broad Nationwide Standards With Limited Relevance to Arctic OCS Operations

Some advocacy groups have suggested that BOEM should apply Clean Air Act standards, such as the NAAQS, in its NEPA analysis of the air quality impacts of Shell's proposed Chukchi Sea operations. However, those Clean Air Act standards are not legally binding on BOEM as applied to the Arctic offshore region[d] and, more important, are not designed for an environment such as the Arctic Ocean. The CAA and its amendments mandated uniform nation-wide standards that are designed to protect public health and welfare everywhere in the United States. The CAA promotes the implementation of air quality controls to limit the exposure of the general public to unhealthy concentrations of pollutants in the air. The keystone of the CAA as originally enacted was Title I, Part A, Section 109, which established

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the ozone NAAQS including precursor emissions of VOCs and NOX. EA, App. B at B-1. BOEM explained that this significance threshold is not necessarily a bright-line test for determining whether impacts are significant under NEPA and must be considered in conjunction with a four-tier "level of effects" matrix, encompassing negligible, minor, moderate, and major effects. A project would have a "major" effect if project emissions by themselves exceed half of any NAAQS. Id. at B-2.

[d] 42 USC § 7627(b)

NAAQS. The NAAQS are designed to provide a set of concentration criteria to protect the public health and public welfare with a margin of safety. The CAA defines the NAAQS as a set of "primary" standards that are implemented to protect human health, and "secondary" standards that protect the general welfare. The CAA required EPA to establish NAAQS based on current scientific knowledge and studies and to update the NAAQS on a five-year schedule to incorporate new information.

B. EPA's Definition of Ambient Air is Not Appropriate for Remote OCS Operations

The primary NAAQS are ambient air pollution concentration thresholds that should not be surpassed in areas accessible to the general public. The CAA does not define "ambient air" or the "general public," leaving the definition and interpretation of these terms to the enforcing agency to allow flexibility in its implementation. EPA adopted the following definition of ambient air: "*Ambient air* means the portion of the atmosphere, external to buildings, to which the general public has access." (40 CFR 50.1(e))

EPA has interpreted the phrase "to which the general public has access" through a series of official memoranda and policy statements. These policy documents exempt that portion of the atmosphere over land that is controlled by a source where public access is precluded by a fence or other physical barrier.[e,f] Ambient air is further limited by applying the NAAQS standards only to the portion of the atmosphere near ground level and building rooftop level, where the general public can reside. If the definition of ambient air were expanded to include all regions of the atmosphere that members of the public could theoretically access, even for short periods of time, air pollution control would be economically unfeasible. For example, the air aloft is accessible to the general public via aircraft, but the exposure period at any given point in a moving vehicle is limited and short compared to the health-based exposure periods recognized in the NAAQS. Thus, to balance the need for economic activity with the protection of human health, EPA has necessarily used common sense in interpreting its definition of ambient air, with recognition that even though access to a given area may not be absolutely impossible, still that area cannot reasonably be considered ambient air.

In making case-by-case determinations of what is ambient air under the CAA, EPA and state agencies have struggled with applying the definition of "ambient air" over water. While EPA has determined that atmosphere over bodies of water reasonably accessible to the general public can fall within the agency's definition of ambient air, the Alaska Department of Environmental Conservation (ADEC) has recognized that certain bodies of water and other geophysical barriers, if not reasonably accessible to the public, can represent a physical barrier that precludes public access.[g] The U.S. Court of Appeals for the Ninth Circuit concurred, finding that it was "just common sense" that the agency be allowed some "leeway" in applying its land-based ambient air definition to overwater situations.[h]

The offshore region of the Chukchi Sea is not under EPA's jurisdiction and the marine environment represents a formidable geographic barrier that limits reasonable access to the general public. The population that does access the offshore regions of the Chukchi Sea consists almost entirely of marine-vessel occupants and subsistence hunters. Both of these populations are transient groups that access any point of the offshore region (usually not more than 30 miles offshore) only briefly. The NAAQS primary standards were established to protect the health of the most vulnerable members of the general public, not persons temporarily working or engaged in hunting and fishing offshore in the Chukchi Sea. Therefore, the NAAQS are not the appropriate standards to promote public health and public welfare in these

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[e] USEPA, Region I-IX Meteorologists, "Regional Meteorologists' Memorandum," dated May 16, 1985.

[f] Resisting Environmental Destruction on Indigenous Lands v. EPA, 704 F. 3d 743, 753 (9th Cir. 2012) (*REDOIL*).

[g] ADEC Modeling Review Procedures Manual, Section 3.3, Sept. 14, 2011.

[h] *REDOIL*, 704 F.3d at 753.

offshore areas of the Chukchi Sea, and BOEM should not apply them in determining the significance of offshore air impacts.

EPA's recent update of the 1-hour NAAQS for nitrogen dioxide (NO_2) illustrates key differences between the exposure data EPA uses to set NAAQS under the CAA and the impact review BOEM is required to conduct under NEPA, and therefore why NAAQS are not appropriate criteria for BOEM's review. First, in setting the new NO_2 standard EPA cited findings that "traffic-related exposures can dominate personal exposures to NO_2," that "[w]hile driving, personal exposure concentrations in the cabin of a vehicle could be substantially higher than ambient concentrations measured nearby," and that concentrations of nitrogen oxides (NO_X), as well as carbon monoxide and ultrafine particulate matter (PM), "typically display peak concentrations on or immediately adjacent to roads."[i] These largely urban exposure scenarios do not exist in the Arctic OCS. Second, EPA set the standard to protect sensitive groups in the population, noting that "subpopulations considered potentially more susceptible to the effects of NO_2 exposure included persons with pre-existing respiratory disease, children, and the elderly."[j] It is unlikely that children, the elderly, and those with respiratory disease will be in the vicinity of the activities BOEM is reviewing.

C. Use of NAAQS for Offshore Significance Determinations is Not Consistent with BOEM's Current Regulatory Approach

Air quality impacts attributable to oil and gas activities on the Outer Continental Shelf in portions of the Gulf of Mexico and offshore of the North Slope Borough of Alaska are governed by CAA Section 328(b), which instructs the Secretary of the Interior to "assure coordination of air pollution control regulation for Outer Continental Shelf Emissions and emissions in the onshore adjacent areas."[k] BOEM has managed oil and gas emissions in the Gulf of Mexico under this standard for over twenty years, and now has jurisdiction for the area of the Outer Continental Shelf offshore of the North Slope Borough of Alaska.

BOEM has not applied a project-specific NAAQS analysis in its review of air quality impacts in the Gulf of Mexico. However, BOEM has enforced air quality limitations on offshore sources to ensure protection of NAAQS onshore. This policy is consistent with a position that the offshore region is relatively inaccessible to the general public. Much of the region is frequented by marine traffic, but it is generally recognized that this population is transient and, as a result, the exposure periods considered in the NAAQS are not applicable. The reasoning behind the Gulf of Mexico exemption applies with even greater force in the Arctic Ocean given inherent limits on access due to remoteness and climatic extremes.

D. Using Clean Air Act Standards Would Compromise BOEM's NEPA Analyses

For the reasons outlined above, the CAA and Alaska onshore air quality standards are not applicable nor are they appropriate to assess offshore air quality impacts under NEPA. The NAAQS and PSD increment limits are national standards that EPA applies to onshore (and some offshore) areas. EPA has no flexibility in applying the NAAQS and applicable increments; they are one-size-fits-all national standards. NAAQS and increments are appropriate to EPA's statutory responsibilities under the Clean Air Act and may be acceptable proxies for determining the significance of OCS source emissions at onshore locations.

But these standards if used as criteria to define significant impacts to OCS air quality under NEPA actually would undermine BOEM's effort to realistically assess these offshore environmental impacts. BOEM's responsibility is to conduct a rigorous analysis of whether air quality impacts will be significant in a specific affected environment (e.g., the Burger Prospect some 60 miles offshore which hosts limited

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[i] 75 Fed. Reg. 6479 (Feb. 9, 2010), citing "Integrated Science Assessment for Oxides of Nitrogen-Health Criteria," Section 2.5 (EPA, 2007).

[j] 75 Fed. Reg. 6480 (Feb. 9, 2010).

[k] 42 USC § 7627(b)

numbers of transient individuals and an ever-changing collection of fauna). EPA's national standards are based on assumptions that do not resemble offshore conditions and exposures. Under the conditions of the offshore Arctic, using the NAAQS and increment as criteria is overly conservative, misleading, and will necessarily predict "significant" environmental impacts where none will actually occur.

3. Shell's Recommendations

Shell has developed more suitable criteria to govern offshore air quality related to its remote, offshore exploration activities in the Chukchi Sea. These proposed air quality standards for air pollutant concentrations in remote offshore regions of the Arctic Ocean consider the characteristics and activities of the population that accesses the region. The standards are appropriately based on the following assumptions:

- Short-term averaging periods due to transience (1 hour is appropriate).
- The population accessing the Arctic OCS region, particularly those who travel in boats far offshore to hunt, generally comprises persons for whom OSHA standards provide appropriate health protection.[l]

Standards for NO_2, $PM_{2.5}$, PM_{10}, carbon monoxide (CO), and sulfur dioxide (SO_2) were developed by Shell based upon these assumptions, scientific evidence, and OSHA standards. Given these conditions, conservative standards for the offshore area are provided that are based on current occupational health standards or studies focused on non-medically compromised individuals.

NO_2:

As discussed previously, NAAQS are not an appropriate set of criteria for assessing levels of impact in offshore Arctic areas. However, EPA has provided valuable information under NAAQS assessments that is relevant when evaluating acceptable air quality levels for offshore areas for the Arctic region in the Chukchi Sea. The EPA Integrated Science Assessment (ISA) for NO_2[m] provides the basis for the current ambient concentration thresholds established in the NAAQS. The 1-hour NAAQS for NO_2 (100 ppb[n]) has been established with regard to the most sensitive individuals. Sensitive asthmatics have shown the highest sensitivity to short-term NO_2 exposure with increased airway response to concentrations as low as 100 ppb after 60 minutes of exposure. Increased sensitivity is evident at 200-300 ppb for shorter, 30 minute periods of exposure. Minimal airway response has been observed in healthy non-smoker non-asthmatics at levels as low as 1.5-2 ppm after continuous 1-hour exposure. Intermittent exposure to 2 ppm NO_2 concentrations evoked no airway response in these individuals.

The ISA also directs attention to NO_2 exposure by laboratory animals that demonstrate increased airway responsiveness after 6-12 weeks of exposure to a concentration of NO_2 at 1-4 ppm. This demonstrates that animals are sensitive to NO_2 at a similar concentration range as humans. Therefore, it is appropriate that the primary and secondary criteria level for NO_2 be roughly equivalent. Secondary criteria for NO_2 are also relevant to the protection of coastal regions from nitrogen deposition that may contribute to a disturbance of the biological balance by encouraging algal growth.[o] Deposition is primarily a concern in onshore coastal regions where build-up of nitrates in coastal estuaries may disrupt biological balances.[p]

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[l] Nevertheless, given that some members of the native population may be more susceptible to the health effects of air pollutant exposure due to genetic predisposition, and might conceivably engage in subsistence activities offshore, the standards are more stringent than the OSHA standards to even more fully protect the subsistence worker population.

[m] USEPA (2008): Integrated Science Assessment for Oxides of Nitrogen – Health Criteria, EPA/600/R-08/071

[n] 1 part per million (ppm) = 1000 parts per billion (ppb)

[o] USEPA (2008): Integrated Science Assessment for Oxides of Nitrogen and Sulfur -- Ecological Criteria, EPA/600/R08/O82F

[p] USEPA (2008): Integrated Science Assessment for Oxides of Nitrogen and Sulfur -- Ecological Criteria, EPA/600/R08/O82F

OSHA has established air quality limits for a range of pollutants to protect the health of laborers in the workplace. Though the established levels are less stringent than the NAAQS, the standards have been recognized as conservative levels of protection for the average healthy worker in the United States. The OSHA standard for NO_2 is defined in Table Z-1 of OSHA Standard 1910.1000 (29 CFR 1910.1). Under the OSHA standard, NO_2 must not exceed 5 ppm at any time.

Given the scientific research and OSHA standards presented here, an NO_2 criteria concentration level in the range of 2 to 5 ppm (3760-9400 µg/m³) over a 1-hour average period is a reasonable and conservative level of health protection for that population that may be exposed to pollutants in the offshore regions of the Chukchi Sea.

PM2.5 and PM10:

The 2009 EPA Integrated Science Assessment for Particulate Matter[q] indicates health effects are generally more related to long-term exposure and the NAAQS values are based on distribution of deaths and hospitalizations with relation to $PM_{2.5}$ concentration. The EPA notes in the 2011 Particulate Matter Policy Statement[r] that "protection from long term and short term $PM_{2.5}$ exposure is most effectively and efficiently provided by relying primarily on the annual standard, with the 24-hour standard providing supplemental protection for days with high peak concentration." This statement demonstrates the EPA's interpretation of the ISA findings that $PM_{2.5}$ exposure is generally a concern for longer (>1 hour) exposures.

The OSHA standard for respirable fraction (PM_{10}) of suspended particulates, otherwise not regulated under another standard, is 5,000 µg/m³, averaged over an 8-hour workday. This value is considerably higher than the 24-hour NAAQS of 150 $\mu g/m^3$ for PM_{10} or 35 $\mu g/m^3$ for $PM_{2.5}$. The most stringent OSHA standard for any respirable dust material is 500 µg/m³ for Paraquat, a highly toxic compound.

The current NAAQS include standards for both PM_{10} and $PM_{2.5}$. $PM_{2.5}$ is of greater concern because particles in this size range stay airborne longer, can penetrate deeper into the lungs, and are generally comprised of the more toxic compounds. When determining criteria, it is highly conservative to set the same concentration threshold value for both PM_{10} and $PM_{2.5}$, given an appropriate health-based limit for $PM_{2.5}$ exposure. This approach effectively assumes that all PM_{10} is $PM_{2.5}$ for the sake of environmental assessment. The 24-hour average concentration NAAQS for $PM_{2.5}$ is roughly a quarter of the PM_{10} NAAQS concentration; it is therefore more conservative to apply a health-based criteria threshold for $PM_{2.5}$ that is less than a quarter of the OSHA respirable fraction limit (PM_{10}).

Given the scientific research and OSHA standards presented here, $PM_{2.5}$ and PM_{10} criteria concentration threshold of 500 $\mu g/m^3$ over a 1-hour average period would provide a reasonable and highly conservative level of health protection (considering that the OSHA standard of 5,000 $\mu g/m^3$ is based on *8-hour average* concentrations) for the population who might be exposed to pollutants in the offshore regions of the Chukchi Sea.

In terms of impacts on the environment, the primary concern being the health of marine life exposed to $PM_{2.5}$ in the offshore regions, there is limited information concerning the impacts of deposited or airborne PM.[r] The body of scientific studies focused on health impacts of $PM_{2.5}$ on animals is sparse, but effects are generally observed at the same concentrations as humans[q] thus, the criteria for humans are appropriate for protection of marine life.

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[q] USEPA (2009): Integrated Science Assessment for Particulate Matter, EPA/600/R-08/139F

[r] USEPA (2011): Policy Assessment for the Review of the Particulate Matter National Ambient Air Quality Standards, EPA-452/R-11-003

CO:

The NAAQS for CO are based on clinical evidence that relate carboxyhemoglobin (COHb) to a number of health impacts. COHb is formed from the bonding of CO and hemoglobin in the blood that hinders the transport and delivery of oxygen throughout the body. The CO NAAQS were set to protect the health of those most vulnerable to the effects of COHb, which include those susceptible to exercise-induced angina, asthma, coronary artery disease, and myocardial ischemia. The developing young and elderly are also more sensitive to CO exposure. It has been noted that persons with normal healthy cardiovascular systems can tolerate "substantial concentrations of CO" if they increase cardiovascular output in response to higher COHb. Individuals with compromised systems have limited ability to respond to higher COHb, making them susceptible to even low concentrations of CO.[s]

The OSHA 8-hour exposure limit for CO is 55,000 $\mu g/m^3$ (50 ppm) (8-hour average). It has been found that a 1-hour exposure of up to 1,200 ppm would cause unpleasant but no dangerous symptoms.[t] Animals and humans have been found to be susceptible to CO at similar concentrations; no secondary standards for CO have been established though. The OSHA exposure limit is a reasonable primary and secondary threshold for workers and those engaged in subsistence activities in the Chukchi Sea and the health of marine life, respectively. A conservative criteria level, based on the OSHA standard, would be 1-hour average threshold of 50 ppm.

SO2:

Short-term SO_2 NAAQS have been established to protect the most susceptible individuals, which include severe asthmatics and those with pre-existing respiratory disease such as Chronic Obstructive Pulmonary Disease. SO_2-related health impacts in healthy individuals have not been demonstrated at concentrations < 1,000 ppb.[u,v] Increase in respiratory symptoms have been observed in exercising asthmatics following 5 to 10 minute exposure to SO_2 levels as low as 200-300 ppb. Given these observations, the 1-hour SO_2 NAAQS has been set at 250 ppb (not to be exceeded more than twice per year) to limit health impacts on the most susceptible individuals.

The OSHA permissible exposure limit is 5 ppm (13 mg/m^3) (8-hour exposure). The California OSHA standard is lower, however, at 2 ppm. Shell has adopted a more protective and conservative value (given the temporal averaging period of the standard) of 2 ppm[w] (1-hour average concentration) to provide adequate protection of workers and subsistence hunters and fishermen on the Chukchi Sea.

The secondary NAAQS are established primarily to protect against the acidification of the environment from SO_2 pollution. Build-up of SO_2 in the air can lead to acid rain and deposition can increase the acidity of isolated marine environments, where pollutants can concentrate. These factors are not an issue over the offshore regions of the Arctic Ocean due to the lack of widespread SO_2 sources. Acidification is primarily a concern in coastal areas due to the buildup of sulfur in estuaries and marshlands: similar buildup is impossible over the open ocean, where any deposited sulfur will disperse quickly. Impacts on marine life can be adverted by adherence to health-based limits set for human exposure.

[s] USEPA (2010): Quantitative Risk and Exposure Assessment for Carbon Monoxide – Amended, EPA-452/R-10-009

[t] Center for Disease Control, IDLHs for Carbon Monoxide: http://www.cdc.gov/niosh/idlh/630080 html

[u] USEPA (2009): Risk and Exposure Assessment to Support the Review of the SO_2 Primary National Ambient Air Quality Standards, EPA-452/R-09-007.

[v] Sulfur dioxide final acute exposure guideline levels (May, 2008)

[w] 2 ppm = 2,000 ppb

Attachment B

Air Quality Technical Report – Onshore Area

Shell OCS Exploration Drilling Program Chukchi Sea

Air Quality Technical Report Onshore Areas

Prepared for:
Bureau of Ocean Energy Management
Anchorage, Alaska

On behalf of:
Shell Gulf of Mexico, Inc.
Anchorage, Alaska

Prepared by:
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Lynnwood, WA

Date:
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Project Number:
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ENVIRON

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Acronyms, Abbreviations, and Definitions

Note that in this section and throughout the rest of this report there are active hyperlinks that will jump to the referenced material or section. General hyperlinks are formatted like this. Hyperlinks for tables and figures are highlighted like **this**.

AERMOD.............................. Air quality dispersion modeling system used in this analysis. The AERMOD modeling system consists of two pre-processors and a dispersion model. The meteorological preprocessor (AERMET) provides meteorological information, and a terrain pre-processor (AERMAP) characterizes terrain, and generates receptor grids for the dispersion model (AERMOD).

Air quality standard .... Health-based standard representing a pollutant concentration in the ambient air usually over some averaging period like 1-hour, intended to protect the health and welfare of people with a margin of safety.

Ambient air............................ the air in outdoor locations to which the public has ready access

Area source............................ an emission source type defined in AERMOD. Area source emissions are released from a two-dimensional rectangular area

Areapoly source...................... an emission source type defined in AERMOD. Areapoly sources are similar to area sources in that emissions are released from two-dimensional areas, but such sources are not restricted to rectangular areas and can have more than four sides.

Attainment/Nonattainment ..... a determination and classification made by EPA indicating whether ambient air quality in an area complies with (i.e., attains) or fails to meet (i.e., nonattainment) the requirements of one or more **NAAQS**

Averaging time .... a specific period of time (e.g., 1 hour, 24-hours, 1 year) over which concentrations of an air pollutant are measured or model-calculated. Note that some NAAQSs are also based on multi-year averages of certain percentiles of measured or calculated concentrations.

BACT .... Best Available Control Technology

CO .... carbon monoxide, a criteria air pollutant

CO_2 .... carbon dioxide

CO_2e .... Greenhouse gas equivalents (emissions of all GHGs expressed in terms of their "global warning potential")

Criteria air pollutant .... an air pollutant specifically governed by the Federal Clean Air Act for which ambient air quality standards have been set. Criteria air pollutants include carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide, ozone, and lead.

Dispersion model................... A computerized calculation tool used to estimate pollutant concentrations in the ambient air based on numeric simulations that consider the locations and rates of pollutant emissions and the effects of meteorological conditions, usually over specific averaging times (e.g., 8-hours)

dwt... Deadweight tonnage is a measure of how much weight a ship is carrying or can safely carry. It is the sum of the weights of cargo, fuel,

	fresh water, ballast water, provisions, passengers, and crew. The term is often used to specify a ship's maximum permissible deadweight, and is expressed in long tons or metric tons (tonnes).
EPA	US Environmental Protection Agency
gr	grains, a measure of mass. 7000 grains per pound.
gr/cf	grains/cubic foot
hp	horsepower
Knot	a unit of speed equal to one nautical mile per hour, or approximately 1.151 mph
Long ton	also called imperial ton and equal to 2,240 pounds (1,016 kg)
Meteorological data set	a compilation of meteorological data representing conditions over some period of time and including such things as wind speed and wind direction, and formatted as required by the dispersion model being used. This analysis used a meteorological data set covering 5 years.
Metric ton	1,000 kilograms (kg) = 2,204.6 pounds = tonne (see also short ton)
Micrometer/Micron	one millionth of a meter; typically used to distinguish particle size; typical human hair is 100 about microns in diameter
Modeling domain	the area included in the **dispersion-modeling** analysis
Modeling receptor	a theoretical (i.e., often non-specific) location used in computer modeling at which air pollutant concentrations are calculated. Modeling may also use site-specific receptors representing individual locations.
NAAQS	National Ambient Air Quality Standard
Nautical mile (nm)	The nautical mile is a unit of length that is about one minute of arc of latitude measured along any meridian, or about one minute of arc of longitude at the equator. By international agreement it is exactly 1,852 meters (approximately 6,076 feet).
NSPS	New Source Performance Standard; rules that pertain to air pollution emission sources subject to air quality permits and newly manufactured equipment
NO_2	nitrogen dioxide, a **criteria** air pollutant
NOx	oxide of nitrogen, a general class of air pollutant without a specific air quality standard but used in monitoring air quality
Particulate matter (PM)	air pollutant comprised of solid or liquid particles; PM is usually characterized based on the particle size. See also PM10 and PM2.5.
PM10	"Coarse" inhalable particulate matter with an aerodynamic size less than or equal to 10 micrometers (**microns**)
PM2.5	"Fine" inhalable particulate matter with an aerodynamic size less than or equal to 2.5 micrometers (**microns**)
Point source	an emission source type defined in AERMOD. Point source emissions are released from a single location.

ppm.. parts per million (a metric used in quantifying concentrations of air pollutants)

Receptor................................. See modeling receptor.

Release height........................ an AERMOD term defining the height above ground at which source emissions are released

Short ton .... 2,000 pounds (see also **metric ton** and long ton)

SO_2.. Sulfur dioxide, a **criteria air pollutant**

tonne .... **metric ton**

tpy.. tons per year, an estimate of annual emissions

$\mu g/m^3$ .... micrograms per cubic meter (a metric used in quantifying concentrations of air pollutants)

Volume source....................... an emission source type defined in AERMOD. Volume sources emit diffuse air pollutants from a three-dimensional area. Line sources, such as emissions from transiting trains, can be simulated using multiple, adjacent volume sources.

Preface

Shell Gulf of Mexico, Inc. has requested authorization from the United States Department of the Interior, Bureau of Ocean Energy Management (BOEM), to drill exploration wells in the Chukchi Sea beyond the 3-mile seaward boundary of Alaska. Exploration drilling will continue to consist of the operation of a drillship and an associated fleet on the Outer Continental Shelf (OCS) of the Chukchi Sea. Shell has an approved Exploration Plan for drilling in the Chukchi Sea at the Burger Prospect (EP for Revision 1). This report was developed for Shell's EP Revision 2 and the supporting EIA for EP Revision 2, for exploration drilling operations for Shell's next season of operations. One of the modifications Shell proposes in its EP Revision 2 is authorization for its exploration drilling program air emissions from the BOEM. See also Attachment A to the EIA for EP Revision 2. This Air Quality Technical Report presents the results of an analysis conducted by Shell to identify emissions to the atmosphere and evaluate associated impacts from the drillship, its associated fleet, and onshore sources of air emissions associated with the exploration program.

BOEM implements its authority to protect air quality under 30 CFR Part 550 Subpart C. See also Attachment A to the EIA for EP Revision 2. This program is referred to as the BOEM Air Quality Regulatory Program (AQRP). BOEM also has the responsibility to evaluate potential impacts of the exploration drilling program pursuant to the National Environmental Policy Act (NEPA). BOEM Alaska indicates that air quality modeling is required to evaluate potential impacts under NEPA[1] and this report details the methods, data and results that document the NEPA air quality analysis of impacts that occur onshore.

This report provides technical information about the existing conditions of the proposed project site and projected effects of project operations. It is provided to the lead federal, state, and local agencies for their use in evaluating the impacts of the exploration drilling program as described in EP Revision 2.

[1] Meeting between BOEM and Shell, May 15, 2013, held in BOEM office, Anchorage, Alaska

1 Summary

The air quality analysis of the Shell OCS Exploration Program for the Chukchi Sea described in this report considers air pollutant emissions and onshore concentrations that may result from the exploration program.

The air quality assessment of the exploration drilling program as described in EP Revision 2 includes development of detailed emission inventories based on spatially and temporally distributed emissions from the following emissions units:

- The drillship itself, including
  - Main generators
  - Propulsion Engine
  - Small internal-combustion engines
  - Seldom-used engines
  - Heaters and boilers
  - An on-board incinerator
- Ice-management vessels (includes anchor handlers), including
  - Propulsion and generator engines
  - Boilers
  - Incinerators
- Oil-spill response vessels
- Resupply vessels
- A fuel tanker
- A science vessel
- Onshore support activities, including
  - Helicopter emissions
  - A 200 person housing facility including associated generator engines
  - A hanger and storage building
  - Miscellaneous onshore vehicles

Emissions from these units and activities were then evaluated with air quality dispersion modeling. The air quality analysis considered emissions and concentrations of "criteria" air pollutants, including oxides of nitrogen, oxides of sulfur, particulate matter and carbon monoxide.

The air quality analysis indicates emissions from the exploration drilling program, including all offshore and onshore support activities, would not result in any onshore air pollutant concentrations exceeding the health-based primary ambient air quality standards or secondary ambient air quality standards.

2 Purpose of the Drilling/Exploration Program

Shell continues to propose the use of a single drillship, the M/V Noble Discoverer (Discoverer), to continue an exploration drilling program that was begun in 2012, at any of six well locations on six leases (one well per lease) offshore in the Chukchi Sea, Alaska. The drill sites are more than 65 nautical miles (nm) offshore in Arctic waters that are inaccessible for eight months or more of the year due to pack ice. Shell's proposed exploration drilling operations will take place on federal OCS leases in the Chukchi Sea, an area of approximately 230,000 square miles (mi^2) (595,000 square kilometers [km^2]). The drill sites are remote from any infrastructure or human habitation. Shell's seasonal exploration drilling operations would begin on or about July 1st and extend no later than October 31st.

Shell's EP Revision 2 proposes to conduct exploration drilling activities on any of six lease blocks all within what is known as the Burger Prospect, acquired in federal OCS Lease Sale 193. The sites are identified "Burger" A, F, J, R, S and V in **Table 1.** Water depth at each location is approximately 150 feet (45.8 meters) or less.

Table 1. Candidate Drilling Sites

Prospect	Well	Area	Lease Number	Lease Block	Latitude	Longitude	UTM Coordinates[2] X(m)	UTM Coordinates[2] Y(m)
Burger	A[1]	Posey	OCS-Y-2280	6764	N71° 18' 30.92"	W163° 12' 43.17"	564800	7912800
Burger	F	Posey	OCS-Y-2267	6714	N71° 20' 13.96"	W163° 12' 21.75"	564800	7917600
Burger	J	Posey	OCS-Y-2321	6912	N71° 10' 24.03"	W163° 28' 18.52"	555200	7898400
Burger	R	Posey	OCS-Y-2294	6812	N71° 16' 06.57"	W163° 30' 39.44"	555200	7908000
Burger	S	Posey	OCS-Y-2278	6762	N71° 19' 25.79"	W163° 28' 40.84"	555200	7912800
Burger	V	Posey	OCS-Y-2324	6915	N71° 10' 33.39"	W163° 04' 21.23"	569600	7898400

Note:[1] Burger A drill site where a partial well was begun in 2012.

[2] Universal Transverse Mercator (UTM) coordinates here are from BOEM's OCS Official Protraction Diagram and are based on the North American Datum 1983 (NAD-83). The coordinates quoted are the approximate center of each lease block.

3 Project Description

3.1 Drilling Program Activities and Emissions Units

The drilling will be conducted by the Discoverer with support from oil-spill response vessels, anchor handlers, ice management vessels, offshore supply vessels (OSVs) and aerial transport. There will be associated onshore support including housing for employees, hangers and other storage buildings, and transport for supplies and personnel. The drillship has been identified, but support vessels are contracted on a yearly basis and multiple vessels could meet the duty requirements for the needed tasks. In this air quality analysis, the size and emission characteristics needed for the tasks have been defined. In the case of the Discoverer, the actual vessel to be used, the types of emission units on board are defined. For the other vessels, a candidate vessel is identified, but because that vessel may not be available or the final vessel chosen before the start of the next exploration drilling season, the types of emission units anticipated are identified, but not the actual units.

The Discoverer is a turret-moored drillship that underwent significant upgrades in 2007 and 2013 so that it could operate in the Arctic. The Discoverer crew will work 12-hour shifts and live on the rig in accommodations located at the stern of the ship. They are expected to be transported to and from the rig by helicopter to shore based locations.

The Discoverer has its own propulsion engine for self-transport. The drilling involves raising and lowering a rotating bit. At intervals the well is cased and cemented, and at intervals the well bore geological information is logged. Mud-line cellars (MLC) are excavated for suppression of well-head equipment into the sea floor to avoid damage by ice keels should ice floes force the rig off the well, and this excavation involves a large (up to 30-foot diameter) bit to drill the initial up to 50 feet below the mud line. Rotation of this bit can involve hydraulic assistance from on-board hydraulic pumps. A hole is drilled for the next interval and a tube (casing) is installed and cemented. Cementing the casing anchors it in the hole and prevents annular formation fluid migration between formations or to the surface. Atop the casing is a guide base with receptacles for guidelines that facilitate reentry into the well.

The Discoverer is equipped with two diesel-powered cranes that will see occasional use. There are also diesel-fueled boilers for keeping both personnel and equipment warm during the drilling. An incinerator is available for disposal of domestic and other non-hazardous waste. The Discoverer also has several smaller engines for emergency purposes.

The close support auxiliary fleet will include anchor handlers for management of the Discoverer anchors, bow washing of any ice buildup on the Discoverer bow, and some ice floe fragmenting in support of the ice management vessel. One anchor handler and one ice management vessel provide primary close support for the Discoverer with regard to these tasks, whereas the second anchor handler or ice management vessel is anticipated to provide occasional support to the Discoverer for the performance of these tasks. The second anchor handler and ice management vessel very likely will have other tasks to conduct outside of the geographic extent of the Chukchi Sea, and often not in support of the exploration drilling program. Up to two ice management vessels may be tasked to fragment any manageable ice flows so that the ice will flow around the Discoverer. The ice management vessels are needed when there are ice features that require disruption in their path or fragmentation in order to provide protection for the drilling vessel, or other assets critical to the safety of the exploration drilling program (i.e., mooring buoys, etc.). One or more ice management vessels may normally works several miles upwind of the drillship and may monitor the leading edge of any ice floe of possible concern, far upwind. An oil-spill response vessel or vessels will be anchored nearby but out of the way downwind of the Discoverer.

Other associated vessels include those for resupply and material transfer to shore. The OSVs would travel to the Discoverer, then "park" in dynamic positioning (DP) mode beside the Discoverer for material or personnel transfer. These vessels are expected to come at most once per week and could remain there for about one day or more. Another OSV, also used as a science vessel, could remain permanently within a few miles of the Discoverer for unspecified but routine materials on and off-loading. A fuel tanker is expected to be permanently located near the Discoverer to resupply the Discoverer and associated fleet.

Onshore associated air emission units could include personnel camps, material storage, helicopter hangers, transport vans and trucks, and helicopters in Barrow.

3.2 Spatial and Temporal Relationships of Emission Units

For air impact analysis purposes, there are three emission unit groups: the Discoverer, the close vessel support, and the onshore activities. Emissions units that are physically close together can have additive impacts, whereas, if the same emissions units are spread over a large area, the impacts will be smaller at any one location (and spread over a larger area).

The emission units on the Discoverer are close together and impacts nearby will be concentrated. The associated fleet will be spread over a five mile radius of the Discoverer so emissions will be spread over this large area and will not be concentrated. At large distances of 50 miles or more all of these emissions will be well dispersed.

Close support includes oil-spill response (OSR) vessels, anchor handlers and ice management vessels. The OSR vessels will normally be two to five nm downwind of the Discoverer. The anchor handler will operate in a similar radius but will work upwind when there is an ice floe moving toward the drillship. The primary ice management vessels are assigned the ice management task, but could also assist in anchoring. When they are managing ice, they will be two to 10 miles upwind of the Discoverer. Typically, there is one ice management vessel, but for short periods of time there could be a second ice management vessel. When these vessels are not working they could be anchored in warm-stack mode, transitioning or working in support of activities inside or outside of the OCS program area.

The close support group includes OSVs, a resupply barge and tug, science vessels, a fuel tanker, and helicopter support. These vessels are only occasionally near the Discoverer, and normally many miles away, including in port. The OSVs normally do not tie up to the Discoverer to transfer materials and personnel, but do so in DP mode.

As discussed further below, associated emissions units on shore will be so far away that there will be essentially no aggregate impacts with the vessels. Any onshore construction will be completed before drilling activity begins so its short-term impact will be gone during the drilling season.

Emissions units may not operate concurrently. Only emissions units that operate concurrently can have additive short-term (one hour and 24-hour) impacts. Those that do not operate concurrently will not have additive short-term concentrations, although all will contribute to concentrations averaged over the season. Drilling and use of the Discoverer's smaller internal combustion (IC) engines will take place only after the drillship is fully anchored and connected to its 8 anchors. The propulsion engine may be used on a limited basis once the Discoverer is anchored. The cementing and logging equipment will only be used when setting casing or logging a well when the Discoverer is anchored at a drill site. None of the smaller diesels are operated during ship transit to and from the drill site. None of the smaller IC engines are used more than occasionally.

The actual drilling could occur during the interval between July 1st and October 31st.

3.3 Pollutants to Evaluate

The regulated pollutants to be evaluated include particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), lead (Pb), and ozone (O_3). Note that O_3 includes evaluation of pre-cursors, volatile organic compounds (VOC) and oxides of nitrogen (NOx). Included in the analysis will be the evaluation of the formation of secondary aerosols, a component of $PM_{2.5}$.

4 Affected Environment

4.1 Regulatory Overview

4.1.1 BOEM Regulatory Authority

As a part of its EP Revision 2, Shell has submitted an Environmental Impact Assessment (EIA). The EIA provides a specific analysis of air quality impacts in the project area. This air quality technical report is a supplement to Shell's EP Revision 2 and its supporting EIA and provides BOEM with additional information necessary to analyze and evaluate the potential air quality impacts of the exploration drilling program at the shoreline. Accordingly, this document supports BOEM's air quality requirements under NEPA for evaluating shoreline impacts.

4.1.2 Ambient Air Quality Standards and Attainment Status

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than ambient air quality standards set to protect human health and welfare. See also Attachment A to the EIA for EP Revision 2. Ambient air quality standards are set for what are referred to as "criteria" pollutants (e.g., carbon monoxide - CO, particulate matter, nitrogen dioxide - NO_2, and sulfur dioxide - SO_2). Onshore, two agencies have jurisdiction over the ambient air quality accessible to the general public: the U.S. Environmental Protection Agency (EPA) and the Alaska Department of Environmental Conservation (ADEC). These agencies establish regulations that govern the concentrations of pollutants in the outdoor air. Although their regulations are similar in stringency, each agency has established its own standards. Unless the state jurisdiction has adopted more stringent standards, the EPA standards apply. Applicable state and federal ambient air quality standards are displayed in **Table 2**. These standards have been set at levels that EPA and ADEC have determined will protect human health with a margin of safety, including the health of sensitive individuals like the elderly, the chronically ill, and the very young.

The ambient air quality standards are commonly used in NEPA assessments to evaluate onshore air quality concentrations. It is expected that the ambient standards will be used by BOEM under NEPA to assess onshore concentrations expected to result from the Shell OCS exploration program.

Neither ADEC nor EPA maintain air quality monitoring stations on the North Slope of Alaska in the vicinity of the nearest onshore areas to the proposed exploration leases addressed here. In general, air quality monitoring stations are located where there may be air quality problems, and so are usually in or near urban areas or close to specific large air pollution sources. Based on monitoring information for criteria air pollutants collected over a period of years, ADEC and EPA designate regions as being "attainment" or "nonattainment" areas for particular pollutants. Attainment status is therefore a measure of whether air quality in an area complies with the federal health-based ambient air quality standards for criteria pollutants. Based largely on the sparse population of the area, and less on actual measurements, the north slope of Alaska is classified as "attainment" or "unclassified" for all regulated air pollutants. In practical terms, "unclassified" areas are treated exactly the same as "attainment" areas.

Table 2. Applicable Ambient Air Quality Standards for Criteria Pollutants

Pollutant	Terms of Compliance [a]	Concentration
Inhalable Particulate Matter (PM_{10}) 24-Hour Average (µg/m³)	The 3 year average of the 98th percentile of the daily concentrations must not exceed	150 µg/m³
Fine Particulate Matter ($PM_{2.5}$) Annual Average (µg/m³)	The 3-year annual average of daily concentrations must not exceed	12 µg/m³ [b]
24-Hour Average (µg/m³)	The 3-year average of the 98th percentile of daily concentrations must not exceed	35 µg/m³
Sulfur Dioxide (SO_2) [b] Annual Average (ppm)	Annual arithmetic mean of 1-hour averages must not exceed	80 µg/m³
24-Hour Average (ppm)	24-hour average must not exceed	365 µg/m³
3-Hour Average (ppm)	3-hour average must not exceed	1,300 µg/m³
1-Hour Average (ppm)	1-hour standard is attained when the three-year average of the annual, 99th percentile, daily maximum, one-hour concentration is less than or equal to	196 µg/m³
Carbon Monoxide (CO) 8-Hour Average (ppm)	The 8-hour average must not exceed more than once per year	10,000 µg/m³
1-Hour Average (ppm)	The 1-hour average must not exceed more than once per year	40,000 µg/m³
Ozone (O_3) 8-Hour Average (ppm)	The 3-year average of the 4th highest daily maximum 8-hour average must not exceed	0.075 ppm
Nitrogen Dioxide (NO_2) Annual Average (ppm)	The annual mean of 1-hour averages must not exceed	0.053 ppm
1-Hour Average (ppm)	3-year avg. of 98th percentile of daily max 1-hour averages must not exceed	0.1 ppm
Lead (Pb) Rolling 3-month Average	Rolling 3-month average not to exceed	0.15 µg/m³

Note: µg/m³ = micrograms per cubic meter; ppm = parts per million

(a) All limits are federal *and* state air quality standards except as noted. All indicated limits represent "primary" air quality standards intended to protect human health.

(b) EPA issued a new 12 µg/m³ annual standard on 12/14/2012 that became effective on March 18, 2013; the previous annual standard was 15 µg/m³. The ADEC has yet to adopt the new standard.

4.2 Existing Air Quality Conditions

There are no existing sources of air pollution near the Chukchi Sea lease area because it is more than 60 miles from land and there are no other oil exploration or development sources in the Chukchi Sea at this time. In the absence of sources, the air quality in the project area is generally expected to be good. The points of land nearest the proposed drill sites are in the remote parts of the Arctic coast of Alaska, and are mostly uninhabited except for occasional subsistence hunting and fishing. The nearest native villages are at Wainwright and Point Lay, approximately 66 and 86 nautical miles away, respectively.

Because the drill site location will be far from the Alaska shoreline and away from significant sources of pollution, existing air quality concentrations can be represented with a regional value. According to EPA's *Guideline on Air Quality Models* (40 CFR 51, Appendix W, Section 8.2.2c), a "regional site" may be used to determine background concentrations if there are no monitors located in the vicinity of the source. A "regional site" is one that is located away from the area of interest, but is impacted by similar natural and distant man-made sources. The majority of the air quality data on the North Slope have been collected by various industrial developments associated with the oil and gas resources of the area.

Shell and ConocoPhillips Alaska began monitoring NO_2, $PM_{2.5}$, PM_{10}, SO_2, CO, and O_3 concentrations at Wainwright, Alaska in November 2008. The Wainwright monitoring station is remotely located (minimal influence of industry and other human activities) and is the most representative "regional site" on the North Slope for estimating offshore monitoring concentrations in the Chukchi Sea. However, its onshore location would be expected to result in higher concentrations of pollutants (especially particulate matter) than actually occur offshore. A map of the ambient monitoring stations on the North Slope is provided in **Figure 2**.

Table 3 shows a summary of the concentrations measured at the Wainwright monitoring station. Comparison of **Table 3** with the Ambient Air Quality Standards in **Table 2** indicates that existing concentrations are all well below ambient air quality standards for all pollutants and all averaging times.

Table 3. Existing Ambient Air Concentrations

Pollutant	Averaging Period	Concentration (µg/m^3)	Data Source
NO_2	1-hour	53	Wainwright
	Annual	2	Wainwright
$PM_{2.5}$	24-hour	18	Wainwright
	Annual	2	Wainwright
PM_{10}	24-hour	57	Wainwright
SO_2	1-hour	16	Wainwright
	3-hour	13	Wainwright
	24-hour	5	Wainwright
	Annual	2	Wainwright
CO	1-hour	1,145	Wainwright
	8-hour	1,145	Wainwright

4.3 Meteorological Conditions and Climate

Climate in the project study area is unique to the polar region. The climate is dominated by severe cold temperatures during winter and a brief period of warming in late summer and early fall.

From an air pollution perspective, the most important meteorological parameters are wind speed and direction because they determine the transport and dispersion of airborne contaminants. Wind conditions are commonly represented by a figure known as a wind rose. **Figure 3** is a wind rose constructed from the meteorological data used in the current analysis. The figure has a series of bars emanating from the center of the drawing. The bars represent the relative frequency of wind directions with the length of each bar representing the relative frequency of the wind direction. In this case it shows the most frequent wind directions at the Burger Lease are coming from the east-northeast.

The colors in the figure illustrate the relative frequencies of wind speeds at the project site. The color code in the figure can be used to interpret the wind speeds.

5 Analytical Methods

The air quality impact analysis includes two basic steps: (1) emission inventory development to estimate emissions related to the exploration drilling program as described in EP Revision 2, and (2) dispersion modeling to estimate resulting air contaminant concentrations in the ambient air . The following sections discuss the methods employed and the critical assumptions involved in each portion of the analysis.

5.1 Emission Inventory Methods

The exploration program would result in emissions from propulsion engines used on the vessels as well as diesel-generators used to power the electric equipment. In addition, there are several smaller specialized engines used for specific purposes in the drilling program as well as several smaller engines used primarily for emergency purposes that are exercised on a regular basis for safety and reliability testing. Finally, there are waste combustion incinerators aboard some of the vessels for destruction of non-hazardous waste. All emission sources considered in the current analysis are combustion sources. The calculations supporting the emission inventory are detailed in Attachment B to Appendix O of the EP Revision 2.

5.1.1 Emission Factor Tools and Sources

Emission factors are values that allow an emission rate to be determined from some other operations parameter. For example, an engine may have an emission factor that states the quantity of NO_X that is produced from the combustion of one gallon of diesel fuel. Thus, by knowing or estimating the quantity of fuel an engine will consume per hour or per season, the quantity of NO_X emissions can be easily calculated.

To the degree possible, emission factors used in the current analysis were based on actual emissions testing of Shell vessels. Where source test results were not available, other information was used. If the unit was a marine engine with an established Tier level under 40 CFR 94.8, Table A-1, the specified Tier emission level was used. In a few cases, it was necessary to use emission factors from EPA's handbook on emission factors, known as AP-42.

SO_2 emissions from diesel fuel combustion were established using a mass–balance with an assumed sulfur level in the fuel of 100 parts per million by weight. Although Shell has committed to purchasing only diesel fuel with sulfur content of 15 ppm or less, this assumption accounts for the possible mixing of residual fuel in the tanks with ULSD that is purchased. This allowed development of an EP-specific emission factor for all diesel fuel sources.

Emission rates for project emissions units are summarized in Table 4.

Table 4. Summary of Estimate Emission Rates

Emission Unit	NOx		PM		CO		VOC		Pb	
	lb/h	t/y	lb/h	t/y	lb/h	t/y	lb/h	t/y	lb/h	t/y
Discoverer										
Generation	36	41	1	1	8	10	2	2	1E-3	2E-3
Propulsion	82	2	2	0.05	57	1	15	0.4	1E-3	3E-5
Small IC engines	12	18	0.4	0.6	11	16	3	4	3E-4	4E-4
Seldom-Used IC engines	8	0.1	0 2	2E-3	4	0.1	1.0	0.01	1E-4	9E-7
Boilers	3	2	0.03	0.02	0.3	0.2	0.04	0.03	1E-4	1E-4
Incinerator	0.4	0.6	1	1	1	2.1	14	20	0.03	0.04
Ice-Management and Anchor Handler Vessels										
Propulsion & Generation										
Boilers	88	36	14	6	9	3	55	22	2E-2	7E-3
Incinerator	3	1	0 1	0.05	0.04	0.02	0.06	0.03	2E-4	9E-5
	1	1	3.6	4	4.4	4	29	29	6E-2	6E-2
Oil Spill Response Vessels										
All IC engines	233	107	6	3	162	74	42	19	4E-3	2E-3
Resupply Vessels										
All IC engines	146	131	4	4	102	91	26	24	3E-3	2E-3
Fuel Tanker										
All IC engines	104	46	3	1	72	32	19	8	2E-3	8E-4
Science Vessel										
All IC engines	66	67	2	2	46	46	12	12	1E-3	1E-3
Onshore Support										
Helicopters	0.20	0.28	0.04	0.05	1	2	1	2		
200 Person Camp Generators	8	13	0.4	0.60	6	11	2	4		
Hanger/Storage Building Boiler	0.5	0.4	0.04	0.03	0.4	5	0.02	0.01	2E-6	2E-6
Vehicles	0.01	0.01	8E-4	0.70	0.3	0.4	8E-3	0.01		
TOTAL	791	467	39	23	486	300	224	149	0.12	0.15

5.1.2 Model Configuration of Emission Units

All of the emission units associated with the exploration drilling program are to some extent mobile. The most stationary of the units are those on the Discoverer. During the drilling of any individual well, the Discoverer remains fixed over the well. However, the ship itself rotates about the drilling stem, placing the bow of the ship in the direction of the oncoming wind, which is usually also the direction any moving ice would come from. The drillship does not rotate as a result of the wind acting on it, but rather is moved by a cranking system aboard the Discoverer. As the vessel is rotated, the locations of many or all the emission units on the drillship are moved.

Although the Discoverer emission units are mobile, for purposes of the modeling study, the units are assumed to be point sources at a fixed location. Given that the nearest onshore receptors are over 100 kilometers from the Discoverer, the actual rotation of the ship is insignificant in the modeled concentrations. Hence the drillship is assumed to be pointing in the direction of the prevailing wind for the entire drill season. The prevailing wind direction was assumed to be coming from 60 degrees measured clockwise from north.

In addition to the Discoverer itself, where the emissions units are assumed to be fixed point sources, the other units are much more mobile. The ice management fleet typically operates many miles upwind of the Discoverer to ensure the Discoverer is protected from any moving ice. But on occasion the ice management fleet may come in closer to the Discoverer for some close support activities. Similarly, the oil spill response vessels typically operate a few miles downwind of the Discoverer. These emission units tend to be moving during periods when exercises or training may be underway.

Finally, other support vessels, such as the fuel tanker, science vessel and the resupply vessel while in transit can be located anywhere in the vicinity of the Discover and will move from time to time to take advantage of the ice-free path that is maintained by the ice management vessels. It should be noted that an OSV may position itself next to the Discoverer while unloading supplies. Emissions from the OSV while in dynamic position mode have also been modeled as a point source.

Given the highly mobile nature of these support vessels it is inappropriate to model them as fixed point sources, but rather as area sources where emissions are distributed out over an area. For the ice management vessels, the area source is modeled as a large triangular area approximately 5 kilometers long and located upwind of the drillship. For the other units, a square area source, 2 kilometers on a side is assumed to represent the remaining emission units.

Figure 4 is a schematic drawing that shows the location of these point and area sources.

5.2 Dispersion Modeling

ENVIRON used air quality dispersion modeling simulations to estimate ambient concentrations due to emission sources associated with the exploration program. This section discusses the methods used to develop these simulations to assess potential future pollutant concentrations in the area surrounding the facility.

Air quality models are computer programs designed to mathematically represent atmospheric transport and dispersion of airborne contaminants. The purpose of the proposed air quality modeling in this protocol is to provide estimates of ambient concentrations of regulated contaminants emitted by the various engines, heaters and other emission units that are part of the Shell exploratory drilling program. There are a variety of air quality models that could be used for this purpose and conversations with BOEM[3] have indicated that they intend to follow EPA Guidance as reflected in the EPA's *Guideline on Air Quality Models* (the Guideline).

5.2.1 Dispersion Model Selection

The two air quality models most commonly recommended in the Guideline for industrial sources of emissions are the AERMOD model and the CALPUFF model. The AERMOD model is recommended by EPA for computation of concentrations within 50 kilometers of a source, while the CALPUFF model is recommended for locations farther than 50 kilometers from a source.

BOEM requires a demonstration that emissions from the exploration program will not exceed certain levels on shore. For that analysis, BOEM agreed in meetings with Shell that the CALPUFF modeling system is appropriate for evaluating concentrations of emissions from the offshore drilling activities because the shoreline is more than 50 km from the lease area.

ENVIRON applied CALPUFF to predict pollutant concentrations from emissions associated with Shell's exploratory drilling in the Chukchi Sea. The CALPUFF predictions were used to display potential regional pollutant concentrations, assess compliance with the NAAQS on shore, and to predict concentrations at selected towns and villages or other locations of interest. The remainder of this section describes the long-range transport dispersion modeling techniques.

A separate air quality modeling study was conducted for the onshore facilities. As seen in

[3] Meeting between Shell and BOEM held on May 15, 2013 at BOEM's offices in Anchorage Alaska.

Table 4, there are emissions source located onshore in the Barrow area, but they represent only a small fraction of the total emissions. Accordingly, the current document focuses mainly on the offshore emissions sources which are the Discoverer and its associated fleet and the methods discussed in this Chapter are those used in the evaluation of the offshore sources. The air quality issues for the onshore facilities (the Barrow personnel camp, the hanger and the helicopter usage) are very different from those associated with the offshore facilities. Since the onshore facilities are located in Barrow, the scale of potential air issues is much closer and the use of CALPUFF is not common for close distances. The AERMOD model was used for evaluating air quality impacts from the onshore facilities. Detail on the AERMOD analysis can be found in Section 6.3.

5.2.2 Methods

ENVIRON applied the regulatory version of the CALPUFF modeling system to simulate emissions from proposed drilling operations in the Chukchi Sea. CALPUFF (Version 5.8) is the EPA recommended dispersion model for long-range transport analyses and source-to-receptor distances beyond 50 km.[4] For the application of CALPUFF, Shell followed the techniques recommended by the Federal Land Managers for Class I area assessments with a few modifications for Arctic conditions and available datasets. The simulations were performed based on meteorological conditions from July to November 2007, 2008, and 2009. The methods used to prepare the meteorological fields and perform the dispersion model analysis are described below.

5.2.3 Domain

The CALPUFF modeling domain is shown in **Figure 5**, where the Burger site, several villages of interest, and 4-km mesh size sampling grid are posted on the plot. The analysis assumes the Discoverer is located at the corner of the potential Burger lease blocks closest to the shoreline. The CALPUFF domain is a rectangular 167-by-118 grid with a horizontal mesh size of 4 km and 10 vertical layers ranging geometrically from the surface to 4,000 m. A Polar Stereographic (PS) projection was used for the coordinate system with an origin at (70 N, 155 W) and standard latitude of 70 N. Receptors were placed along the shoreline at a spacing of 1-km, at the villages, and places of interest shown on **Figure 5**, in keeping with BOEM suggestions at Shell's meeting with BOEM on May 15, 2013.

5.2.4 MMIF/WRF

ENVIRON used the Mesoscale Model Interface Format tool (MMIF)[5] and the Weather Research Forecast (WRF) model to construct the meteorological fields for input to CALPUFF. MMIF passes through and reformats the WRF output for CALPUFF. MMIF (Version 2.3) was applied to process the WRF model simulations for the Chukchi Sea provided to ENVIRON by the EPA. These WRF simulations for July to November of 2007 to 2009 supported previous ConocoPhillips permitting activities in the Chukchi Sea.[6] The WRF simulations have the three domains shown in **Figure 5** with grid mesh sizes of 36/12/4-km and 37 vertical levels. The boundary layer, nudging and other options selected for the WRF simulations are

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[4] 40 CFR Part 51 Appendix W: Guideline on Air Quality Models

[5] Brashers, B., and C. Emery, 2013. *Draft User's Manual: The Mesoscale Model Interface Program (MMIF), Version 2.3, 2013-4-30.* Prepared by Environ International Corp. for U.S. EPA, OAQPS, Air Quality Assessment Division, Air Quality Modeling Group, Mail Code C439-01, Research Triangle Park, NC, 27771, Accessed at http://www.epa.gov/ttn/scram/dispersion_related htm#mmif.

[6] McNally, D. and Wilkinson, J.G., 2011. *Model Application and Evaluation – ConocoPhillips Chukchi Sea WRF Modeling* Application, Prepared by Alpine Geophysics, 7341 Poppy Way, Arvada, CO, 8007, November 21, 2011.

based on comparisons to meteorological data in the Arctic and the results of ongoing studies sponsored by BOEM. ,[7]

ENVIRON used the following MMIF options to process and reformat the WRF meteorological fields for CALPUFF:

- Use only the 4-km WRF inner domain
- Select the *GOLDER* option for calculation of the Pasquill-Gifford stability class
- Use layer mapping of the 37 vertical WRF levels to 10 layers with tops of 20, 40, 160, 320, 640, 1200, 2000, 3000, and 4000m
- No recalculation of the mixing height, the WRF diagnostic output will be used directly
- Trim five cells along from the outer edge of the WRF 4-km mesh size domain to account for potential edge effects in the WRF simulations

ENVIRON used MMIF to prepare daily input files for CALPUFF to account for changing sea-ice coverage in the Arctic Ocean. The corresponding changes to the hourly energy fluxes and other important variables predicted by WRF governing dispersion and transport are already incorporated directly into the MMIF data provided to CALPUFF. However several algorithms (e.g. deposition velocity calculations) in CALPUFF still need to distinguish between over water and over land characteristics based on land use that is only read in at the start of each meteorological input file. Daily input files allowed CALPUFF to consider daily changes to land use for these algorithms.

5.2.5 CALPUFF

ENVIRON performed six CALPUFF simulations for the Chukchi Sea using short-term and annual emissions for each July to November period of 2007 to 2009. Short-term and annual emissions were used in the analysis to address the different averaging periods of the NAAQS for each pollutant. Regulatory default dispersion options used for long-range transport modeling were selected by invoking the *MREG=1* switch within the input files. The respective short-term and annual emission rates for emission units included in the simulations are discussed in the emission inventory presentation in Attachment B of Appendix O to EP Revision 2. Short-term emissions were conservatively assumed to occur every hour of the July to November drilling season for each of the three years in the simulations.

The release characteristics of the point sources on the Discoverer and area sources (Ice Management, Re-Supply vessels and Oil Spill Recovery (OSR) Fleets) have been discussed in the emission inventory section above. ENVIRON assumed the Discoverer was pointed into the prevailing wind direction for the entire period. The prevailing wind direction from buoy measurements at the Burger site during July to November 2009 was 60 degrees from North. The Ice Management Fleet activity is assumed to occur within a wedge from the center of the Discoverer out to 5 km upwind. The OSR Fleet is assumed to be downwind with emissions distributed into a 2 km-by-2 km square area source.

5.2.6 Secondary Aerosols

CALPUFF incorporates algorithms to consider secondary aerosols formed from emitted NO_X and SO_2. Total PM_{10} and $PM_{2.5}$ were calculated from the sum of the emitted primary species, ammonium nitrate, and ammonium sulfate. The primary PM_{10} emissions for each source were divided into six species,

[7] Zhang, J., Liu, F., Krieger, J., Tao, W, and X. Zhang, 1981. *Project Report for the 5-year Experimental Mesoscale Meteorology Reanalysis for the Beaufort/Chukchi Seas for Beaufort and Chukchi Mesoscale Meteorology Model Study.* Prepared for US DOI, Bureau of Ocean Energy managements, Alaska Outer Continental Shelf Region, Anchorage Alaska, Contract 0106CT39787, November 2011.

including: soot or elemental carbon (EC), fine soil particles (PMF), coarse particles (PMC), organic carbon (OC), sulfate (SO_4), and nitrate (NO_3). PMC fractions were calculated from the difference between PM_{10} and $PM_{2.5}$ emission rates. $PM_{2.5}$ emissions were divided into the remaining five species using the source profiles for diesel engines and incinerators based on profiles recommended by the EPA for the Community Multi-Scale Air Quality (CMAQ) model.[8]

Reaction rates and aerosol formation in the CALPUFF chemistry algorithms are influenced by background ozone and ammonia concentrations. ENVIRON used hourly ozone observations from the NOAA Barrow Observatory and BP's Pad A monitoring site. The maximum hourly observation from these two locations was used to represent background ozone concentrations in the simulations. The background ammonia concentration was assumed to be 0.5 ppb for all hours. This same ammonia background concentration was assumed for the Alaska Regional Haze Best Available Retrofit Technology (BART) modeling simulations.[9]

The CALPUFF utilities POSTUTIL and CALPOST were used to manipulate the large CALPUFF output files and summarize the results for comparison with the NAAQS. ENVIRON applied POSTUTIL to sum the individual PM_{10} species together after accounting for the differences in molecular weight between the species in the CALPUFF output files and the actual component species of PM_{10} and $PM_{2.5}$.

CALPOST (Version 6.221) was used to calculate the annual average and maximum concentrations for each averaging period and pollutant. The 8^{th} highest daily $PM_{2.5}$ concentration for each year of the simulations was calculated with CALPOST. For comparisons to the recent 1-hour NAAQS for SO_2 and NO_2, ENVIRON converted hourly time-series from CALPOST to files that mimic the output files from AERMOD. ENVIRON then applied a program to calculate the 8^{th} highest daily 1-hour concentration and 4^{th} highest daily 1-hour concentration, for NO_2 and SO_2, respectively.

ENVIRON conservatively assumed all NO_X predicted at downwind receptor is NO_2 for comparisons to the NAAQS. A second tier approach assuming a conversion factor of 0.8 is also appropriate and could be applied in any future analyses. It should be noted, although not performed here, a Tier 3 approach can be used to limit the potential formation of NO_2 by the amount of ozone available. The Ozone Limiting Method (OLM) could be applied by post-processing the CALPUFF output files and assuming a constant NO_2/NO_X in-stack ratio, an equilibrium ratio of 0.8. The amount of NO_2 formed will be limited using the same hourly ozone input file used in the CALPUFF simulations.

5.2.7 Building Downwash

Given that the nearest receptors are located more than 100 km from the source at the shoreline, building downwash effects did not significantly affect the modeled results. However, previous modeling analyses for the Shell exploration program have developed building downwash parameters. The modeling did use the previous downwash values developed for the Shell exploration program in the CALPUFF modeling analysis.

[8] CMAQ is the preferred regulatory model for $PM_{2.5}$ and regional haze simulations. The EPA website containing PM speciation by source categories is: http://www.epa.gov/ttn/chief/emch/speciation/.

[9] The Alaska BART and Regional Haze programs are described at http://www.dec.state.ak.us/air/anpms/rh/rhhome htm. In the original BART simulations a background of 0.1 ppb was assumed. In the more refined simulations performed by applicants seeking exemption from BART, a more conservative 0.5 ppb ammonia concentrations was assumed.

6 Potential Impacts of the Exploration Program

6.1 Construction-Related Air Quality: Potential Impacts

Support for the exploration drilling program would include construction of new onshore buildings and other infrastructure improvements. Activities would include the expansion of 75-person camp facility to one that will support up to 200 persons in Barrow or some other North Slope area. Such activities could result in temporary, localized increases in particulate concentrations due to emissions from construction-related equipment. For example, dust from construction activities such as excavation, grading, sloping and filling would contribute to ambient concentrations of suspended particulate matter. Construction contractor(s) would be required to comply with ADEC regulations requiring that reasonable precautions be taken to minimize dust emissions.

Construction could require the use of heavy trucks, excavators, graders, work vessels, and a range of smaller equipment such as generators, pumps, and compressors. The exploration program will minimize emissions from diesel-powered construction equipment to the extent practicable by taking steps such as those specified in section **Error! Reference source not found.**. With appropriate controls, onstruction-related diesel emissions would not be likely to substantially affect air quality in the project vicinity.

With implementation of the controls required for the various aspects of construction activities and consistent use of best management practices to minimize on-site emissions, construction of any onshore support facilities would not be expected to significantly affect air quality.

6.2 Air Quality Impacts of the Operation Phase

The operation phase is defined as the phase of the project when the main drillship is anchored at the drill site.

A total of 5,034 receptors were selected to represent the onshore area as depicted in **Figure 5**. Maximum predicted concentrations from all 5,034 receptors are presented in **Table 5** for each pollutant and averaging time.

Table 5. Maximum Predicted Concentrations at Onshore Receptors

Pollutant	Averaging Time	Max. Conc.[1]	50% NAAQS Criteria	50% MAI Criteria	Background Conc.[2]	Design Conc.	NAAQS
NO_2	1-hour	7.0	96	NA	53	60	88
	Annual	0.007	50	2.5	2	2	00
PM_{10}	24-hour	1.4	75	5	57	58	50
$PM_{2.5}$	24-hour	1.4	17.5	.5	18	19	5
	Annual	0.005	6		2	2	2
CO	1-hour	8.0	20,000	NA	1,145	1,153	0,000
	8-hour	4.3	5,000	NA	1,145	1,149	0,000
SO_2	1-hour	0.8	98	NA	16	17	96
	3-hour	0.6	650	56	13	14	,300
	24-hour	0.2	182.5	5	5	5	65
	Annual	0.0006	40	0	2	2	0

[1] Averaged over a 20 square kilometer area
[2] See Table 3.1.3-1.

All model-predicted concentrations are well below criteria BOEM applies to evaluate significant impacts.

6.3 Onshore Facilities

As noted in

Table 4 , onshore facilities related to the exploration drilling program are potential sources of emissions. Shell proposes to support the offshore drilling program with an onshore support facility located in the Barrow area. The exact details of the facility are uncertain at this time, but some elements are known. From an air emissions and modeling perspective, the facilities include:

- A support personnel camp, housing as many as 200 persons,
- A hanger and warehouse at the Barrow airport, and
- Helicopter operations at the Barrow airport for transport of personnel and some equipment to the Discoverer.

Air Sciences, Inc. developed an estimated inventory of air quality emissions for the proposed onshore operations assuming maximum levels of activity and equipment. Details of these calculations can be found in Attachment B to Appendix O of EP Revision 2.

Table 4 shows a summary of the calculated emissions for the onshore emissions units.

The emission rates were used as inputs in a separate air quality modeling study conducted solely for the onshore facilities. The air quality modeling for the onshore facilities was separate from the modeling of the Discoverer emissions for two reasons:

- The distance between the Discoverer and the onshore facilities is over 135 statute miles, so no significant overlap in the impact areas of the two operations is expected.
- The areas of potential impact for the onshore facilities are very close to those facilities, on the order of a mile or less, while the point of land nearest the Discoverer is more than 60 statute miles away.

As a result of these two factors the air quality modeling for the onshore facilities was performed separately, using a different air quality model, different meteorological data and different receptors.

The onshore facilities were modeled with the EPA's AERMOD model. AERMOD is recommended by EPA and other regulatory agencies as the appropriate model where the distance between the emission sources and the receptor is less than 50 kilometers. Since the proposed onshore facilities are located near the Barrow Airport, meteorological data from the Barrow Airport were the most appropriate for use in the modeling analysis. A five year data set covering the period from 2008 through 2012 was obtained for the Barrow Airport and processed through the AERMET meteorological pre-processor in preparation for running AERMOD. The Barrow Airport collects both surface data and upper air data, and both data sets were used. **Figure 6** is a wind rose depicting the Barrow airport data.

Receptors were placed along the fence line of the proposed personnel camp pad where workers may be housed near the Barrow Airport. The receptor spacing for these fence line receptors was 10 meters. In addition a grid of receptors covering an area three kilometers by three kilometers was established in two nests, with the outer nest having a grid spacing of 50 meters, and an inner nest covering an area two kilometers by two kilometers having a spacing of 25 meters. **Figure 7** depicts the location of the receptors used in the onshore facility modeling analysis.

Emission sources were modeled using a combination of point and area sources. The emissions from the camp area were modeled as three point sources reflecting the three generators that would be present at full build-out for the camp. A separate point source was used for the hanger/storage building, which could have a boiler for space heat. Finally, an area source was used for the helicopter emissions. The EDMS model was used to calculate the emissions from the helicopter. EDMS also has the ability to implement the AERMOD model, entering runway and taxiway emissions as a series of area sources at different heights. Given the low level of emissions and simplicity of the Barrow Airport setting, AERMOD was applied directly with the emissions entered in a single area source, 500 meters long and 40 meters wide located at the center of the runway.

The maximum predicted concentrations are compared with the NAAQS in **Table 6** . All model-predicted concentrations plus background values are well below ambient air quality standards.

Table 6. Maximum Predicted Concentrations Attributable to Onshore Facilities

Pollutant	Averaging Time	Onshore Facility Peak Concentration (µg/m^3)	Background Air Concentration (µg/m^3)	Total Concentration (µg/m^3)	NAAQS	Exceeds NAAQS?
NO_2	1-hour	60.92	53	114	188	No
	Annual	2.25	2	4	100	No
SO_2	1-hour	5.50	16	22	196	No
	3-hour	9.25	13	22	1300	No
	24-hour	5.76	5	11	365	No
	Annual	0.20	2	2	80	No
PM_{10}	24-hour	3.33	57	60	150	No
$PM_{2.5}$	24-hour	3.33	18	21	35	No
	Annual	0.12	2	2	12	No
CO	1-hour	478.69	1,145	1,624	40,000	No
	8-hour	143.27	1,145	1,288	10,000	No

Although as noted above, no significant overlap with the Discoverer impacts is expected due to the large separation distance, a brief examination of potential cumulative concentrations was conducted. Concentrations at receptors in Barrow computed by the CALPUFF model for the Discoverer and associated fleet emission sources were examined to determine the potential for overlapping impacts. These would generally not be additive with the onshore facility impacts for the short-term averaging times (1-hour, 3-hour, 8-hour and 24-hour), because the meteorological conditions that produce peak concentrations from the off-shore sources are not likely to be the same as the conditions that produced peak impacts from off-shore sources.

For all pollutants and averaging times, the increase in concentrations in Barrow attributable to emissions from the Discoverer and associated fleet was less than 2.0 µg/m^3. For most of the pollutants (all SO_2 averaging times, and all particulate concentrations as well as annual NO_2 concentrations) the peak Discoverer concentration was less than 1 µg/m^3. Only 1-hour NO_2 and 1-hour and 8-hour CO concentrations were above 1 µg/m^3 but all were below 2 µg/m^3. Accordingly, even if the impacts from the Discoverer were assumed to directly augment the concentrations from the onshore facility, the total concentrations would still be well below the NAAQS.

7 References

US Environmental Protection Agency (EPA)

2004. *AERMOD User's Guide*. EPA-454/B-03-001. September 2004

CALPUFF User's Guide

8 Figures

Note that figures are formatted for printing on the "front" side of double-sided pages, and the "back" sides of these pages are unnumbered, but nonetheless included in the page count.

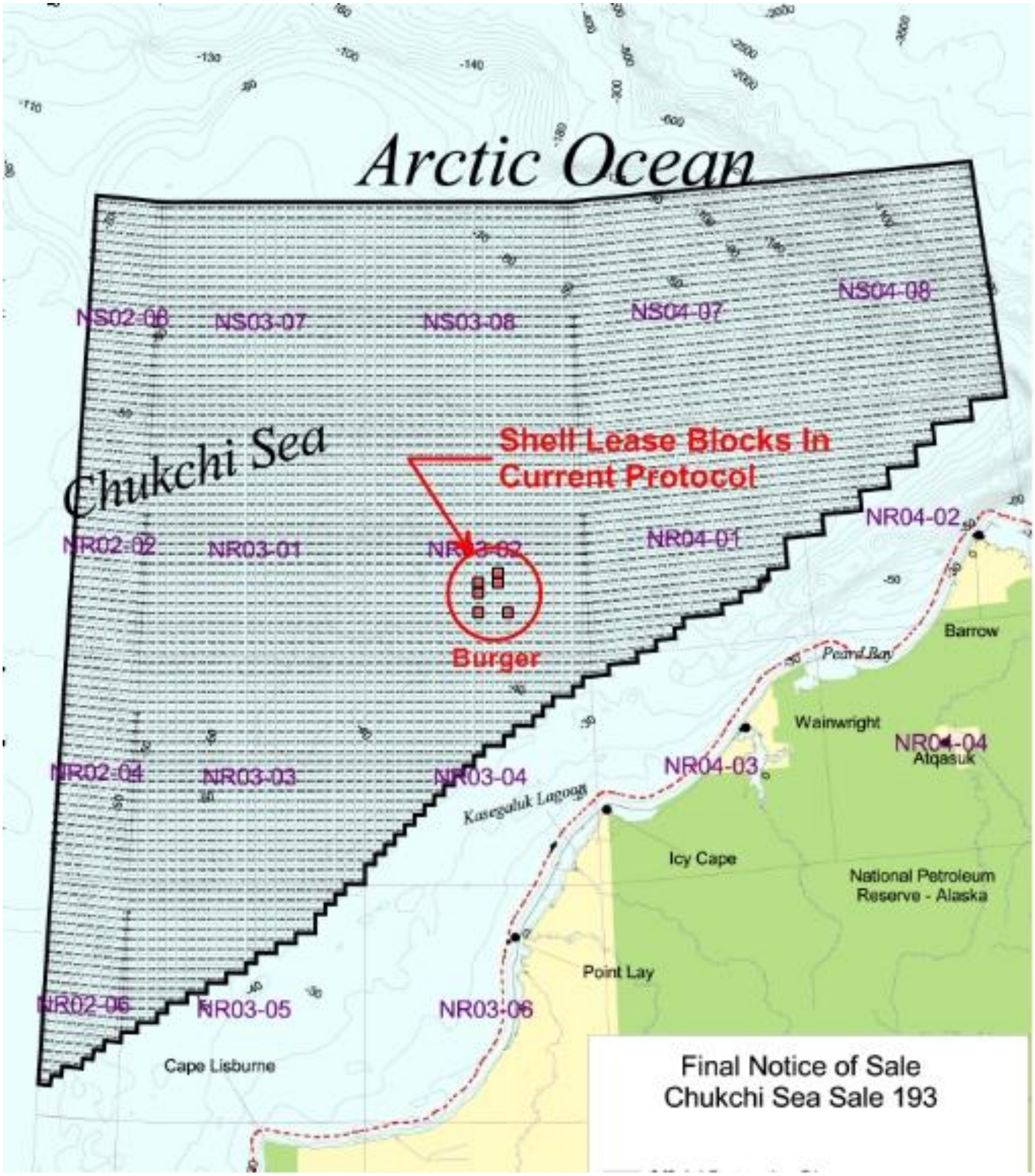

Figure 1. Project Vicinity Map

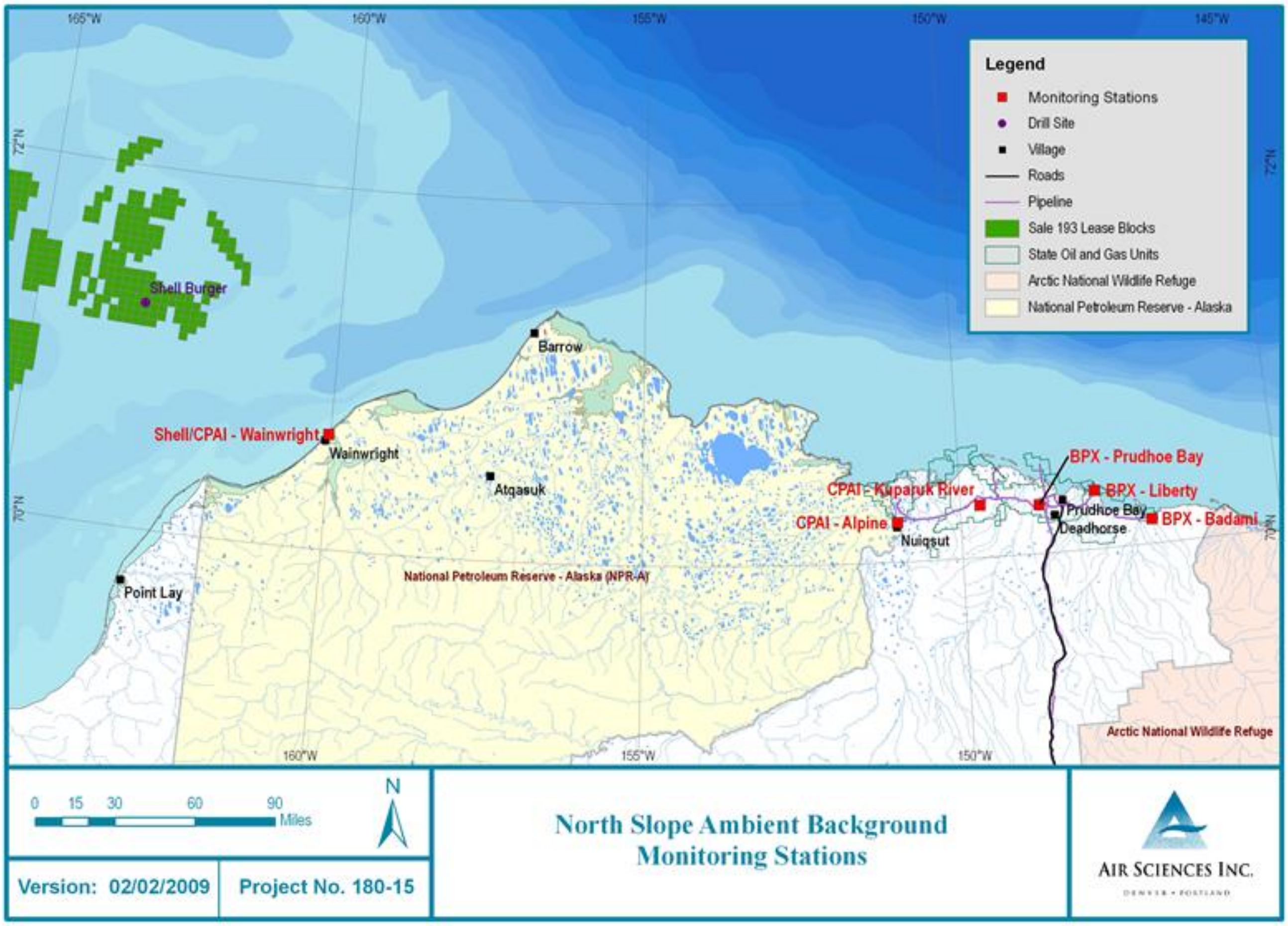

Figure 2. Regional Air Quality Monitoring Site Locations

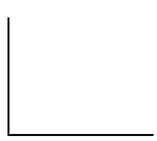

Figure 3. Wind Rose for Shell Burger Lease Area

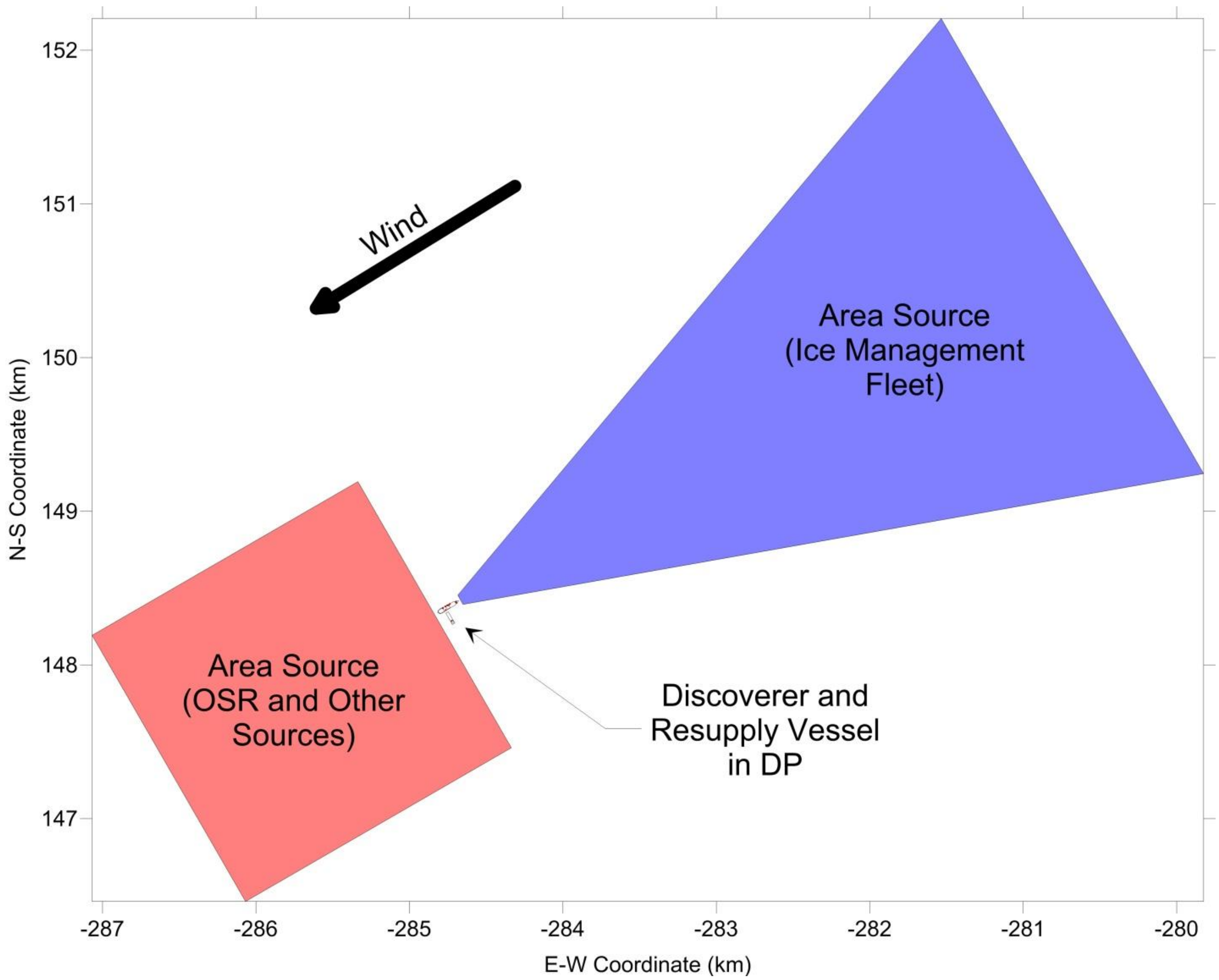

Figure 4. Orientation of Model Emissions Sources

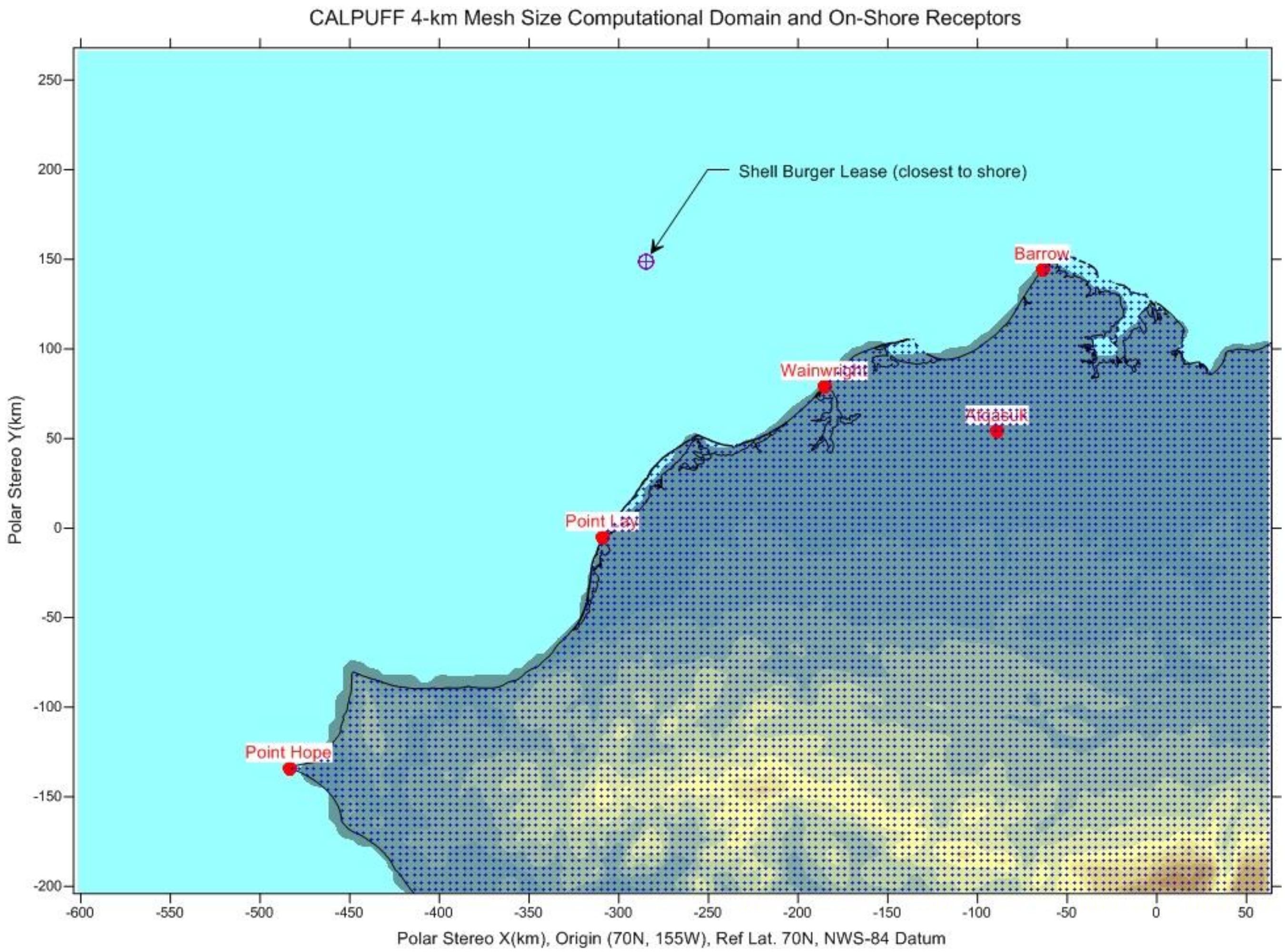

Figure 5. Onshore Receptors Used in the CALPUFF Modeling

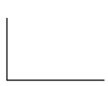

Figure 6. Wind Rose for Barrow, Alaska 2008 – 2012

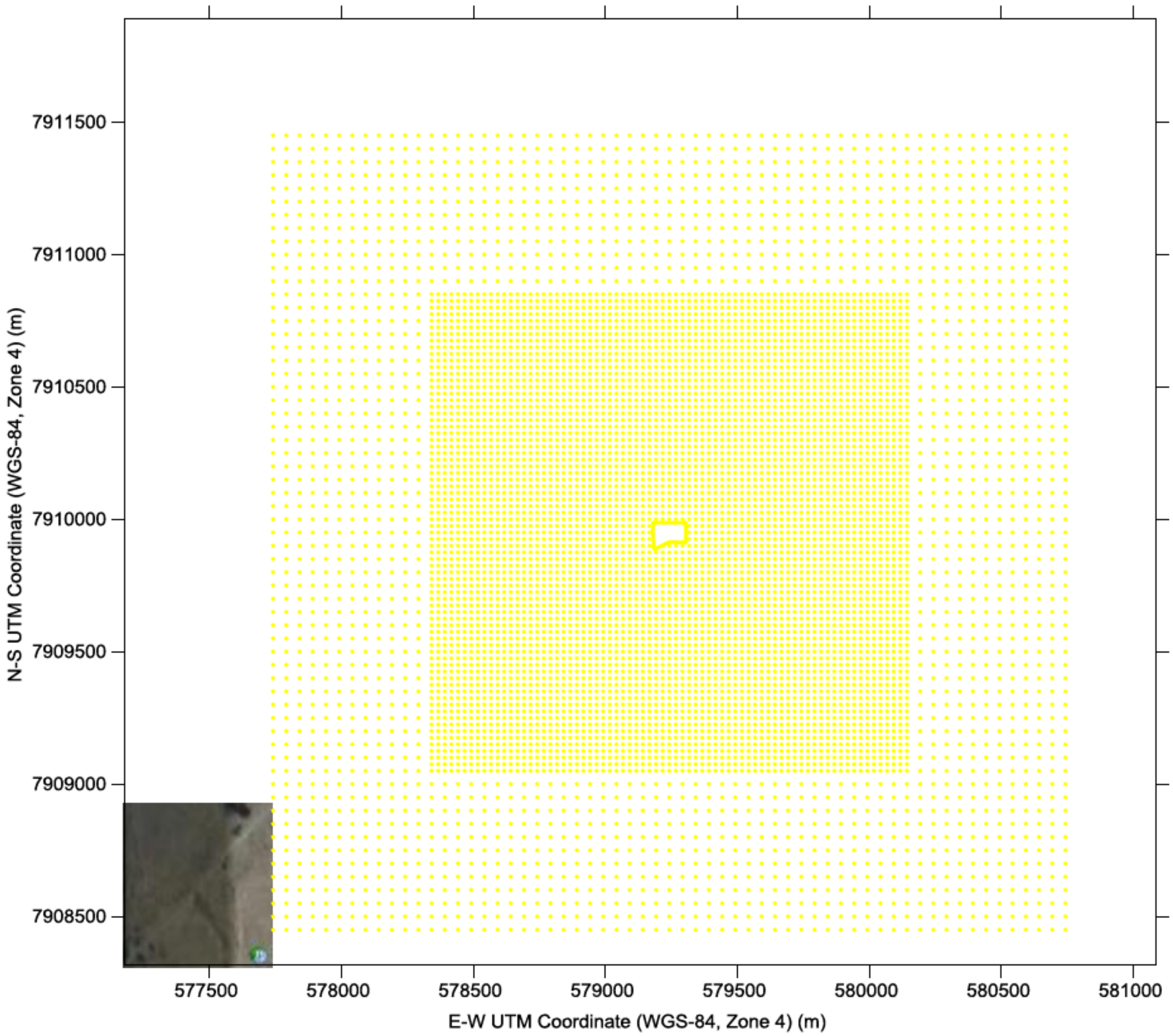

Figure 7. Receptors Used In Onshore Facility Modeling Analysis

Attachment C

Air Quality Technical Report – Subsistence Area

Shell OCS Exploration Drilling Program Chukchi Sea

Air Quality Technical Report Offshore Subsistence Area

Prepared for:
Bureau of Ocean Energy Management
Anchorage, Alaska

On behalf of:
Shell Gulf of Mexico, Inc.
Anchorage, Alaska

Prepared by:
ENVIRON International Corporation
Lynnwood, WA

Date:
October 2013

Project Number:
03-31900

ENVIRON

Contents

List of Tables

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Acronyms, Abbreviations, and Definitions

Note that in this section and throughout the rest of this report there are active hyperlinks that will jump to the referenced material or section. General hyperlinks are formatted like this. Hyperlinks for tables and figures are highlighted like **this**.

AERMOD	Air quality dispersion modeling system used in this analysis. The AERMOD modeling system consists of two pre-processors and a dispersion model. The meteorological preprocessor (AERMET) provides meteorological information, and a terrain pre-processor (AERMAP) characterizes terrain, and generates receptor grids for the dispersion model (AERMOD).
Air quality standard	Health-based standard representing a pollutant concentration in the ambient air usually over some averaging period like 1-hour, intended to protect the health and welfare of people with a margin of safety.
Ambient air	the air in outdoor locations to which the public has access, e.g., outside the property boundary of the emissions source
Area source	an emission source type defined in AERMOD. Area source emissions are released from a two-dimensional rectangular area and typically used to represent fugitive emission sources.
Areapoly source	an emission source type defined in AERMOD. Areapoly sources are similar to area sources in that emissions are released from two-dimensional areas, but such sources are not restricted to rectangular areas and can have more than four sides.
Attainment/Nonattainment	a determination and classification made by EPA indicating whether ambient air quality in an area complies with (i.e., attains) or fails to meet (i.e., nonattainment) the requirements of one or more **NAAQS**
Averaging time	a specific length of time (e.g., 1 hour, 24-hours, 1 year) over which measured or model-calculated concentrations of an air pollutant are averaged for comparison with the **NAAQS** based on the same averaging period. Note that some NAAQSs are also based on multi-year averages of certain percentiles of measured or calculated concentrations.
BACT	Best Available Control Technology
cf	cubic foot, a measure of volume
cfm	cubic feet per minute, a measure of air flow
Criteria air pollutant	an air pollutant specifically governed by the Federal Clean Air Act for which ambient air quality standards have been set. Criteria air pollutants include carbon monoxide, particulate matter, sulfur dioxide, nitrogen dioxide, ozone, and lead.
Dispersion model	A computerized calculation tool used to estimate pollutant concentrations in the ambient air based on numeric simulations that consider the locations and rates of pollutant emissions and the effects of meteorological conditions, usually over specific averaging times (e.g., 8-hours)
EPA	US Environmental Protection Agency
Fugitive dust	Potential air pollutant in the form of dust (or other pollutant) emitted from a non-point or non-mobile source such as dust from a road or from a coal pile caused by wind

gr..grains, a measure of mass
gr/cf ....grains/cubic foot
hp...horsepower
Knot.......................................a unit of speed equal to one nautical mile per hour, or approximately 1.151 mph
Long ton ....also called imperial ton and equal to 2,240 pounds (1,016 kg)
Meteorological data set..........a compilation of meteorological data representing conditions over some period of time and including such things as wind speed and wind direction, and formatted as required by the dispersion model being used. This analysis used a meteorological data set covering 5 years.
Metric ton ....1,000 kilograms (kg) = 2,204.6 pounds = tonne (see also short ton)
Micrometer/Micron ....one millionth of a meter; typically used to distinguish particle size; typical human hair is 100 about microns in diameter
Modeling domain ....the area included in the **dispersion-modeling** analysis. Modeling receptors are distributed within this domain, usually over a standard grid pattern with receptors every 100 to 500 meters.
Modeling receptor ....a theoretical (i.e., often non-specific) location used in computer modeling at which air pollutant concentrations are calculated. Modeling may also use site-specific receptors representing individual locations.
NAAQS ....National Ambient Air Quality Standard
Nautical mile (nm)..................The nautical mile is a unit of length that is about one minute of arc of latitude measured along any meridian, or about one minute of arc of longitude at the equator. By international agreement it is exactly 1,852 meters (approximately 6,076 feet).
NSPS ....New Source Performance Standard; rules that pertain to air pollution emission sources subject to air quality permits and newly manufactured equipment
NO_2.......................................nitrogen dioxide, a **criteria** air pollutant
Nonattainment area.................An area delineated by regulatory agencies including US EPA in which ambient air quality standards have been violated and where there is a program in place designed to reduce air pollution so that the standard attained.
NOx ....oxide of nitrogen, a general class of air pollutant without a specific air quality standard but used in monitoring air quality
Particulate matter (PM) ....air pollutant comprised of solid or liquid particles; PM is usually characterized based on the particle size. See also PM10 and PM2.5.
PM10 ....“Coarse” inhalable particulate matter with an aerodynamic size less than or equal to 10 micrometers (**microns**)
PM2.5 ....“Fine” inhalable particulate matter with an aerodynamic size less than or equal to 2.5 micrometers (**microns**)
Point source ....an emission source type defined in AERMOD. Point source emissions are released from a single location.
ppm..parts per million (a metric used in quantifying concentrations of air pollutants)
Receptor.................................See modeling receptor.

Release height........................ an AERMOD term defining the height above ground at which source emissions are released

Short ton .... 2,000 pounds (see also **metric ton** and long ton)

SO_2.. Sulfur dioxide, a **criteria air pollutant**

Soiling .... A non-health-related effect of air pollution such as staining or deposition of a fine film typically on exterior surfaces

tonne .... **metric ton**

tpy.. tons per year, an estimate of annual emissions

$\mu g/m^3$ .... micrograms per cubic meter (a metric used in quantifying concentrations of air pollutants)

Volume source....................... an emission source type defined in AERMOD. Volume sources emit diffuse air pollutants from a three-dimensional area. Line sources, such as emissions from transiting trains, can be simulated using multiple, adjacent volume sources.

Preface

Shell Gulf of Mexico, Inc. has requested authorization from the United States Department of the Interior, Bureau of Ocean Energy Management (BOEM), to drill exploration wells in the Chukchi Sea beyond the 3-mile state seaward boundary of Alaska. Exploration drilling will continue to consist of the operation of a drillship and an associated fleet on the Outer Continental Shelf (OCS) of the Chukchi Sea. Shell has an approved Exploration Plan for drilling in the Chukchi Sea at the Burger Prospect (EP for Revision 1). This report was developed for Shell's EP Revision 2, and the supporting EIA for EP Revision 2, for exploration drilling operations for Shell's next season of operations. One of the modifications Shell proposes in its EP Revision 2 is authorization for its exploration drilling program air emissions from the BOEM. See also Attachment A to the EIA for EP Revision 2. An Air Quality Technical Report has been prepared and presents the results of an analysis conducted by Shell to identify emissions to the atmosphere and evaluate associated impacts from the drillship, its associated fleet, and onshore sources.[1] The purpose of that document was to assess air quality impacts at on-shore locations where ambient air quality standards are applicable.

BOEM implements its authority to protect air quality under 30 CFR Part 550 Subpart C. See also Attachment A to the EIA for EP Revision 2. This program is referred to as the BOEM Air Quality Regulatory Program (AQRP). BOEM also has the responsibility to assess potential impacts of the exploration drilling program pursuant to the National Environmental Policy Act (NEPA). BOEM Alaska indicates that air quality modeling is required to evaluate potential impacts under NEPA[2] and the referenced ENVIRON report details the methods, data and results of the NEPA air quality analysis for onshore impacts.

This report is in response to an additional request made by BOEM to evaluate potential air quality impacts of the continued drilling program in certain offshore areas that are used by native communities for subsistence activities. The basic assumptions, methods and analyses used in this report are identical to those in the referenced ENVIRON report, with the following exceptions:

- The locations of predicted concentrations are offshore in a specific area defined as the Subsistence Area.
- The criteria used for evaluation of these impacts are based on occupational criteria rather than ambient air quality standards that are designed to protect sensitive populations such as the elderly, sick or very young.

Much of the detail in this report is identical to the onshore assessment but has been repeated here for the convenience of the reader.

[1] "Shell OCS Exploration Drilling Program – Chukchi Sea, Air Quality Technical Report, Onshore Impacts" ENVIRON International Corporation, September 2013.

[2] Meeting between BOEM and Shell, May 15, 2013, held in BOEM office, Anchorage, Alaska

1 Summary

The air quality analysis of the Shell OCS Exploration Drilling Program for the Chukchi Sea described in this report considers air pollutant emissions and subsistence area concentrations that may result from the exploration drilling program.

The air quality assessment of EP Revision 2 includes development of detailed emission inventories based on spatially and temporally distributed emissions from the following emissions units:

- The drillship itself, including
    - Main generators
    - Propulsion Engine
    - Small internal-combustion engines
    - Seldom-used engines
    - Heaters and boilers
    - An on-board incinerator
- Ice-management vessels, (includes anchor handlers) including
    - Propulsion and generator engines
    - Boilers
    - Incinerators
- Oil-spill response vessels
- Resupply vessels
- A fuel tanker
- A science vessel

There are also onshore activities in Barrow that have not been included in this subsistence area analysis and are evaluated under the “Shell OCS Exploration Drilling Program – Chukchi Sea, Air Quality Technical Report, Onshore Impacts” that is included under Attachment C of Appendix F of this revised EP.

Emissions from these units and activities were evaluated with air quality dispersion modeling. The air quality analysis considered emissions and concentrations of "criteria" air pollutants, including oxides of nitrogen, oxides of sulfur, particulate matter and carbon monoxide.

The air quality analysis indicates emissions from the exploration drilling program, including all offshore activities, would not result in any subsistence area air pollutant concentrations that endanger the health or welfare of subsistence area users.

2 Purpose of the Drilling/Exploration Program

Shell continues to propose the use of a single drillship, the M/V Noble Discoverer (Discoverer), to continue an exploration drilling program that was begun in 2012, at any of six well locations on six leases (one well per lease) offshore in the Chukchi Sea, Alaska. The drill sites are more than 65 nautical miles (nm) offshore in Arctic waters that are inaccessible for eight months or more of the year due to pack ice. Shell's proposed exploration operations will take place on federal OCS leases in the Chukchi Sea, an area of approximately 230,000 square miles (mi^2) (595,000 square kilometers [km^2]). The drill sites are remote from any infrastructure or human habitation. Shell's seasonal exploration drilling operations would begin on or about July 1st and extend no later than October 31st.

Shell's EP Revision 2 proposes to conduct exploration drilling activities on any of six lease blocks all within what is known as the Burger Prospect, acquired in federal OCS Lease Sale 193. The sites are identified "Burger" A, F, J, R, S and V in **Table 1**. Water depth at each location is approximately 150 feet (45.8 meters) or less.

Table 1. Candidate 2014 Drilling Sites

Prospect	Well	Area	Lease Number	Lease Block	Latitude	Longitude	UTM Coordinates[3] X(m)	Y(m)
Burger	A[1]	Posey	OCS-Y-2280	6764	N71° 18' 30.92"	W163° 12' 43.17"	564800	7912800
Burger	F	Posey	OCS-Y-2267	6714	N71° 20' 13.96"	W163° 12' 21.75"	564800	7917600
Burger	J	Posey	OCS-Y-2321	6912	N71° 10' 24.03"	W163° 28' 18.52"	555200	7898400
Burger	R	Posey	OCS-Y-2294	6812	N71° 16' 06.57"	W163° 30' 39.44"	555200	7908000
Burger	S	Posey	OCS-Y-2278	6762	N71° 19' 25.79"	W163° 28' 40.84"	555200	7912800
Burger	V	Posey	OCS-Y-2324	6915	N71° 10' 33.39"	W163° 04' 21.23"	569600	7898400

Note:[1] Burger A drill site where a partial well was begun in 2012.

[3] Universal Transverse Mercator (UTM) coordinates here are from BOEM's OCS Official Protraction Diagram and are based on the North American Datum 1983 (NAD-83). The coordinates quoted are the approximate center of each lease block.

3 Project Description

3.1 Drilling Program Activities and Emissions Units

The drilling will be conducted by the Discoverer with support from oil-spill response vessels, anchor handlers, ice management vessels, offshore supply vessels (OSVs) and aerial transport. The drillship has been identified, but support vessels are contracted on a yearly basis and multiple vessels could meet the duty requirements for the needed tasks. In this air quality analysis, the size and emission characteristics needed for the tasks have been defined. In the case of the Discoverer, the actual vessel to be used, the types of emission units on board are defined. For the other vessels, a candidate vessel is identified, but because that vessel may not be available or the final vessel chosen before the start of the next exploration drilling season, the types of emission units anticipated are identified, but not the actual units.

The Discoverer is a turret-moored drillship that underwent significant upgrades in 2007 and 2013 so that it could operate in the Arctic. The Discoverer crew will work 12-hour shifts and live on the rig in accommodations located at the stern of the ship. They are expected to be transported to and from the rig by helicopter to shore based locations.

The Discoverer has its own propulsion engine for self-transport. The drilling involves raising and lowering a rotating bit. At intervals the well is cased and cemented, and at intervals the well bore geological information is logged. Mud-line cellars (MLC) are excavated for suppression of well-head equipment into the sea floor to avoid damage by ice keels should ice floes force the rig off the well, and this excavation involves a large (up to 30-foot diameter) bit to drill the initial up to 50 feet below the mud line. Rotation of this bit can involve hydraulic assistance from on-board hydraulic pumps. A hole is drilled for the next interval and a tube (casing) is installed and cemented. Cementing the casing anchors it in the hole and prevents annular formation fluid migration between formations or to the surface. Atop the casing is a guide base with receptacles for guidelines that facilitate reentry into the well.

The Discoverer is equipped with two diesel-powered cranes that will see occasional use. There are also diesel-fueled boilers for keeping both personnel and equipment warm during the drilling. An incinerator is available for disposal of domestic and other non-hazardous waste. The Discoverer also has several smaller engines for emergency purposes.

The close support auxiliary fleet will include anchor handlers for management of the Discoverer anchors, bow washing of any ice buildup on the Discoverer bow and some ice floe fragmenting in support of the ice management vessel. One anchor handler and one ice management vessel provide primary close support for the Discoverer with regard to these tasks, whereas the second anchor handler or ice management vessel is anticipated to provide occasional support to the Discoverer for the performance of these tasks. The second anchor handler and ice management vessel very likely will have other tasks to conduct outside of the geographic extent of the Chukchi Sea, and often not in support of the exploration drilling program. Up to two ice management vessels may be tasked to fragment any manageable ice flows so that the ice will flow around the Discoverer. The ice management vessels are needed when there are ice features that require disruption in their path or fragmentation in order to provide protection for the drilling vessel, or other assets critical to the safety of the exploration drilling program (i.e., mooring buoys, etc.). One or more ice management vessels may normally works several miles upwind of the drillship and may monitor the leading edge of any ice floe of possible concern, far upwind. An oil-spill response vessel or vessels will be anchored nearby but out of the way downwind of the Discoverer.

Other associated vessels include those for resupply and material transfer to shore. The OSVs would travel to the Discoverer, then park in dynamic positioning (DP) mode beside the Discoverer for material or personnel transfer. These vessels are expected to come at most once per week and could remain there for about one day or more. Another OSV, also used as a science vessel could remain permanently within a few miles of the Discoverer for unspecified but routine materials on and off-loading. A fuel tanker is expected to be permanently located near the Discoverer to resupply the Discoverer and associated fleet.

3.2 Spatial and Temporal Relationships of Emission Units

For air impact analysis purposes, there are two emission unit groups considered in this analysis: the Discoverer and the close vessel support. Emissions units that are physically close together can have additive impacts, whereas, if the same emissions units are spread over a large area, the impacts will be smaller at any one location (and spread over a larger area).

The emission units on the Discoverer are close together and impacts nearby will be concentrated. The associated fleet will be spread over a five mile radius of the Discoverer, so emissions will be spread over this large area and will not be concentrated. At large distances of 50 miles or more all of these emissions will be well dispersed.

Close support includes oil-spill response (OSR) vessels, anchor handlers and ice management vessels. The OSR vessels will normally be two to five nm downwind of the Discoverer. The anchor handler will operate in a similar radius but will work upwind when there is an ice floe moving toward the drillship. The primary ice management vessels are assigned the ice management task, but could also assist in anchoring. When they are managing ice, they will be two to ten miles upwind of the Discoverer. Typically, there is one ice management vessel, but for short periods of time there could be a second ice management vessel. When these vessels are not working they could be anchored in warm-stack mode, transitioning or working in support of activities inside or outside of the OCS program area.

The close support group includes OSVs, a resupply barge and tug, science vessels, a fuel tanker, and helicopter support. These vessels are only occasionally near the Discoverer, and normally many miles away, including in port. The OSVs normally do not tie up to the Discoverer to transfer materials and personnel, but does so in DP mode.

Emissions units may not operate concurrently. Only emissions units that operate concurrently can have additive short-term (one hour and 24-hour) impacts. Those that do not operate concurrently will not have additive short-term concentrations, although all will contribute to concentrations averaged over the season. Drilling and use of the Discoverer's smaller internal combustion (IC) engines will take place only after the drillship is fully anchored and connected to its 8 anchors. The propulsion engine may be used on a limited basis once the Discoverer is anchored. The cementing and logging equipment will only be used when setting casing or logging a well when the Discoverer is anchored at a drill site. None of the smaller diesels are operated during ship transit to and from the drill site. None of the smaller IC engines are used more than occasionally.

The actual drilling could occur during the interval between July 1st and October 31st.

3.3 Pollutants to Evaluate

The regulated pollutants to be evaluated include particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), lead (Pb), and ozone (O_3). Note that O_3 includes evaluation of pre-cursors, volatile organic compounds (VOC) and oxides of nitrogen (NOx). Included in the analysis will be the evaluation of the formation of secondary aerosols, a component of $PM_{2.5}$.

4 Affected Environment

4.1 Regulatory Overview

4.1.1 BOEM Regulatory Authority

As a part of its EP Revision 2, Shell has submitted an Environmental Impact Assessment (EIA). The EIA for EP Revision 2 provides a specific analysis of air quality impacts in areas known to be used by native communities for subsistence activities, known as the Subsistence Area. This air quality technical report is a supplement to Shell's EP Revision 2 and supporting EIA, and provides BOEM with additional information necessary to analyze and evaluate the potential air quality impacts of the exploration drilling program in the Subsistence Area.

4.1.2 Evaluation Criteria

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than prescribed criteria. As discussed in Attachment A of the EIA for EP Revision 2, ambient air quality standards are not appropriate criteria for offshore locations because the area is not readily accessible to the public and those who are able to reach the area are more apt to be healthy individuals capable of hunting, fishing, or working on commercial vessels. See Attachment A of the EIA for EP Revision 2. The criteria applied in the current evaluation are based on occupational exposure criteria and are displayed in **Table 2**. The BOEM AQRP has been designed to ensure that proposed new offshore sources of emissions will not cause or significantly contribute to any concentrations in excess of the ambient standards in onshore locations. The criteria in **Table 2** have been selected to protect subsistence area users in offshore locations.

Neither ADEC nor EPA maintain air quality monitoring stations on the North Slope of Alaska in the vicinity of the nearest onshore areas to the proposed exploration leases addressed here. In general, air quality monitoring stations are located where there may be air quality problems, and so are usually in or near urban areas or close to specific large air pollution sources. Based on monitoring information for criteria air pollutants collected over a period of years, ADEC and EPA designate regions as being "attainment" or "nonattainment" areas for particular pollutants. Attainment status is therefore a measure of whether air quality in an area complies with the federal health-based ambient air quality standards for criteria pollutants. Based largely on the sparse population of the area, and less on actual measurements, the north slope of Alaska is classified as "attainment" or "unclassified" for all regulated air pollutants. In practical terms, "unclassified" areas are treated exactly the same as "attainment" areas.

Table 2. Evaluation Criteria for Offshore Subsistence Area Users

Pollutant	Averaging Time	Offshore Subsistence Area Criteria (μg/m^3)
Nitrogen Dioxide (NO_2)	1-hour	3,760
Particulate Matter (PM_{10} and $PM_{2.5}$)	1-hour	500
Carbon Monoxide (CO)	1-hour	55,000
Sulfur Dioxide (SO_2)	1-hour	5,200

4.2 Existing Air Quality Conditions

There are no existing sources of air pollution near the Chukchi Sea lease area because it is more than 60 miles from land and there are no other oil exploration or development sources in the Chukchi Sea at this time. In the absence of sources, the air quality in the project area is generally expected to be good. The points of land nearest the proposed drill sites are in the remote parts of the Arctic coast of Alaska, and are mostly uninhabited except for occasional subsistence hunting and fishing. The nearest native villages are at Wainwright and Point Lay, approximately 66 and 86 nautical miles away, respectively.

Because the drill site location will be far from the Alaska shoreline and away from significant sources of pollution, existing air quality concentrations can be represented with a regional value. According to the EPA's *Guideline on Air Quality Models* (40 CFR 51, Appendix W, Section 8.2.2c), a "regional site" may be used to determine background concentrations if there are no monitors located in the vicinity of the source. A "regional site" is one that is located away from the area of interest, but is impacted by similar natural and distant man-made sources. The majority of the air quality data on the North Slope have been collected by various industrial developments associated with the oil and gas resources of the area.

Shell and ConocoPhillips began monitoring NO_2, $PM_{2.5}$, PM_{10}, SO_2, CO, and O_3 concentrations at Wainwright, Alaska in November 2008. The Wainwright monitoring station is remotely located (minimal influence of industry and other human activities) and is the most representative "regional site" on the North Slope for estimating offshore monitoring concentrations in the Chukchi Sea. However, its on-shore location would be expected to result in higher concentrations of pollutants (especially particulate matter) than actual occur offshore. A map of the ambient monitoring stations on the North Slope is provided in **Figure 2**.

Table 3 shows a summary of the concentrations measured at the Wainwright monitoring station. Comparison of **Table 3** with the Evaluation Criteria in **Table 2** indicates that existing concentrations are all well below the criteria for all pollutants and all averaging times.

Table 3. Existing Ambient Air Concentrations

Pollutant	Averaging Period	Concentration (μg/m^3)	Data Source
NO_2	1-hour	53	Wainwright
	Annual	2	Wainwright
$PM_{2.5}$	24-hour	18	Wainwright
	Annual	2	Wainwright
PM_{10}	24-hour	57	Wainwright
SO_2	1-hour	16	Wainwright
	3-hour	13	Wainwright
	24-hour	5	Wainwright
	Annual	2	Wainwright
CO	1-hour	1,145	Wainwright
	8-hour	1,145	Wainwright

4.3 Meteorological Conditions and Climate

Climate in the project study area is unique to the polar region. The climate is dominated by severe cold temperatures during winter and a brief period of warming in late summer and early fall.

From an air pollution perspective, the most important meteorological parameters are wind speed and direction because they determine the transport and dispersion of airborne contaminants. Wind conditions are commonly represented by a figure known as a wind rose. **Figure 3** is a wind rose constructed from the meteorological data used in the current analysis. The figure has a series of bars emanating from the center of the drawing. The bars represent the relative frequency of wind directions with the length of each bar representing the relative frequency of the wind direction. In this case it shows the most frequent wind directions at the Burger Lease are coming from the east-northeast.

The colors in the figure illustrate the relative frequencies of wind speeds at the project site. The color code in the figure can be used to interpret the wind speeds.

5 Analytical Methods

The air quality impact analysis includes two basic steps: (1) emission inventory development to estimate emissions related to operation of the EP, and (2) dispersion modeling to estimate resulting air contaminant concentrations in the ambient air. The following sections discuss the methods employed and the critical assumptions involved in each portion of the analysis.

5.1 Emission Inventory Methods

The exploration drilling program would result in emissions from propulsion engines used on the vessels as well as diesel-generators used to power the electric equipment. In addition, there are several smaller specialized engines used for specific purposes in the drilling program as well as several smaller engines used primarily for emergency purposes that are exercised on a regular basis for safety and reliability testing. Finally, there are waste combustion incinerators aboard some of the vessels for destruction of non-hazardous waste. All emission sources considered in the current analysis are combustion sources. The calculations supporting the emission inventory are detailed in Attachment B to Appendix O of the EP.

5.1.1 Emission Factor Tools and Sources

Emission factors are values that allow an emission rate to be determined from some other operations parameter. For example, an engine may have an emission factor that states the quantity of NO_X that is produced from the combustion of one gallon of diesel fuel. Thus, by knowing or estimating the quantity of fuel an engine will consume per hour or per season, the quantity of NO_X emissions can be easily calculated.

To the degree possible, emission factors used in the current analysis were based on actual emissions testing of Shell vessels.

Where source test results were not available, other information was used. If the unit was a marine engine with an established Tier level under 40 CFR 94.8, Table A-1, the specified Tier emission level was used. In a few cases, it was necessary to use emission factors from EPA's handbook on emission factors, known as AP-42.

SO_2 emissions from diesel fuel combustion were established using a mass–balance with an assumed sulfur level in the fuel of 100 parts per million by weight. Although Shell has committed to purchasing only diesel fuel with sulfur content of 15 ppm or less, this assumption accounts for the possible mixing of residual fuel in the tanks with ULSD that is purchased. This allowed development of an EP-specific emission factor for all diesel fuel sources.

Emission rates for project emissions units are summarized in

Table 4. Summary of Estimate Emission Rates

Emission Unit	NOx		PM		CO		VOC		Pb	
	lb/h	t/y	lb/h	t/y	lb/h	t/y	lb/h	t/y	lb/h	t/y
Discoverer										
Generation	36	41	1	1	8	10	2	2	1E-3	2E-3
Propulsion	82	2	2	0.05	57	1	15	0.4	1E-3	3E-5
Small IC engines	12	18	0.4	0.6	11	16	3	4	3E-4	4E-4
Seldom-Used IC engines	8	0.1	0 2	2E-3	4	0.1	1.0	0.01	1E-4	9E-7
Boilers	3	2	0.03	0.02	0.3	0.2	0.04	0.03	1E-4	1E-4
Incinerator	0.4	0.6	1	1	1	2.1	14	20	0.03	0.04
Ice-Management and Anchor Handler Vessels										
Propulsion & Generation										
Boilers	88	36	14	6	9	3	55	22	2E-2	7E-3
Incinerator	3	1	0 1	0.05	0.04	0.02	0.06	0.03	2E-4	9E-5
	1	1	3.6	4	4.4	4	29	29	6E-2	6E-2
Oil Spill Response Vessels										
All IC engines	233	107	6	3	162	74	42	19	4E-3	2E-3
Resupply Vessels										
All IC engines	146	131	4	4	102	91	26	24	3E-3	2E-3
Fuel Tanker										
All IC engines	104	46	3	1	72	32	19	8	2E-3	8E-4
Science Vessel										
All IC engines	66	67	2	2	46	46	12	12	1E-3	1E-3

5.1.2 Model Configuration of Emission Units

All of the emission units associated with the exploration drilling program are to some extent mobile. The most stationary of the units are those on the Discoverer. During the drilling of any individual well, the Discoverer remains fixed over the well. However, the ship itself rotates about the drilling stem, placing the bow of the ship in the direction of the oncoming wind, which is usually also the direction any moving ice would come from. The drillship does not rotate as a result of the wind acting on it, but rather is moved by a cranking system aboard the Discoverer. As the vessel is rotated, the locations of many or all the emission units on the drillship are moved.

Although the Discoverer emission units are mobile, for purposes of the modeling study, the units are assumed to be point sources at a fixed location. Given that the nearest subsistence area receptors are over 70 kilometers from the Discoverer, the actual rotation of the ship is insignificant in the modeled concentrations. Hence the drillship is assumed to be pointing in the direction of the prevailing wind for the entire drill season. The prevailing wind direction was assumed to be coming from 60 degrees measured clockwise from north.

In addition to the Discoverer itself, where the emissions units are assumed to be fixed point sources, the other units are much more mobile. The ice management fleet typically operates many miles upwind of the Discoverer to ensure the Discoverer is protected from any moving ice. But on occasion the ice management fleet may come in closer to the Discoverer for some close support activities. Similarly, the oil spill response vessels typically operate a few miles downwind of the Discoverer. These emission units tend to be moving during periods when exercises or training may be underway.

Finally, other support vessels, such as the fuel tanker, science vessel and the resupply vessel while in transit can be located anywhere in the vicinity of the Discover and will move from time to time to take advantage of the ice-free path that is maintained by the ice management vessels. It should be noted that an OSV may position itself next to the Discoverer while unloading supplies. Emissions from the OSV while in dynamic position mode have also been modeled as a point source.

Given the highly mobile nature of these support vessels it is inappropriate to model them as fixed point sources, but rather as area sources where emissions are distributed out over an area. For the ice management vessels, the area source is modeled as a large triangular area approximately 5 kilometers long and located upwind of the drillship. For the other units, a square area source, 2 kilometers on a side is assumed to represent the remaining emission units.

Figure 4 is a schematic drawing that shows the location of these point and area sources.

5.2 Dispersion Modeling

ENVIRON used air quality dispersion modeling simulations to estimate ambient concentrations due to emission sources associated with the exploration program. This section discusses the methods used to develop these simulations to assess potential future pollutant concentrations in the area surrounding the facility.

Air quality models are computer programs designed to mathematically represent atmospheric transport and dispersion of airborne contaminants. The purpose of the proposed air quality modeling in this protocol is to provide estimates of ambient concentrations of regulated contaminants emitted by the various engines, heaters and other emission units that are part of the Shell exploratory drilling program. There are a variety of air quality models that could be used for this purpose and conversations with BOEM[4] have indicated that they intend to follow EPA Guidance as reflected in the EPA's *Guideline on Air Quality Models* (the Guideline).

5.2.1 Dispersion Model Selection

The two air quality models most commonly recommended in the Guideline for industrial sources of emissions are the AERMOD model and the CALPUFF model. The AERMOD model is recommended by EPA for computation of concentrations within 50 kilometers of a source, while the CALPUFF model is recommended for locations farther than 50 kilometers from a source.

BOEM requires a demonstration that emissions from the exploration program will not exceed certain levels on shore. For that analysis, BOEM agreed in meetings with Shell that the CALPUFF modeling system is appropriate. For this special analysis of offshore impacts in the subsistence area, the same logic is used. Because the nearest subsistence area is located more than 70 kilometers from the closest candidate drilling location, the CALPUFF model is the appropriate model to use.

ENVIRON applied CALPUFF to predict pollutant concentrations from emissions associated with Shell's exploration drilling in the Chukchi Sea. The CALPUFF predictions were used to display potential regional pollutant concentrations, and to assess compliance with the subsistence area criteria. The remainder of this section describes the long-range transport dispersion modeling techniques.

5.2.2 Methods

ENVIRON applied the regulatory version of the CALPUFF modeling system to simulate emissions from proposed drilling operations in the Chukchi Sea. CALPUFF (Version 5.8) is the EPA recommended dispersion model for long-range transport analyses and source-to-receptor distances beyond 50 km.[5] For the application of CALPUFF, Shell followed the techniques recommended by the Federal Land Managers for Class I area assessments with a few modifications for Arctic conditions and available datasets. The simulations were performed based on meteorological conditions from July to November 2007, 2008, and 2009. The methods used to prepare the meteorological fields and perform the dispersion model analysis are described below.

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[4] Meeting between Shell and BOEM held on May 15, 2013 at BOEM's offices in Anchorage Alaska.

[5] 40 CFR Part 51 Appendix W: Guideline on Air Quality Models

5.2.3 Domain

The CALPUFF modeling domain is shown in **Figure 5** where the Burger site, several villages of interest, and the subsistence area and the receptors used to characterize it are depicted. The areas of offshore subsistence use in the Chukchi Sea are identified under Figure 3.11.7-11 of the EIA appended to the approved Outer Continental Shelf Lease EP for the Chukchi Sea. The analysis assumes the Discoverer is located at the corner of the potential Burger lease blocks closest to the Subsistence Area. The CALPUFF domain is a rectangular 167-by-118 grid with a horizontal mesh size of 4 km and 10 vertical layers ranging geometrically from the surface to 4,000 m. A Polar Stereographic (PS) projection was used for the coordinate system with an origin at (70 N, 155 W) and standard latitude of 70 N. Receptors were placed throughout the subsistence area at a spacing of 4-km, as shown on **Figure 5**, in keeping with BOEM suggestions at Shell's meeting with BOEM on May 15, 2013.

5.2.4 MMIF/WRF

ENVIRON used the Mesoscale Model Interface Format tool (MMIF)[6] and the Weather Research Forecast (WRF) model to construct the meteorological fields for input to CALPUFF. MMIF passes through and reformats the WRF output for CALPUFF. MMIF (Version 2.3) was applied to process the WRF model simulations for the Chukchi Sea provided to ENVIRON by the EPA. These WRF simulations for July to November of 2007 to 2009 supported previous ConocoPhillips permitting activities in the Chukchi Sea.[7] The WRF simulations have three domains with grid mesh sizes of 36/12/4-km and 37 vertical levels. The boundary layer, nudging and other options selected for the WRF simulations are based on comparisons to meteorological data in the Arctic and the results of ongoing studies sponsored by BOEM. ,[8]

ENVIRON used the following MMIF options to process and reformat the WRF meteorological fields for CALPUFF:

- Use only the 4-km WRF inner domain
- Select the *GOLDER* option for calculation of the Pasquill-Gifford stability class
- Use layer mapping of the 37 vertical WRF levels to 10 layers with tops of 20, 40, 160, 320, 640, 1200, 2000, 3000, and 4000m
- No recalculation of the mixing height, the WRF diagnostic output will be used directly
- Trim five cells along from the outer edge of the WRF 4-km mesh size domain to account for potential edge effects in the WRF simulations

ENVIRON used MMIF to prepare daily input files for CALPUFF to account for changing sea-ice coverage in the Arctic Ocean. The corresponding changes to the hourly energy fluxes and other important variables predicted by WRF governing dispersion and transport are already incorporated directly into the MMIF data provided to CALPUFF. However several algorithms (e.g. deposition

[6] Brashers, B., and C. Emery, 2013. *Draft User's Manual: The Mesoscale Model Interface Program (MMIF), Version 2.3, 2013-4-30.* Prepared by Environ International Corp. for U.S. EPA, OAQPS, Air Quality Assessment Division, Air Quality Modeling Group, Mail Code C439-01, Research Triangle Park, NC, 27771, Accessed at http://www.epa.gov/ttn/scram/dispersion_related htm#mmif.

[7] McNally, D. and Wilkinson, J.G., 2011. *Model Application and Evaluation – ConocoPhillips Chukchi Sea WRF Modeling* Application, Prepared by Alpine Geophysics, 7341 Poppy Way, Arvada, CO, 8007, November 21, 2011.

[8] Zhang, J., Liu, F., Krieger, J., Tao, W, and X. Zhang, 1981. *Project Report for the 5-year Experimental Mesoscale Meteorology Reanalysis for the Beaufort/Chukchi Seas for Beaufort and Chukchi Mesoscale Meteorology Model Study.* Prepared for US DOI, Bureau of Ocean Energy managements, Alaska Outer Continental Shelf Region, Anchorage Alaska, Contract 0106CT39787, November 2011.

velocity calculations) in CALPUFF still need to distinguish between over water and over land characteristics based on land use that is only read in at the start of each meteorological input file. Daily input files allowed CALPUFF to consider daily changes to land use for these algorithms.

5.2.5 CALPUFF

ENVIRON performed three CALPUFF simulations for the Chukchi Sea using short-term emissions for each July to November period of 2007 to 2009. Short-term emissions were used in the analysis to address the one-hour maximum concentrations for each pollutant in accordance with the criteria developed in **Table 2.** The respective short-term emission rates for emission units included in the simulations are discussed in the emission inventory presentation in Attachment B of Appendix O to the revised EP. Short-term emissions were conservatively assumed to occur for every hour of the July to November drilling season for each of the three years in the simulations.

The release characteristics of point sources on the Discoverer and area sources (Ice Management, Re-Supply vessels and Oil Spill Recovery (OSR) Fleets) have been discussed in the emission inventory section above. ENVIRON assumed the Discoverer was pointed into the prevailing wind direction for the entire period. The prevailing wind direction from buoy measurements at the Burger site during July to November 2009 was 60 degrees from North. The Ice Management Fleet activity is assumed to occur within a wedge from the center of the Discoverer out to 5 km upwind. The OSR Fleet is assumed to be downwind with emissions distributed into a 2 km-by-2 km square area source.

5.2.6 Secondary Aerosols

CALPUFF incorporates algorithms to consider secondary aerosols formed from emitted NO_X and SO_2 Total PM_{10} and $PM_{2.5}$ were calculated from the sum of the emitted primary species, ammonium nitrate, and ammonium sulfate. The primary PM_{10} emissions for each source were divided into six species, including: soot or elemental carbon (EC), fine soil particles (PMF), coarse particles (PMC), organic carbon (OC), sulfate (SO_4), and nitrate (NO_3). PMC fractions were calculated from the difference between PM_{10} and $PM_{2.5}$ emission rates. $PM_{2.5}$ emissions were divided into the remaining five species using the source profiles for diesel engines and incinerators based on profiles recommended by the EPA for the Community Multi-Scale Air Quality (CMAQ) model.[9]

Reaction rates and aerosol formation in the CALPUFF chemistry algorithms are influenced by background ozone and ammonia concentrations. ENVIRON used hourly ozone observations from the NOAA Barrow Observatory and BP's Pad A monitoring site. The maximum hourly observation from these two locations was used to represent background ozone concentrations in the simulations. The background ammonia concentration was assumed to be 0.5 ppb for all hours. This same ammonia background concentration was assumed for the Alaska Regional Haze Best Available Retrofit Technology (BART) modeling simulations.[10]

The CALPUFF utilities POSTUTIL and CALPOST were used to manipulate the large CALPUFF output files and summarize the results for comparison with the criteria. ENVIRON applied POSTUTIL to sum the individual PM_{10} species together after accounting for the differences in molecular weight between the species in the CALPUFF output files and the actual component species of PM_{10} and $PM_{2.5}$.

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[9] CMAQ is the preferred regulatory model for $PM_{2.5}$ and regional haze simulations. The EPA website containing PM speciation by source categories is: http://www.epa.gov/ttn/chief/emch/speciation/.

[10] The Alaska BART and Regional Haze programs are described at http://www.dec.state.ak.us/air/anpms/rh/rhhome htm. In the original BART simulations a background of 0.1 ppb was assumed. In the more refined simulations performed by applicants seeking exemption from BART, a more conservative 0.5 ppb ammonia concentrations was assumed.

CALPOST (Version 6.221) was used to calculate the maximum 1-hour concentrations for each pollutant. The results used in this analysis are the maximum 1-hour values for each pollutant, without any statistical analysis to determine the 98th or 99th percentile that is commonly used in analyses for on-shore criteria.

ENVIRON conservatively assumed all NO_X predicted at downwind receptor is NO_2 for comparisons to the criteria. A second tier approach assuming a conversion factor of 0.8 is also appropriate and could be applied in any future analyses. It should be noted, although not performed here, a Tier 3 approach can be used to limit the potential formation of NO_2 by the amount of ozone available. The Ozone Limiting Method (OLM) could be applied by post-processing the CALPUFF output files and assuming a constant NO_2/NO_X in-stack ratio, an equilibrium ratio of 0.8. The amount of NO_2 formed will be limited using the same hourly ozone input file used in the CALPUFF simulations.

5.2.7 Building Downwash

Given that the nearest receptors in the subsistence area are located more than 70 km from the source, building downwash effects did not significantly affect the modeled results. However, previous modeling analyses for the Shell exploration program have developed building downwash parameters. The modeling did use the previous downwash values developed for the Shell exploration program in the CALPUFF modeling analysis.

6 Potential Impacts of the Exploration Drilling Program

6.1 Air Quality Impacts of the Operation Phase

The operation phase is defined as the phase of the project when the main drillship is anchored at the drill site. A total of 1,800 receptors were selected to represent the subsistence area as depicted in **Figure 5**. Maximum predicted concentrations from all 1,800 receptors are presented in **Table 5** for each pollutant and averaging period.

Table 5. Maximum Predicted Concentrations at Subsistence Area Receptors

Pollutant	Averaging Time	Peak CALPUFF Model Predicted Off-Shore Subsistence Area Concentration (□g/m^3)	Background Concentration (µg/m^3)[1]	Total Concentration (Model + Background) (µg/m^3)	Offshore Subsistence Area Criteria (µg/m^3)
Nitrogen Dioxide (NO_2)	1-hour	12.4	53	65	3,760
Particulate Matter (PM_{10})	1-hour	5.90	143	149	500
Particulate Matter ($PM_{2.5}$)	1-hour	5.90	143	149	500
Carbon Monoxide (CO)	1-hour	10.8	1,145	1,156	55,000
Sulfur Dioxide (SO_2)	1-hour	1.26	16	17	5,200

[1] Background concentrations are documented in Table 3.1.3-1 of the Air Quality Technical Report for On-Shore Areas.

All model-predicted concentrations are well below appropriate criteria for offshore locations.

7 References

US Environmental Protection Agency (EPA)

2004. *AERMOD User's Guide*. EPA-454/B-03-001. September 2004

CALPUFF User's Guide

8 Figures

Note: Figures are formatted for printing on the "front" side of double-sided pages, and the "back" sides of these pages are unnumbered, but nonetheless included in the page count.

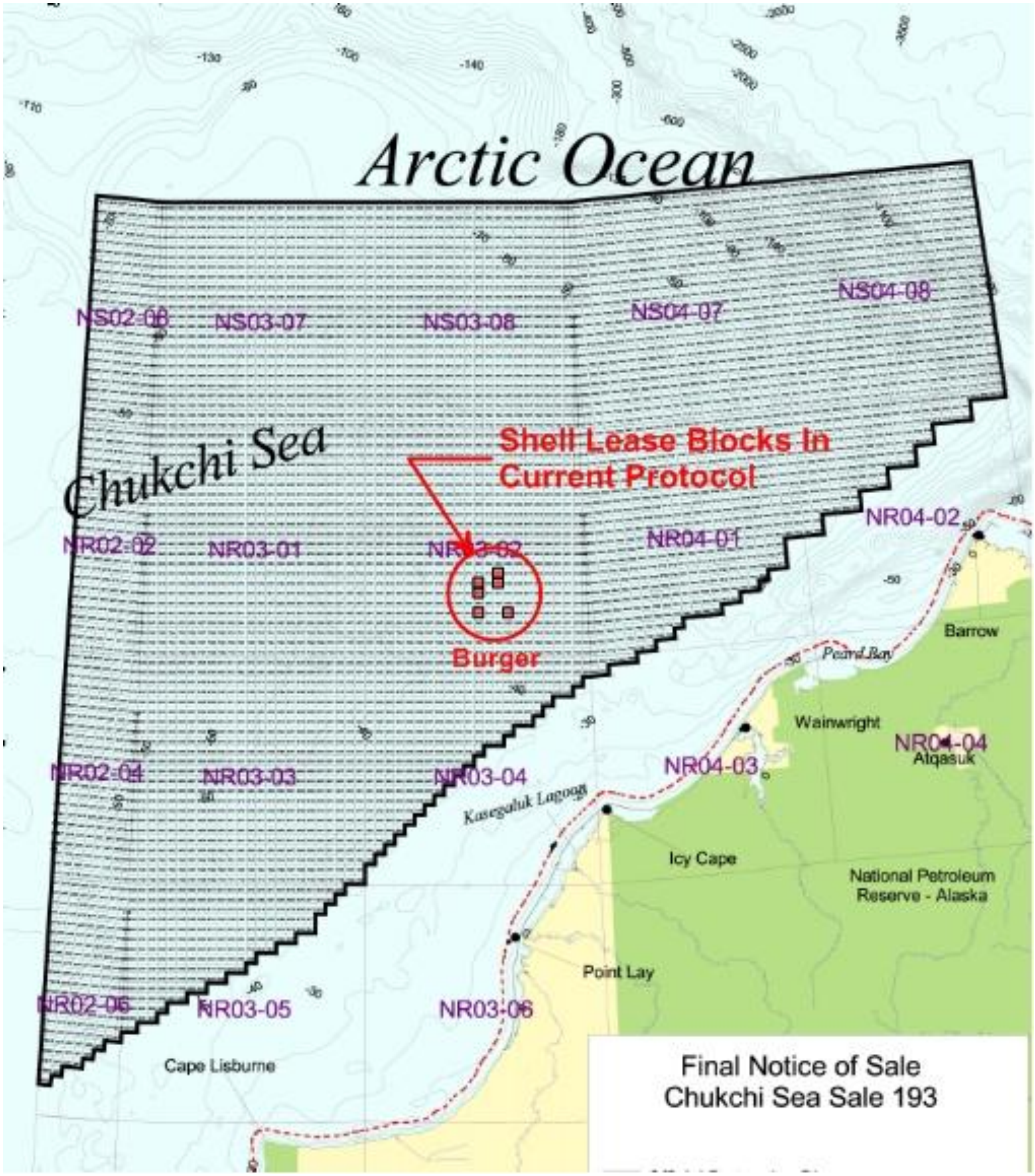

Figure 1. Project Vicinity Map

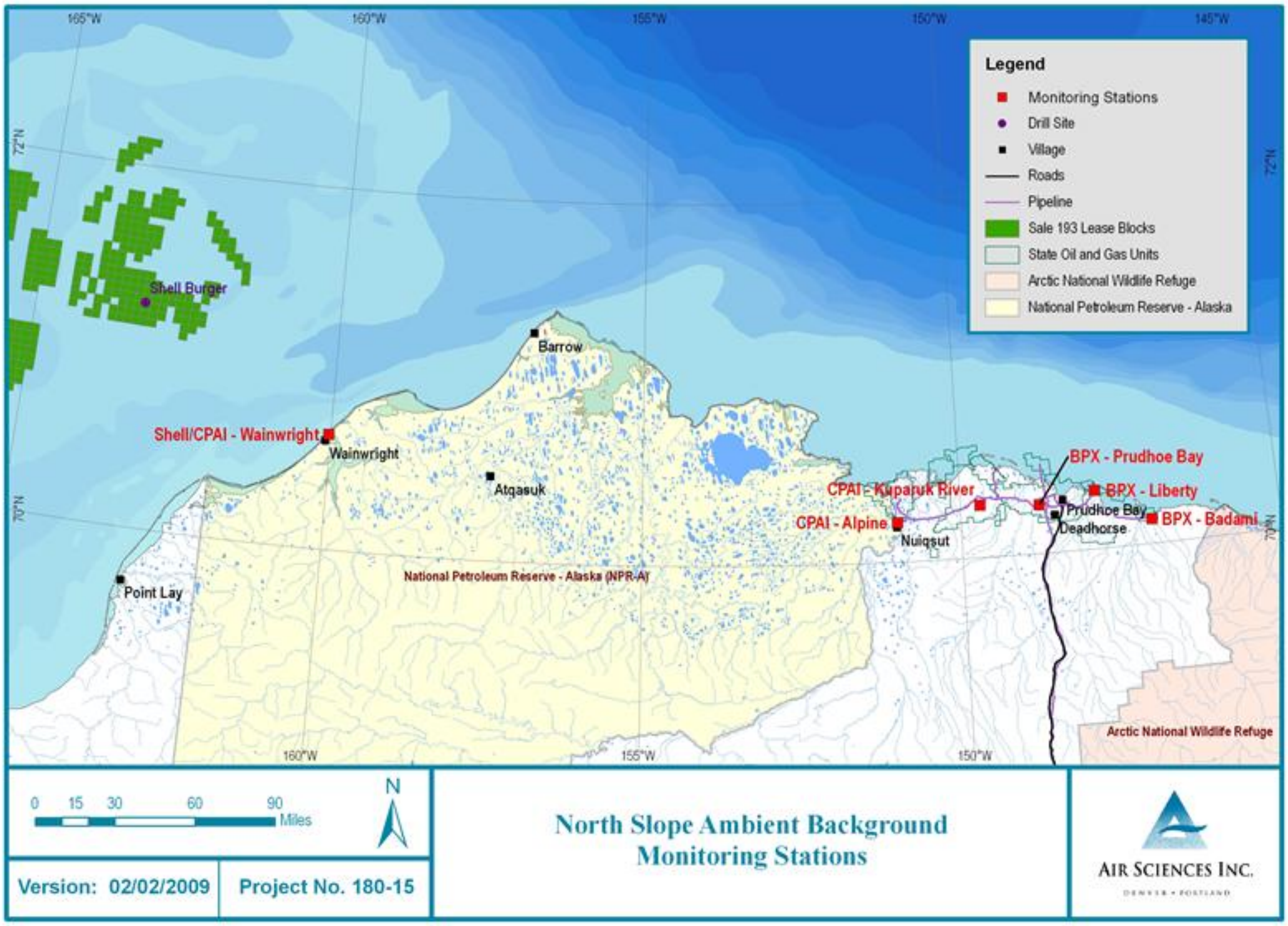

Figure 2. Regional Air Quality Monitoring Site Locations

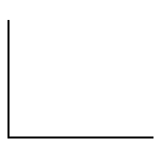

Figure 3. Wind Rose for Shell Burger Lease Area

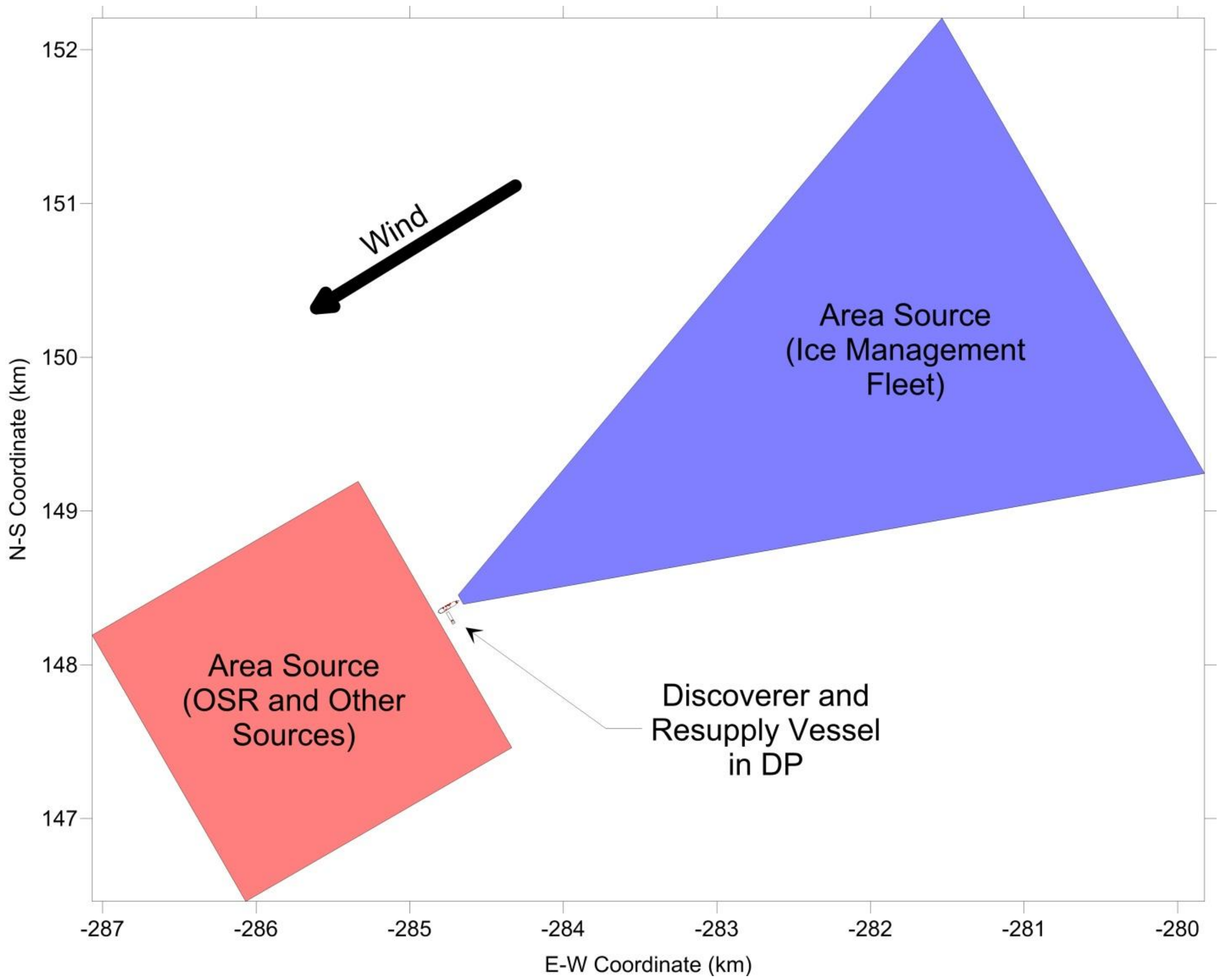

Figure 4. Orientation of Model Emissions Sources

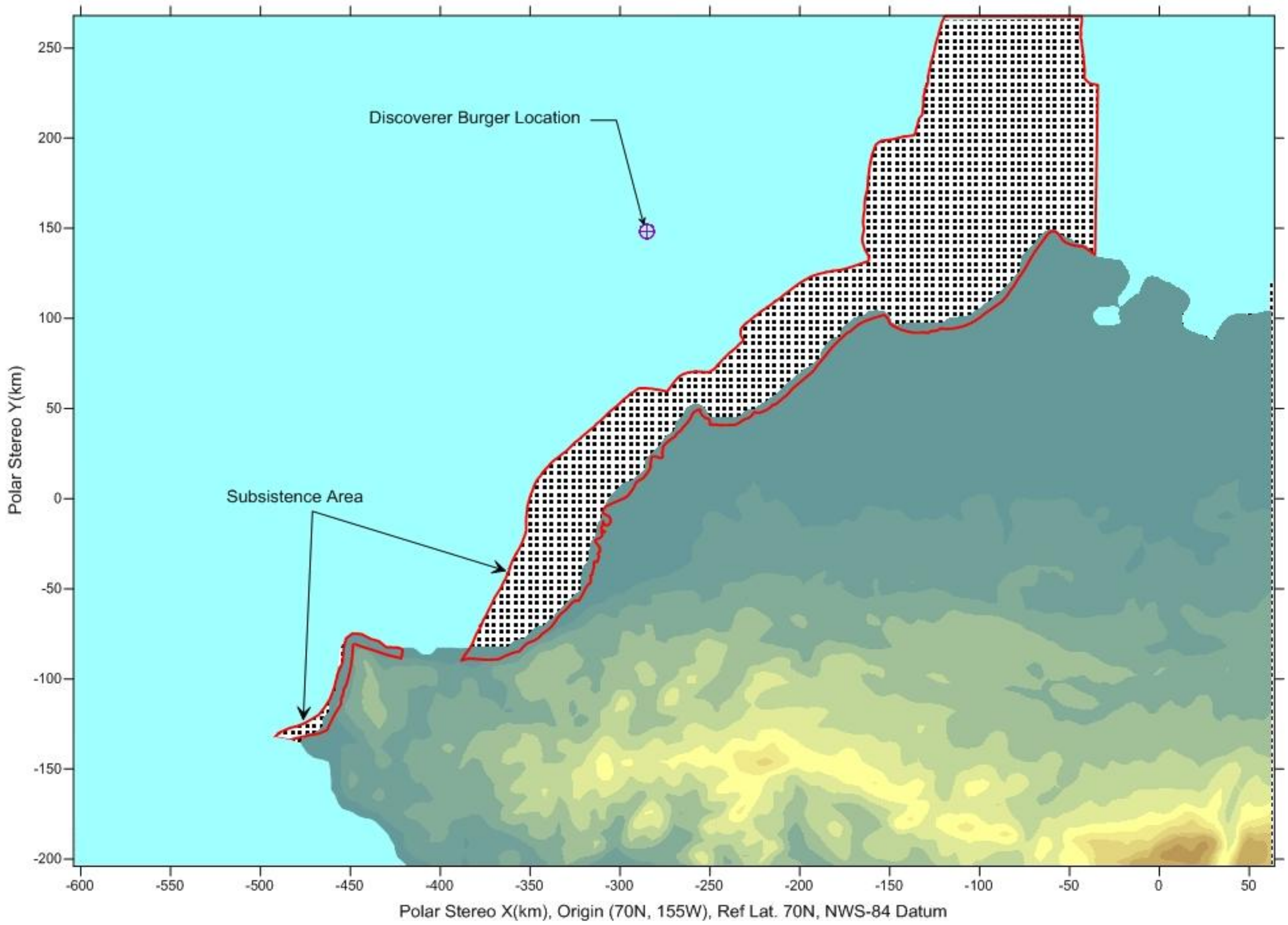

Figure 5. Subsistence Area Receptors Used in the CALPUFF Modeling

Appendix I

Bird Strike Avoidance and Lighting Plan Chukchi Sea, Alaska

Bird Strike Avoidance and Lighting Plan

Chukchi Sea, Alaska

October 2011
Revised November 2013

Shell Gulf of Mexico Inc.

3601 C Street, Suite 1000
Anchorage, AK 99503

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Attachments

ACRONYMS

BOEM	Bureau of Ocean Energy Management
Discoverer	Motor Vessel *Noble Discoverer*
EP Revision 1	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska, approved by BOEM December 15, 2011
EP Revision 2	Revised Outer Continental Shelf Lease Exploration Plan, Chukchi Sea, Alaska November, 2013
ESA	Endangered Species Act
ft	feet/foot
hr(s)	hour(s)
km	kilometer(s)
LBCHU	Ledyard Bay Critical Habitat Unit
m	meter(s)
MBTA	Migratory Bird Treaty Act
MHz	Megahertz
mi	statute mile(s)
PSO	Protected Species Observer
MMS	U.S. Department of the Interior, Minerals Management Service
M/V	Motor Vessel
OCS	Outer Continental Shelf
Plan	Bird Strike Avoidance and Lighting Plan
Shell	Shell Gulf of Mexico Inc.
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service

1.0 INTRODUCTION

1.1 Background

This document comprises Shell Gulf of Mexico Inc.'s (Shell) Bird Strike Avoidance and Lighting Plan, Chukchi Sea, Alaska (Plan) and applies to Shell's exploration drilling program as detailed in EP Revision 2 (2013) (see Figure 1.1). The Plan meets all the requirements of Stipulation No. 7 under the Chukchi Sea Lease Sale 193 (MMS 2008a).

Growing scientific evidence indicates some bird species are attracted to light sources, which may increase the risk of bird strikes. Most related studies conclude that increased darkness, coupled with inclement weather, increases attraction by birds to lighted vessels and structures. Birds drawn to light often become disoriented and can then collide with these structures resulting in injury and death. The chance of a bird strike to the drillship occurring during Shell's exploration drilling program is considered low because the drill sites are more than 64 status miles (mi) (103 kilometers [km]) offshore (Figure 1.1) in an area of the Chukchi Sea with low eider densities, and because of the length of daylight during the exploration drilling season. Nevertheless, Shell will implement the Plan to minimize the chance of bird strikes occurring during exploration drilling operations.

Emphasis of the Plan is on preventing bird strikes by threatened spectacled (*Somateria fischeri*) and Steller's (*Polysticta stelleri*) eiders that may be present in the Chukchi Sea during the period of operations and may, occasionally, venture into the area near Shell's exploration drilling operations. In addition, the Plan includes reporting requirements for any bird strikes and bird observations, which will help better understand the risks of bird strikes associated with drilling vessels.

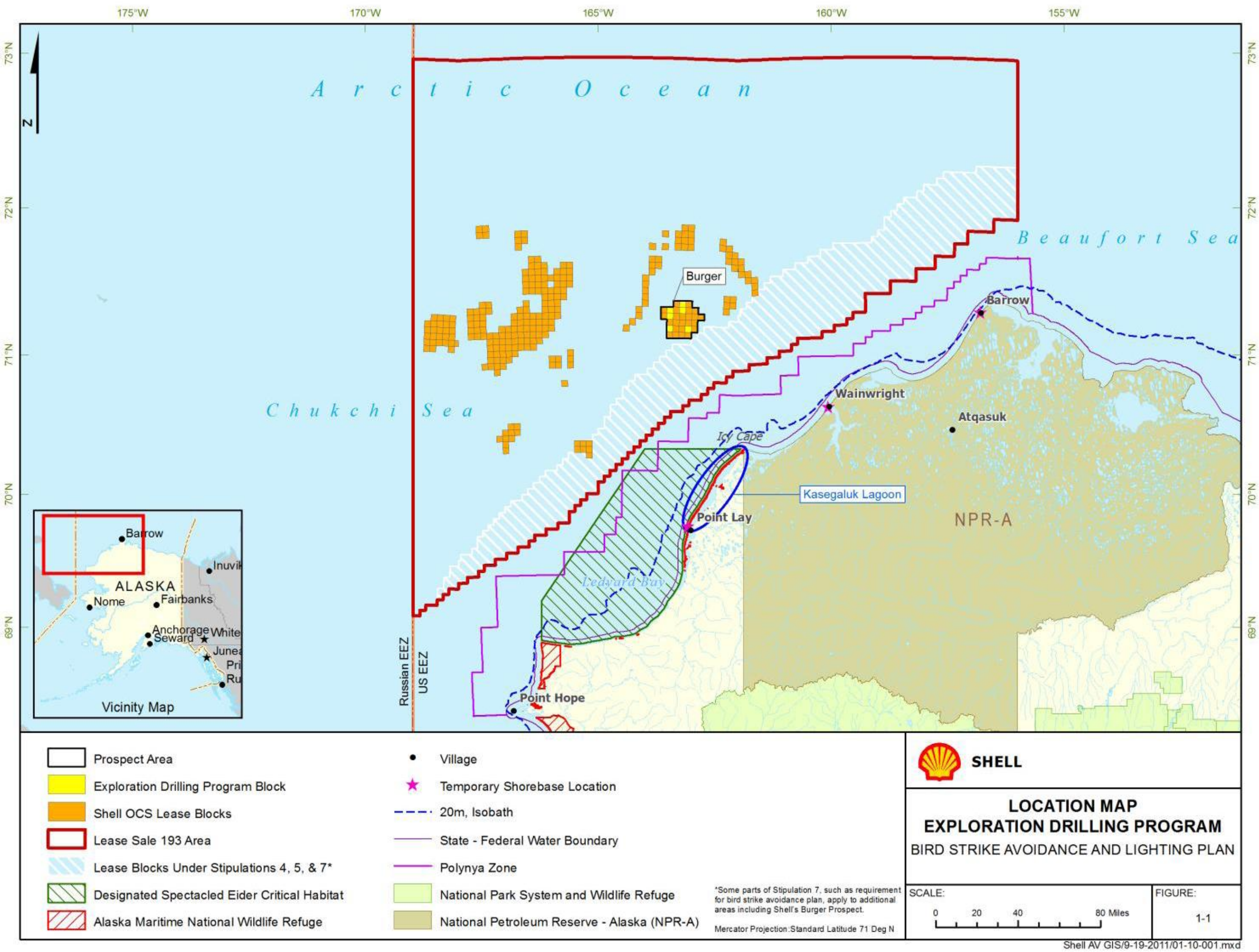
1.2 Proposed Exploration Plan

Shell plans to continue an exploration drilling program on its leases in the Chukchi Sea Planning Area of the Outer Continental Shelf (OCS). Shell's leases were acquired in Oil and Gas Lease Sale 193 (Figure 1.1). Shell plans to drill exploration wells on lease blocks within its Burger Prospect. The locations of the lease blocks are indicated in Figure 1.1. These activities started in 2012. Each drilling season spans the summer and fall (July-October) when migratory birds may be present.

The ice-strengthened drillship Motor Vessel (M/V) *Noble Discoverer* (*Discoverer*) will be used to drill the wells. The *Discoverer* will be attended by vessels that will be used for ice management, anchor handling, oil spill response (OSR), refueling, resupply, and servicing of the drilling operations.

The *Discoverer* and its attending ice management and support vessels will transit through the Bering Strait into the Chukchi Sea on or after 1 July, arriving on location in Shell's prospect on or about 4 July. Exploration drilling may commence as early as 4 July, as ice, weather, and other conditions allow for safe operations, and could continue until 31 October.

Figure 1.1 Shell Exploration Drilling Program Location Map



1.3 Endangered Species Act, Migratory Bird Treaty Act, and Lease Stipulation

The exploration activities proposed in Shell's EP Revision 2 (and presumably any future revision) are subject to the Endangered Species Act (ESA), the Migratory Bird Treaty Act (MBTA), and Bureau of Ocean Energy Management's (BOEM) Lease Stipulation No. 7, which requires offshore operators to implement certain measures to minimize the likelihood of exploration affecting spectacled and Steller's eiders. Shell has prepared the Plan in response to these statutory requirements. The Plan represents a practical approach towards using appropriate mitigation measures to reduce potential avian collisions between Shell vessels and the threatened eider species and other migratory birds in the project area.

1.3.1 Endangered Species Act

The purpose of the ESA is to conserve "the ecosystems upon which endangered and threatened species depend" and to conserve and recover listed species. Under the law, species may be listed as either "endangered" or "threatened." Endangered means a species is in danger of extinction throughout all, or a significant portion of, its range. Threatened means a species is likely to become endangered within the foreseeable future. All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened (USFWS 2006a). The law requires federal agencies, in this case BOEM, to consult with the U.S. Fish and Wildlife Service (USFWS) to ensure that the actions they authorize would not jeopardize listed species.

Section 7 of the ESA requires federal agencies to ensure that their actions do not jeopardize the continued existence of listed species. To comply with Section 7, the consulting federal agency, or its designated non-federal representative, must review the proposed project for potential impacts to protected species. The two species listed under the ESA that this Plan is intended to help protect are the Steller's eider and the spectacled eider.

1.3.1.1 Steller's Eider

The Alaska-breeding population of Steller's eider was federally designated as threatened in 1997 and is an Alaska Species of Special Concern. Historically, Steller's eiders nested throughout the coastal areas of western and northern Alaska (USFWS 2005b). Today, the Alaska-breeding population is primarily confined to the Arctic Coastal Plain in low densities and is extremely scarce in western Alaska (USFWS 2005b). The Steller's eider may have abandoned much of the eastern North Slope in recent decades, but still occur in low densities from Wainwright to as far east as Prudhoe Bay (USFWS 2003). The threatened Alaska-breeding population is thought to be in the hundreds or low thousands on the Arctic Coastal Plain and in the dozens on the Yukon-Kuskokwim Delta (USFWS 2005b). The species also occurs in Russia; although not precisely known, the Russian Atlantic population is thought to be 30,000 to 50,000 individuals, and the Russian Pacific population 50,000 to 100,000 (USFWS 2005b).

1.3.1.2 Spectacled Eider

The spectacled eider was federally designated threatened throughout its range in 1993 and is an Alaska Species of Special Concern. The breeding distribution of the spectacled eider includes the central coast of the Yukon-Kuskokwim Delta, the Arctic Coastal Plain of Alaska, and the Arctic Coastal Plain of Russia (USFWS 2005b). Spectacled eiders on the Arctic Coastal Plain of Alaska originally ranged to the Canadian border (USFWS 1996). The threatened spectacled eider population is estimated to be about 360,000 worldwide, which includes non-breeders (USFWS 2005b). The population may be in slow decline on the Arctic Coastal Plain of Alaska, where 3,000 to 4,000 nest today (USFWS 2005b). At least 40,000 pairs are thought to nest in Arctic Russia. Molting flocks of spectacled eiders gather in shallow waters off the coast in usually less than 120 feet (ft) (36 meters [m]) deep and travel along the coast up to 31 mi (50 km) offshore (USFWS 2005b).

1.3.2 Migratory Bird Treaty Act

Under the MBTA (16 United States Code [U.S.C.] 703), it is illegal for anyone to "take" migratory birds, their eggs, feathers or nests. “Take” includes by any means or in any manner, any attempt at hunting, pursuing, wounding, killing, possessing or transporting any migratory bird, nest, egg, or part thereof. The MBTA does not distinguish between intentional and unintentional take. In Alaska, some species of migratory birds may be taken, killed, or possessed during approved hunting seasons for those specified migratory species.

1.3.3 Lease Stipulations

Lease Stipulation No. 7 (full text provided in Attachment A of the Plan) for the Chukchi Sea Lease Sale 193 Area is intended to minimize the likelihood of spectacled and Steller’s eiders striking drilling structures or vessels. The stipulation has 4 parts as discussed below:

Part A(1) mandates that EPs for exploration drilling programs include a plan for recording and reporting bird strikes. This component of the stipulation applies to exploration drilling programs located anywhere in the Chukchi Sea Planning Area, and therefore applies to Shell’s program.

Parts A(2) and B(2) place travel restrictions and lighting protocol requirements on vessel and aircraft operations when they take place in certain listed blocks, in federal waters shoreward of those blocks, and in the Ledyard Bay Critical Habitat Unit (LBCHU), during specific dates. The listed blocks are shown in Figure 1.1 (as lease blocks under Stipulation No. 7) and are listed at the end of Attachment A of this document. These stipulation components would apply to any aircraft or vessels that are part of Shell’s exploration drilling program under EP Revision 2 (and presumably any future revision), if and when the vessels or aircraft are in the identified parts of the Chukchi Sea.

Part B(1) places lighting protocol requirements on drilling structures in the Chukchi Sea. This stipulation requirement applies to drilling structures operating on a lease or staged anywhere in the Chukchi Sea Planning Area, and therefore applies to Shell’s drillship.

The above-referenced travel restrictions or conditions and lighting protocol restrictions are summarized below:

General Conditions

- Lessees must include a plan for recording and reporting bird strikes that occur during approved activities to BOEM.
- Vessels associated with the exploration drilling operations should avoid traversing listed blocks (stipulation area), and federal waters between the stipulation area and shore, to the maximum extent possible between 15 April and 10 July. If such traffic cannot be avoided, hazing equipment must be onboard.
- Except during emergencies or for safety, vessels must avoid travel within the LBCHU between 1 July and 15 November. Any required travel in this area must be reported to BOEM within 24 hours (hr).
- Aircraft supporting the exploration drilling operations must avoid operating below an altitude of 1,500 ft (457 m) over the stipulation area and federal waters between the stipulation area and shore between 15 April and 10 June, or the LBCHU between 1 July and 15 November, to the maximum extent possible. If weather does not permit these altitudes then the flight should take place along a BOEM/USFWS-approved pre-determined flight path. Any deviations from the path due to safety or other issues must be reported within 24 hr.

Lighting Protocols

- Lessees are required to prepare a plan that identifies measures that will be undertaken to minimize the likelihood that migrating and coastal birds will strike exploration drilling structures (drillship), and obtain approval for the plan from BOEM. The plan must include measures that reduce the radiation of light outward from the drillship to minimize the likelihood that birds will strike the structure.
- Surface support vessels must minimize the use of high-intensity work lights, especially while traversing the stipulation area and federal waters between the stipulation area and the coastline. Exterior lights must be used only as necessary to illuminate on-deck work areas during periods of darkness or inclement weather. Interior lights and lights used during navigation may remain on for safety.

The lighting requirements and protocols in the Plan apply to activities conducted between 15 April and 15 November.

1.4 Relative Risk Evaluation

The risk of bird collision is largely determined by the timing and location of exploration activities in relation to the presence of spectacled and Steller's eiders in the Chukchi Sea. Spectacled and Steller's eiders nest onshore across the coastal North Slope. The distribution and density of breeding eiders on the North Slope are indicated in Figure 1.4-1 and Figure 1.4-2.

The Alaska-breeding population of the Steller's eider is primarily confined to the Arctic Coastal Plain of Alaska's North Slope, with a concentration of nesting eiders around Barrow (USFWS 2005a, Figure 1.4-2). Their use of offshore waters of the northeastern Chukchi Sea can be generally discussed in terms of spring migration and post-breeding, which includes fall migration and molting.

Spring migration of eiders in the Chukchi Sea occurs in May and June (MMS 2007a,b; MMS 2008b). The migration occurs along the coastal waters (MMS 2006), where many marine birds use the lead system as a migratory pathway to breeding grounds in northern Alaska and the Canadian Arctic (Richardson and Johnson 1981, Woodby and Divoky 1982). Eiders may also migrate overland during spring as they move to the eastern North Slope from the Chukchi Sea (Troy Ecological Research Associates 1999 *cited* in MMS 2003). Offshore exploration drilling operations in the Chukchi Sea would begin no earlier than approximately 4 July, which is after spring migration has ended.

Post-breeding spectacled and Steller's eiders generally move to the marine environment where they molt and start their fall migration. However, their movement to the marine environment varies by sex and timing. Males and some females with failed nests leave nesting areas for marine waters in late June or in July (MMS 2006). Successful female Steller's eiders and their broods gather near the coast later in the summer (MMS 2006) and some successful female spectacled eiders stay with their young on the nesting grounds until late August to early September, at which time they start their southward migration (USFWS 2005a).

Molting flocks of spectacled eiders gather in shallow waters, usually less than 120 ft (36 m) deep, and travel along the coast up to 30 mi (50 km) offshore (USFWS 2005a). Critical habitat for the spectacled eider includes Ledyard Bay (i.e., LBCHU), a large offshore area northeast of Cape Lisburne. This area is used for molting by spectacled eiders from July through October (USFWS 2005a). Other important molting and staging areas in the Chukchi Sea include Peard Bay and Kasegaluk Lagoon (Petersen et al. 1999). These areas are outside and shoreward of the lease blocks where the proposed exploration drilling program is scheduled to occur. No habitat on the North Slope has been designated as critical for the Steller's eider (USFWS 2005a).

Fall migration of spectacled and Steller's eiders has been documented by telemetry studies. Spectacled eiders were found to winter in a dense concentration within Norton Sound and fall migrations have been documented to go through the critical habitat described above (Petersen et al. 1999). Telemetry studies have shown Steller's eiders leaving the Arctic Coastal Plain nesting areas near Barrow on 23 June for the coastal marine waters between Wainwright and Dease Inlet between Cape Lisburne and Point Lay (MMS 2006). Eight individuals were tracked from Barrow across the Chukchi Sea to Siberia and back to Alaska (MMS 2006).

Spectacled and Steller's eiders will be most widely distributed in the Chukchi Sea during the post-nesting period. Although the majority of the eiders are likely stay close to the coast where they migrate and molt, some may be encountered far from shore within the exploration drilling areas. In the Chukchi Sea, proposed exploration drilling operations would begin no earlier than July and would be at least 96 km (60 mi) offshore in water depths of 130-150 ft (40-46 m). Steller's eiders would not be expected to occur in Shell's Burger Prospect, but a small number of spectacled eiders may be found in there during the time period when exploration drilling is planned. Bird surveys were conducted in the Burger Prospect area in July-October in 2009 and 2010 as part of a series of baseline studies. One spectacled eider was observed in the Burger Prospect during two years of these intensive surveys, and no Steller's eiders were recorded (Gall and Day 2009, 2010).

In addition to the risk of bird strikes being minimized by the timing and location of exploration drilling operations, the high amount of daylight hours experienced in the area during the months of July and August also reduces the relative risk of bird strikes.

Figure 1.4-1 Spectacled Eider Densities

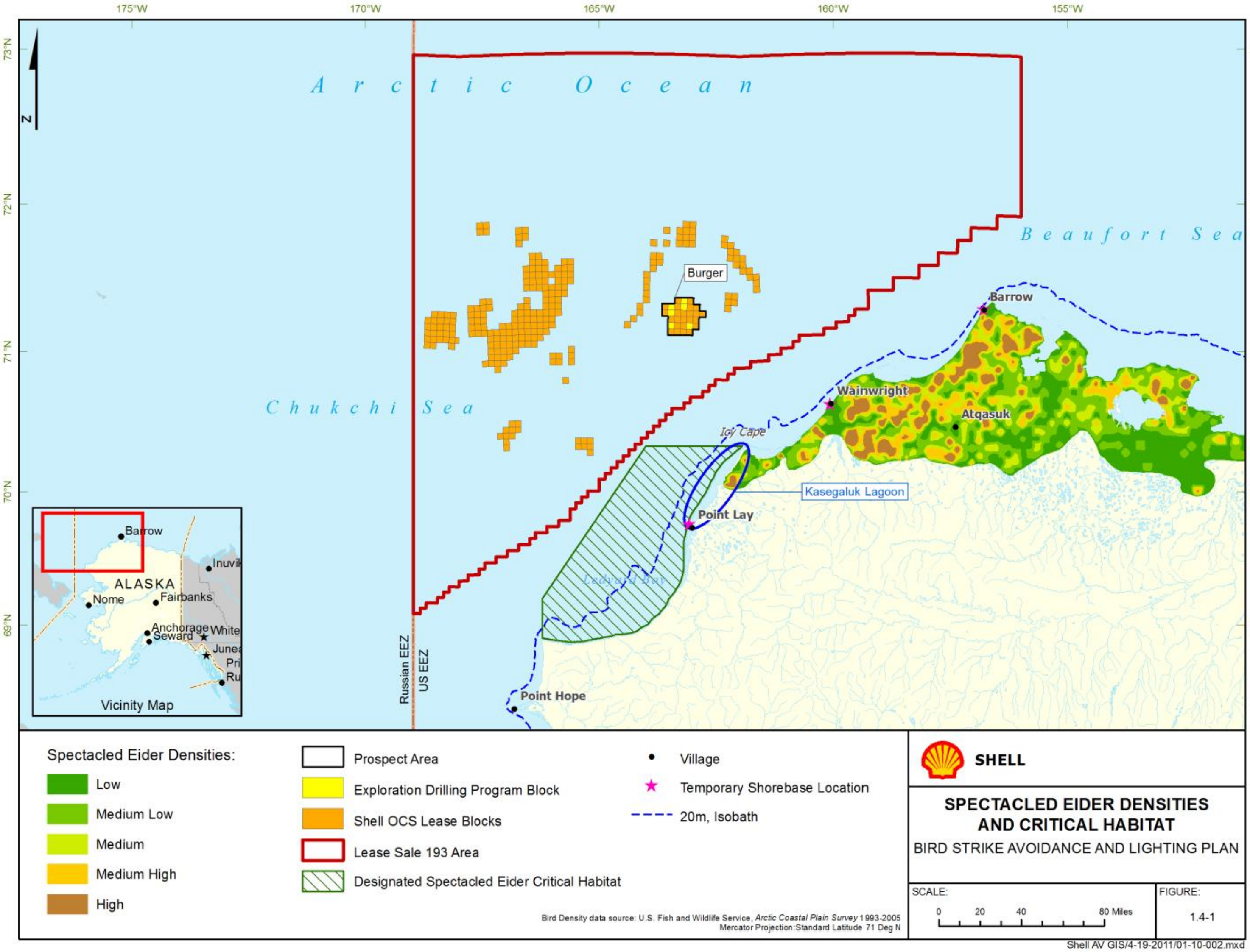
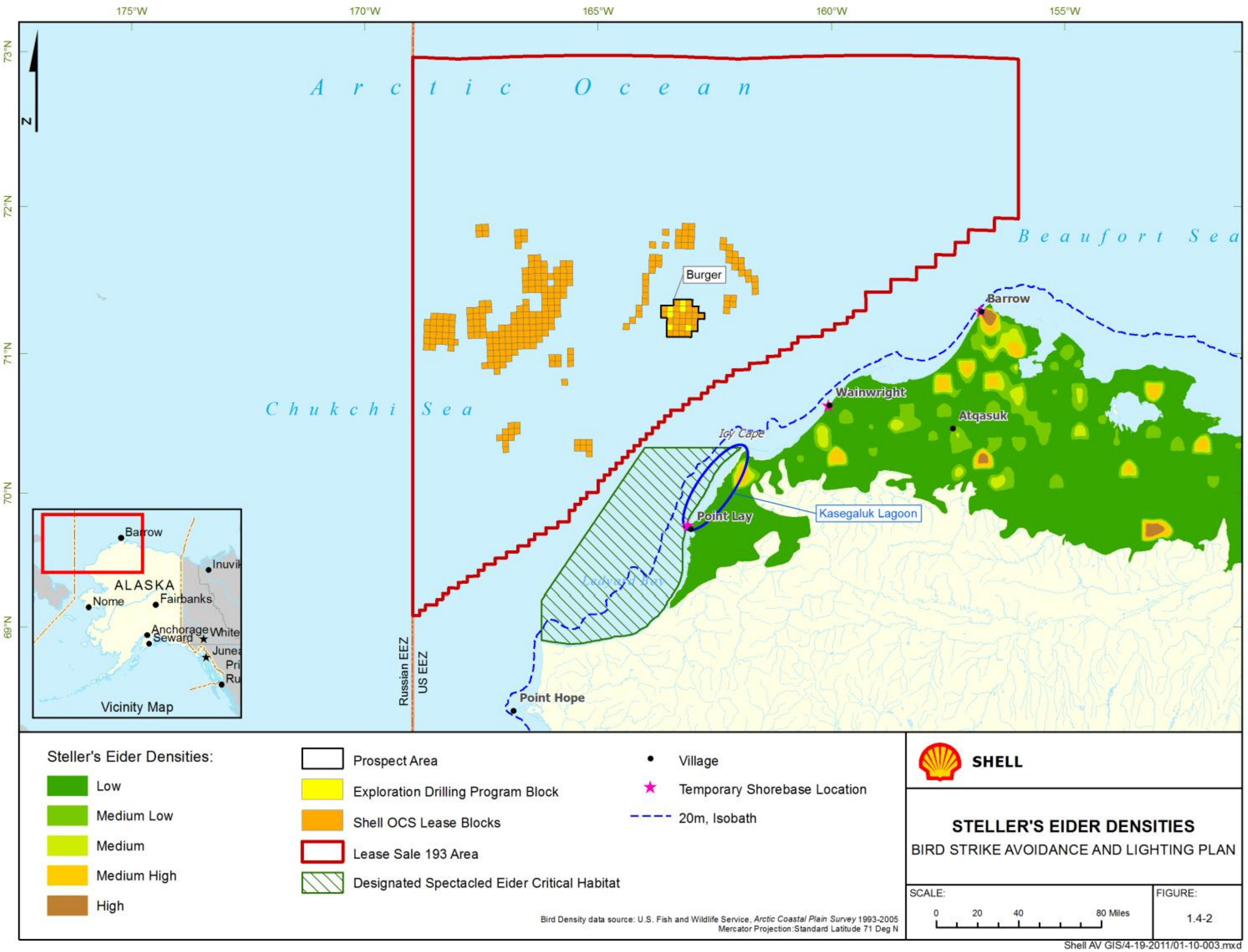


Figure 1.4-2 Steller's Eider Densities



2.0 REVIEW OF MITIGATION MEASURES

A literature review of existing mitigation measures used in Alaska and the lower 48 states was conducted to assess the efficacy of existing mitigation to reduce the chances of bird strikes. The studies were reviewed to determine what mitigation measures would be appropriate for use during Shell's exploration drilling program in the Chukchi Sea. None of the studies are specific to either the spectacled eider or the Steller's eider. Most of the work to date deals with documenting bird collisions with communication towers in the lower 48 states or seabirds with fishing vessels in the Aleutian Islands of Alaska. Light sources, especially from taller structures exceeding 200 ft (60.9 m) and during periods of low visibility, are implicated in many bird collisions. The following is a brief summary of measures considered by Shell with regard to mitigating the effects of light on birds and reducing avian collisions. The effectiveness of some of these measures has not been studied, and some studies that have been conducted are not conclusive. Shell recognizes the need to reduce vessel light emissions to lower the risk of bird strikes, and has selected the most proven and practical measures for the Plan.

2.1 Low Reflecting Finishes

Painting vessels a dark color would decrease ambient reflected light, thus reducing light output beyond the deck. The amount of light reduced by such an action is unknown. Another option is to paint alternating and contrasting colors, which may allow a vessel to be more easily seen by birds. No studies evaluating the effects of low reflecting finishes are available for review, therefore the efficacy of these measures is unknown.

2.2 Minimum Vessel Light

Birds can be disoriented by and attracted to artificial lights, potentially resulting in injury and mortality if a collision occurs. Organizations working on reducing bird mortality, such as Bird Life International, include minimizing vessel light use (without compromising vessel worker safety) in their general recommendations for reducing bird strikes. This has proven effective in some situations. For a lighthouse, narrowing and decreasing light intensity resulted in a drastically lower bird mortality rate from an average of 200.6-18.5 birds per season during spring and 392.5-9.6 birds during fall (Jones and Francis 2003). Minimization of light can include shading, directing lights towards the deck, avoiding the use of unnecessary lights, and using minimal light output through the replacement of high intensity lights.

2.3 Light Color

It is likely that any light visible to humans is visible to birds, and thus constitutes a potential attractant (Verheijen 1985). Different colors of light (wavelengths) have been considered as mitigation to reduce bird strikes. Research in the North Sea has indicated that white light caused attraction, red light caused disorientation, and that green and blue light caused a weak response (Marquenie 2007). White lights in this study were replaced with specially designed lights that excluded the red spectrum and appeared green (Marquenie 2007). The green lights resulted in 2 to 10 times fewer birds circling offshore platforms when only a limited number of light sources were replaced with green lights. Therefore the results likely underestimate the effect that would occur if all external lights were replaced with green lights (Marquenie 2007).

2.4 Anti-Collision Lighting

The effects of anti-collision lighting systems at Northstar Island were studied for four years for eiders and other birds (e.g. gulls, loons, geese) found in the Beaufort Sea (Day et al. 2005). Analysis of the data revealed some statistically significant responses and some weak responses by eiders to the anti-collision lights. In general, results of the analyses indicate a net movement of eiders away from the island, and a significant slowing of the eiders flight speed at night. The lights clearly did not cause non-eider species to avoid the island and actually appeared to cause attraction at times. Eiders exhibited a natural anti-collision response to the island, which the strobe lights were thought to increase modestly. Day et al. (2005) concluded the anti-collision lights caused some eiders to avoid Northstar Island, but the avoidance response was not consistent and was not dramatic. The effectiveness of the anti-collision lights in reducing the risk of eider collisions was not clear, and the lights did not appear to deter other non-eider species at all. The following summarizes the lighting system used at Northstar (Day et al. 2005):

- 14 white strobe lights (Honeywell Flashguard 2000B strobe lights) are mounted on tall masts approximately 13.7 m (45 ft) above the ocean surface around Northstar Island
- Each strobe light is set to flash at the rate of 40 flashes/minute
- The strobe lights are not set to flash in pattern or synchrony
- The strobe lights emit white light (all wavelengths) at 20,000 candlepower during the day and 2,000 candlepower during the night
- Photocell controls the switching between the two modes

Anti-collision lights may vary by wavelength, flashing rate, flashing synchrony, and intensity. Some evidence exists that passerines may avoid white lights better than red lights (Manville 2005). White strobe lights are considered less likely to attract night-migrating birds than non-flashing white and red lights (New Mexico Department of Game & Fish 2001). However, the appropriate light wavelength is unknown for best deterring eiders and a continued search for a lighting system that is more effective than the one used at Northstar Island is recommended by Day et al. (2005).

2.5 Radar Assessment

Radar can be used to examine the impact and collision risk of birds with man-made structures. It is a tool that has been used for decades to study birds and track bird movements in a three dimensional space and time. Radar can detect birds that are beyond the visual limit of observers and it is a particularly useful tool when visual observations are limited by darkness, fog, or precipitation. Radar in this respect can be a valuable monitoring tool to help better understand the risks to birds and can used to make informed decisions about whether mitigation efforts (e.g., changes to lighting) are required.

There are limitations to consider when using radar. Radars do not have the ability to determine the species of a bird, however; tracks can be assigned to taxa on the basis of flight speed (Larkin and Thompson 1980) and other variables captured within the return signal echo. During periods of high precipitation and or other radar-clutter causing events (e.g. high sea states), detecting small targets, such as birds, can be challenging.

There are several types of radar that have been used to study bird movements, from low-powered airport surveillance radars and mobile marine surveillance radars to high-powered weather radars and military tracking radars. Each type of radar has characteristics that make it suitable for its particular application (tracking features, range, cost, etc.). In 2005, a German team investigated the avian avoidance response to offshore wind turbines using the radar system Furuno FR2125 (Desholm and Kahlert 2005). The species involved in that analysis were primarily common eider (*Somateria mollissima*) and geese. In another study (Gauthreaux and Livingston 2006), the VERTRAD/TI radar system was used to estimate the potential collision risk of migrating birds with man-made obstacles of various heights. Another system (BIRDRAD) was able to detect the departure of migrants from different types of habitat within a few kilometers of the radar (Gauthreaux and Belser 2005). This system used a high resolution, marine surveillance radar (Furuno 2155 BB) with a 50-kilowatt transceiver. Gauthreaux and Belser (2005) also discussed the use of WSR-88D Doppler Weather Surveillance Radar to characterize bird echoes to better understand bird migration rates. Overall, radar has many applications making it a valuable tool to help better understand bird movements in relationship to specific conservation concerns.

3.0 PROPOSED MITIGATION

Based upon the mitigation measures reviewed in Section 2.0, Shell has determined appropriate mitigation measures for use during Shell's exploration drilling program in the Chukchi Sea. The mitigation proposed by Shell is based on what is currently and technically feasible and proven effective, in reducing the prospect of bird strikes, while fully considering the lighting requirements needed to maintain a safe work environment. Additional mitigation may be considered as more information becomes available regarding the effectiveness of new mitigation to reduce the risk of bird strikes.

Given the location of Shell's exploration program, impacts from bird strikes with vessels likely would affect only small numbers of individuals with no significant effects at the population level for any species. Implementing the mitigation measures as specified in this Plan will reduce the probability of bird strikes associated with Shell's planned activities.

Shell has prepared this Plan to reduce the chance of bird strikes of the drillship, especially strikes by spectacled and Steller's eiders. The major elements of the Plan are provided below:

- Bird strike monitoring that includes recording and reporting bird strikes for the collection of information on bird strikes and lighting configuration and a better understanding of methods to reduce bird strikes.
- Avian monitoring, including visual observations and radar assessments to determine bird use of the prospect area during the exploration drilling period.
- 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.
- Minimizing the use of high-intensity work lights on support vessels.
- Restricting aircraft and vessel travel routes and flight altitudes.

3.1 Bird Strike Monitoring

The overall objective of bird strike monitoring is to provide the USFWS with data for risk assessment of bird strikes related to operational activities and weather conditions, with a focus on threatened eiders. The monitoring program is intended to expand the knowledge on the risks of bird strikes in the Chukchi Sea and to determine the effectiveness of mitigation measures. If bird strikes are determined to be a serious risk to birds despite the proposed mitigation measures presented in this document, Shell will evaluate additional mitigation measures for future offshore activities.

All mortalities and injuries from strike events of a spectacled or Steller's eider will be reported to the Alaska OCS Regional Office of the BOEM and the Ecological Services Branch of the USFWS in Anchorage within three days of the event or as soon as is practical. This includes any collisions associated with the drillship, support vessels, and associated aircraft. Other pertinent information that may help better understand the risk of bird strikes will be sent to the USFWS after the end of the drilling season.

The following data will be collected upon a determination that a bird strike has occurred:

- Description of event
- Bird species, if can be determined
- Weather conditions
- Date and time
- Vessel location
- Photographs if practical

Shell will conduct routine deck searches for live, injured birds, or dead birds, especially during or following periods of darkness or inclement weather such as rain or fog. Birds perching on ship structures (such as antennae and rigging) will be allowed to rest and depart on their own.

Any observed bird strike shall be documented and reported within three days to BOEM. Minimum information will include species, date/time, location, weather, identification of the vessel involved and its operational status when the strike occurred. If a bird strikes and remains on the vessel, it will be photographed (if possible) and left there to recover and depart on its own. If necessary to take it out of harm's way, it will be moved to a dry place from where it can depart on its own. If the bird does not depart after about 12 hr and is still alive, it will be gently returned to the sea surface. Shell will consult with the USFWS to further determine the proper handling of injured birds in the event of a bird strike. Carcasses from any lethal strikes will be photographed (if possible) and returned to the sea. Photographs will be taken of the bird with wings spread, top and bottom views, and of the head, to assist with species verification and will be submitted to BOEM and USFWS as part of the collision report.

Strike information will be recorded on the Avian Collision Form provided in Attachment B of this Plan. An avian observer or Protected Species Observer (PSO) with training in bird identification will collect the data associated with any bird strike. Placards will be posted in common areas to inform all personnel to report dead or injured birds. This will increase awareness and the likelihood that data will be recorded. The observer will have equipment such as a bird identification guide, a flashlight, and a camera to help with data collection.

Although Shell will make every effort to record all bird strikes; it is recognized that some bird strikes may not be noticed. Eiders often fly low and fast over water, which suggests that they could possibly strike the hull of the drillship and fall into the water unobserved. In addition, darkness and inclement weather can make visual observations difficult.

3.2 Avian Monitoring

Avian monitoring will consist of observations made by observers on the drillship and radar assessments. These methods will be used concurrently to maximize the value of the data collected by either method.

3.2.1 Avian Observations

Avian monitoring will be performed by PSOs or other designated individuals aboard the drillship that have been trained in bird identification, sampling protocols, and the reporting of bird strikes to the USFWS and BOEM. Monitoring will be conducted systematically during daylight hours from a vantage point on the drillship using binoculars. These avian observers will have an adequate understanding of bird identification, especially of eiders in flight. The daily tasks performed by the observers will include recording weather conditions, bird counts with species identification, observations of general bird flight directions, estimates of bird distances from vessels, strike events, data entry, and report writing.

3.2.2 Radar Assessment

In 2012, a pilot study was conducted using the shipboard radar antenna and dedicated bird radar unit to detect birds near the drillship in the Chukchi Sea. Preliminary results suggest that birds were detected on radar and their movements were able to be tracked near the drillship. Further analysis and research is needed to continue to test the efficacy of using radar to monitor and compare bird movements near drillships during periods of good and poor visibility and to optimize radar settings in the offshore environment.

Visual observations (Section 3.2.1) will be conducted in conjunction with radar observations. Comparison of radar and visual observations will be used to help to determine numbers of individuals in flocks and possibly species group (based on flight patterns). Visual observations will supplement radar data by more accurately determining species and obtaining better estimates of individuals in flocks.

Shell will conduct the radar assessment during the course of the field season as time, conditions and availability of personnel permit. The number of sampling sessions will depend on the number of biologists available to collect data. Sampling sessions will be stratified to include all portions of the diurnal cycle as equally as possible.

Some of the data collected by radar observations will be the same as those collected by visual observers although species, number, sex, and height above water may not be determined by radar. For each observation of a bird flock, radar observers will record the date and time, the species type if possible (e.g., eider or goose), flock size, compass direction of the birds in relation to the drillship, direction of flight, initial distance of the birds from the drillship, the closest point of approach of the flock to the drillship, and notes on any avoidance behavior displayed by the flock. The data from the radar assessment will be analyzed to determine:

- If migrating bird flocks pass closer to the drillship during periods of poor versus good visibility;
- If birds deflect their flight patterns to avoid the drillship; and
- If deflections of flight patterns occur at further distances during period of good versus poor visibility

3.3 Lighting Protocols

Much of the drillship lighting will be directed inward and downward, where practical, to minimize escaping light. Additionally, some lights will be fitted with shading that will direct lights to working areas and prevent light escaping to areas where lights are not needed for safety and operations. When practical, lights will be turned off when not in use.

3.3.1 Shading and Minimization

Shell plans to reduce or shade light output from the following locations on the drillship *Discoverer*:

- Deck lighting, doorway and stairway lighting, and pipe rack lighting: lights will be shaded to direct light downward and inward and/or the wattage reduced.
- Crane boom lights: lights to remain unshielded for safety during crane operations.
- Heliport lighting: lights to be dimmed or shut off when not in use.
- Navigation and clearance lights: no change will be made due to safety concerns.
- Lights from windows: shades will be used during darkness.

Shell will minimize the use of high-intensity work lights on the support vessels, especially when traversing the stipulation area and federal waters between the stipulation area and the shoreline. Exterior lights will be used on these vessels only as necessary to illuminate on-deck work areas during periods of darkness or inclement weather. Otherwise the lights will be turned off. Interior lights and lights used for navigation will remain on for safety.

3.4 Vessel and Aircraft Traffic

Surface vessels associated with exploration drilling operations will avoid operating or traversing within the LBCHU between 1 July and 15 November as much as possible (except for emergencies or human/navigation safety). Vessels that do enter into the LBCHU (Figure 1.1) during this time period for emergencies or human/navigation safety will report the information to BOEM within 24 hr.

Aircraft supporting exploration drilling operations will avoid operating below 1,500 ft (457 m) above sea level over the LBCHU (Figure 1.1) between 1 July and 15 November as practicable. Pre-designated flight routes, which will be approved by the USFWS and BOEM during review of the exploration plan, may be used if the area must be traversed and weather prevents attaining an altitude of 1,500 feet. Flights that are below 1,500 ft (457 m) and over the LBCHU between 1 July and 15 November will be reported to BOEM within 24 hr of the event.

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Attachment A
Lease Stipulation No. 7
Oil and Gas Lease Sale 193 Chukchi Sea

LEASE STIPULATION NO. 7
OIL AND GAS LEASE SALE 193 CHUKCHI SEA

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 hr 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. Predesignated 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 hr 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:

STIPULATION NO. 7
OIL AND GAS LEASE SALE 193, CHUKCHI SEA
LISTED BLOCKS (STIPULATION AREA)

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

Attachment B
Avian Collision Form

AVIAN COLLISION FORM

Observer (Name or Initials)		Vessel Name	

Collision Observations

Casualty ID*	Date/Time (dd/mm/yy /military)	Injury Status[1]	Species	Sex[2] (M, F, U)/Age[3] (A, J, U)	Cause of Strike	Injury Description (broken wing, etc.)		Photo ID[4]	Observer Comments
		D W U			□ Window □ Structure □ Light □ Other______				
		D W U			□ Window □ Structure □ Light □ Other______				
		D W U			□ Window □ Structure □ Light □ Other______				
		D W U			□ Window □ Structure □ Light □ Other______				
		D W U			□ Window □ Structure □ Light □ Other______				
		D W U			□ Window □ Structure □ Light □ Other______				

*For each new casualty, Create a unique ID value for each new casualty observed. Always start the ID with date (e.g. "020104DUCK" for injured duck found Feb. 1, 2004). Include additional info in ID as needed (e.g. "020104DUCK3" for 3rd injured duck found Feb. 1, 2004). "DUCK" refers to 4-letter species code.

[1] D= dead, W= wounded, U= unknown

[2] M= male, F= female, U = unknown

[3] A= adult, J= juvenile, U= unknown

[4] Name digital photo starting with CASUALTY ID and adding chronological number starting with 001

AVIAN COLLISION FORM

Casualty ID #[1]	Bird ID[2]	Observer	Vessel	Date Time Recorded	Time of Strike	Latitude	Longitude	Injury Status[3]	Sex[4]	Age[5]	Cause of Strike	Injury Description	Carcass Condition[6]	Bf	Visibility	Photo ID[7]	Vessel Light Conditions	Vessel Activity	Observer Comments

[1] For each new casualty create a unique ID value for each casualty observed. Always start the ID with date YYYYMMDD (e.g."20120804DUCK" for injured duck found Aug. 04 2012). Include additional information in the ID as needed (e.g. "20120804DUCK3" for 3rd injured duck found Aug. 04 2012). "DUCK" refers to 4-letter species code (see Species 4-letter Code List

[2] Use 4-letter species code. Identify to closest known taxa. Don't guess if unknown record- Unidentified Bird (UNBD).

[3] D = dead W = wounded U = unknown

[4] M = male F = female U = unknown

[5] A = adult J = juvenile U = unknown

[6] 0-barely alive 1 – very fresh (no rotten smell) 2 – slight decomposition but feathers still firmly attached 3 – very decomposed rotten (feathers falling off) 4 – very old mummified (likely many weeks dead) 5- alive

[7] Record the number of photos for an individual bird in a series using alphabetic letters starting with A. For example if you take four photos of a single DUCK note photo range as A-D. When labeling photos name digital photo starting with CASUALTY ID Vessel Name and use alphabetic letters starting with A B C... (e.g. 20120804DUCK3_TorVikA).

Appendix L

Well Control Plan

Well Control Plan Outline[1]
Chukchi Sea Exploration Plan Revision 2

Well control is the process of maintaining pressure inside the drilled wellbore in a manner that prevents gas or fluids from underground reservoirs flowing into the wellbore and escaping to the environment in an uncontrolled manner.

Shell Gulf of Mexico Inc. (Shell) designs and executes operations such that no single operational error or equipment failure should lead to loss of well control. The foundation of Shell's well integrity and well control philosophy is to maintain two barriers between any subsurface zone that can potentially flow and the environment.

Below is a summary highlighting the well control mitigations organic to the well planning process:

- Site Selection:

  The location of the well is selected to avoid or minimize the following shallow hazards:

  1) Shallow faults that extend to the mudline
  2) Overpressure water sands created by rapid depositional environments.
  3) Overpressure gas sands pressured by biogenic gas from rapidly decaying biologic materials in rapid depositional environments.

- Pore Pressure / Fracture Gradient Information:

  Casing setting points & mud weights are based on reviewed and approved pore pressure / fracture gradient information. These plots are based on the best technical data at the time of generation, reviewed and then subsequently approved by Shell's Technical Authorities in this area. The data set can include 3-D seismic data, shallow seismic surveys, and known offset well information. Casing points and mud weights are planned to provide the maximum well control potential, isolation of shallow over pressured zones, unconsolidated zones and maximum borehole stability.

- Casing Design:

  Casing design loads are based on Shell's Casing and Tubing Design Manual and the Code of Federal Regulations depending on which set of requirements has the most stringent design / assurance protocol. Shell's manual outlines conventional well loads and survival loads to be placed on the casing strings based on the specific tubular function. Each well design is reviewed and assured by Shell's Well Design Technical Authority. Additional screening and confirmation applied to wells drilled in OCS waters:

  1) In additional to Shell's standard survival loads, additional well containment is demonstrated with the JITF / BSEE: Well Containment Screening Tool.
  2) Well designs, barriers and cementing programmed are developed with the involvement of a registered Professional Engineer.
  3) Minimum CFR requirements for margins between pore pressure, mud weight and fracture gradient are applied to the design.

[1] The Well Control Plan Outline has been re-worded to use language more familiar to Shell's well engineers and responders to a potential well control event. In this rewording, Shell has not changed the quality or substance of its well control response effort.

Using these principles the well design has the required integrity to perform safely and without undue risk during conventional drilling scenarios and survive extreme loads placed on the system during well containment efforts.

- Pressure Control Equipment:

Shell specifies and maintains pressure control equipment in accordance with the CFR and/or Shell's Pressure Control Manual. The minimum compliance level is based on the stricter requirement for pressure control equipment.

Specific requirements applied to pressure control equipment in Alaskan-OCS waters:

1) Documentation and review of well control equipment / processes as specified in the CFR for permit approval.
3) Confirmation by onsite BSEE witnessing of Pressure Testing of critical well control equipment in accordance with the CFR.
4) Testing of the casing & BOP equipment meets at a minimum MASP + 500 psi to demonstrate the equipment can successfully operate at the highest pressures expected in a well control event.
5) Physical tests are done on the same make and model of the BOP equipment to demonstrate that in a well control situation the equipment performs as designed with the planned drill pipe and worst case internal pressures.
6) The BOP is independently reviewed and approved by a 3rd party as being suitable for the given well design and well conditions.
7) Incorporation of a Dead Man system in the BOP controls allows the BOPs to automatically be closed in the event that the Lower Marine Riser Package (LMRP) is disconnected from the BOP. This feature is tested during the stump testing / initial run of the BOP at the location.

The minimum requirements in the Shell's Pressure Control Manual and the requirements in the CFR provide very high levels of assurance the BOP's will operate in the planned manner if required.

- Operational Monitoring:

Operational monitoring is conducted to minimize the potential of penetrating an overpressure zone resulting in a loss of hydrostatic overbalance.

1) Flow checks are conducted with the pumps off to confirm the static mud weight over balances pore pressure.
2) Frequent pit drills and mock well control drills are planned and conducted.
3) Drilling Contractor / Shell Staff have relevant and current Well Control Certificates.
4) Shell requires its operational staff to attend and pass its internal Advanced Well Control Training.
5) Real Time monitoring of the well and operational parameters is conducted by the Real Time Monitoring Center that is staffed by a team of experts. Any anomalous signals or indications are immediately relayed to the rig.

This extra set of monitoring provides a secondary team of individuals to monitor the wells status and minimize the potential for loss of situation awareness by the drilling team.

In the unlikely event that primary well control is lost, despite these design and operational protocols, Shell will initiate Incident Command, Source Control Teams and contingency / response equipment. This includes Shell's Arctic Capping Stack and Arctic Containment System, to the well site. Shell may also mobilize additional internal / external resources to fully plan and execute contingency response plans and operations.

Secondary Well Control

In the event primary well control is lost, a series of escalating responses are planned to regain primary well control by establishing borehole hydrostatic pressure above formation pore pressures.

The first response is to close the BOP. There are four functions on the BOP capable of closing around pipe, two of which are annular preventers, designed to close around a range of pipe sizes and shapes. Once the BOP has been closed, conventional well control methods will be employed to reestablish hydrostatic overbalance, these steps include Wait & Weight, Driller's Method and/or Bull Head Kill Methods. If there is no pipe in the hole, or if the functions above fail, the shear rams will be closed and hydrostatic overbalance reestablished by a Bull Head Kill.

Well Containment and Response

If secondary well control measures fail, the *Discoverer* will disconnect the LMRP / riser and pull away to a site upwind and up-current from the blowout location and initiate relief well drilling operations. As a precautionary measure, relief well preparation operations are initiated in parallel with surface capping/intervention methods being employed on the incident well.

Shell will have in theater a purpose built 10ksi, Dual Blind Ram Arctic Capping Stack capable of capping and containing the incident well. This asset will be kept in theater on the Ice Management Vessel Fennica and ready for deployment. The capping stack also has a spool below the dual rams allowing a Bull Head Well kill while the rig is not on location.

If closure of the BOP is not achieved with either control pod, a remotely operated vehicle (ROV) can interface with the Remote Controlled BOP Panel (a.k.a ROBOCOP) that is connected to the BOP Intervention Panel and close the BOP. The ROBOCOP panel is a self contained accumulator / BOP control system that can activate the BOP in a contingency situation. This ROBOCOP system is attached to the BOP and function tested in the same manner required for conventional BOP Intervention Panels in the CFR.

Unless it is damaged, the *Discoverer* can commence relief well drilling if intervention measures prove to be unsuccessful. An additional BOP will be available to facilitate relief well drilling. It is noted that throughout incident response efforts and relief well drilling, Shell's Oil Spill Response (OSR) fleet will be onsite collecting and storing oil from the surface of the sea.

When the incident well is intercepted with the relief well, a dynamic kill will be performed to re-establish hydrostatic overbalance. Once the incident well is controlled it will be abandoned per the CFR & Shell's Abandonment Manual, followed by the relief well.

Relief Well Location and Timing

Shell will have in the region two drilling assets capable of drilling a relief well. The first drilling asset to respond would be the *Discoverer* since it is already at the location. The placement of the relief well will be based on specific environmental conditions at the time of the response. A second relief well drilling asset, *Polar Pioneer*, will be in a holding position at Dutch Harbor for the 2014 Open Water Season. This contingency drilling asset would be used as directed by Incident Command, or made the primary relief well drilling asset if the primary is unable to perform the work scope.

A relief well in this situation will not have a mudline cellar (MLC). The relief well will intercept the blowout and perform the kill even if extensive ice management efforts are required. A detailed Relief Well Plan will be submitted to BSEE as part of the Application for Permit to Drill for each planned exploration well.

The estimated total duration from the start of a blowout to well killing through a relief well would be approximately 28 days for a Burger blowout well from initial mooring through kill pumping. Transiting from Dutch Harbor, the *Polar Pioneer* would take an additional 10 days to reach the well location in the Chukchi Sea.

Appendix O

Air Emissions Inventory

AIR SCIENCES INC.
DENVER • PORTLAND

Revised Outer Continental Shelf
Lease Exploration Plan
Chukchi Sea, Alaska
AQRP and NEPA Emission Inventories
October 2013

This report describes the sources of air emissions and maximum projected actual air emissions from the exploration drilling program that Shell Gulf of Mexico Inc. (Shell) proposes to continue on Outer Continental Shelf (OCS) leases in the Chukchi Sea. Shell has an approved Exploration Plan (EP Revision 1) for drilling in the Chukchi Sea at the Burger Prospect. Shell has submitted a further revision to its approved EP Revision 1. As a part of its exploration drilling program as described in EP Revision 2, Shell requests authorization for its exploration drilling program air emissions from the United States, Department of Interior, Bureau of Ocean Energy Management (BOEM), in lieu of an air permit from the Environmental Protection Agency, Region 10 that existed when Shell conducted exploration drilling during 2012 under the approved EP Revision 1. This report of air emissions has been prepared to assist BOEM in the assessment of and authorization of air emissions Shell's next season of exploration drilling operations. The following addresses two types of emission inventories. For purposes of demonstrating exemption from the BOEM Air Quality Regulatory Program (BOEM AQRP) (30 CFR Part 550, Subpart C), Shell is required by 30 CFR 550.218(a)(3) to base the projected emissions on the maximum rated capacity of the equipment on the proposed drilling unit under its physical and operational design. This first inventory is referred to as the AQRP emission inventory. A second emission inventory is also discussed that provides a more representative emissions estimate. This second inventory is referred to as NEPA emission inventory.

1.0 The Exploration Program and Associated Air Emission Units

Shell has authorization from the United States Department of the Interior, BOEM to drill exploration wells in the Chukchi Sea beyond the three-mile seaward boundary of Alaska. Exploration drilling in the Chukchi Sea will continue to consist of the operation of a drillship and an associated vessel on the OCS of the Chukchi Sea.

Under EP Revision 2, Shell plans to use a single drillship, the M/V *Noble Discoverer* (*Discoverer*), to continue its exploration drilling program at any of six well locations in the Burger Lease Block on six leases (one well per lease) offshore in the Chukchi Sea, Alaska, which began in 2012 and will continue in subsequent seasons. Seasonal exploration drilling operations are planned to begin on or about July 4th, through no later than October 31st.

Drilling will be conducted by the *Discoverer* with support from ice management vessels, anchor handlers, oil-spill response (OSR) vessels, offshore supply vessels (OSVs), a science vessel, and aerial transport. There will be associated onshore support, including housing for employees, helicopter hangars, possible other storage buildings, and transport for supplies and personnel. The drillship has been identified, but the remaining vessels are contracted and multiple vessels could meet the duty requirements for the needed tasks. In the case of the *Discoverer*, the actual vessel to be used is defined, as are the types of emission units on board. As for the other vessels, a candidate vessel has been identified, but since these vessels may not be available or the final vessel chosen before the start of an exploration drilling season, only the types of emission units anticipated are identified in this report.

The *Discoverer* has its own propulsion engine for self-transport. The drilling involves rotating the drill bit and raising and lowering the bit. At intervals, the well is cased and cemented, and the well bore geological information is logged. The *Discoverer* is equipped with two diesel-powered cranes that will have occasional use. There are also diesel-fueled heaters for keeping both personnel and equipment warm during the drilling. An incinerator is available for disposal of domestic and other non-hazardous waste. The *Discoverer* also has several smaller engines for generating hydraulic pressure, pumping cement, and emergency purposes.

The auxiliary vessels will include two anchor handlers, for management of the *Discoverer* anchors, bow washing of any ice buildup on the *Discoverer* bow and some ice floe fragmenting in support of the ice management vessel. One anchor handler and one ice management vessel provide primary close support for the *Discoverer* with regard to these tasks, whereas the second anchor handler or ice management vessel are anticipated to provide occasional support to the *Discoverer* for the performance of these tasks. The second anchor handler and ice management vessel are likely to conduct other tasks outside of the geographic extent of the Chukchi Sea, and often not in support of this exploration drilling program. Up to two ice management vessels will be tasked to fragment any manageable ice flows so that the ice will flow around the *Discoverer*. The ice management vessels are needed when there are ice features that require disruption in their path or fragmentation in order to provide protection for the drilling unit or other assets critical to the safety of the exploration drilling program (i.e., mooring buoys, etc.). They are planned to normally work several miles upwind of the drillship and may monitor the leading edge of any ice floe of possible concern, far upwind. OSR vessels may be anchored nearby but out of the way downwind of the *Discoverer* in case of any unanticipated petroleum liquid leaks.

Other associated vessels include those for resupply and material transfer to shore. The OSVs will transit to the *Discoverer*, then park in dynamic positioning (DP) mode beside the *Discoverer* for material or personnel transfer. These vessels are expected to transit to the *Discoverer* at most once per week and may remain there for about one day, sometimes longer. For the AQRP emission inventory, OSV operation in DP mode beside the *Discoverer* is assumed to occur continuously. However, actual operations of OSVs in DP mode will be substantially less to a fraction of this assumption. Another OSV, also used as the science vessel, may remain permanently within a few miles of the *Discoverer* for unspecified but routine material on and off-loading. That science vessel is also expected to monitor at regular intervals the muds and cuttings plume as required. An Arctic oil storage tanker is expected to be located near the *Discoverer* to resupply the *Discoverer* and associated vessels with fuel.

Onshore associated air emission sources for the exploration project may include a man-camp, some material storage there, helicopter hangars, transport pickup trucks, and helicopters, all located in Barrow.

2.0 Emission Unit Description

This section describes the sources and methods used to estimate the project emissions of the criteria (NAAQS[1]) pollutants, both on a short-term and a seasonal basis. Two emission inventories are provided here, the first directed to the requirements of the BOEM AQRP (30 CFR Part 550 Subpart C). The AQRP emission inventory addresses the emissions from the"facility" (as defined under 30 CFR 550.302), which is the *Discoverer* drillship and the auxiliary support vessels within 25 miles of the drillship, over the period when the *Discoverer* is secured to the sea floor. This AQRP emission inventory was developed for sources without consideration of emission controls, but does include the expected use imposed by safety considerations (i.e., engine readiness testing) and good engine operating practices (i.e., engine power restrictions for extended equipment life). The NEPA emission inventory contains the controlled emissions from the drillship, auxiliary support while the *Discoverer* is a stationary source, and the on-land support. Both inventories are built on an externally imposed 120-day maximum drilling season.

There will be pre- and post-drilling emissions from the vessels preparing the drill site and travelling in and out of the air basin (Bering Strait to Barrow) from the drill site and possible land-based facility expansion. These are recognized to occur, but are not quantified for either emission inventory because they and their associated impacts will occur when there will be no drilling emissions, so the short-term impacts will not be additive. The pre-drilling and post-drilling emissions will be spread over a very large region, so their short-term and seasonal impacts will be very low, well below those of the drilling phase. A brief qualitative discussion of the types of emissions that could occur pre- and post-season is provided in section 4.10.

Land-based emissions include those from personnel and supply transport to and from the drill site, and any housing emissions dedicated to the project. There may be construction emissions from man-camps and possible storage buildings, but these will occur pre- and post-drilling. As with the vessels, only those emissions that occur concurrent with the *Discoverer* being a stationary source are quantified herein; the others will be insignificant.

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[1] National Ambient Air Quality Standards

All drilling program vessels are contracted on a year-by-year basis, except for the *Discoverer*, and it is not certain that the vessels currently considered for the project will be available. Furthermore, any one, or more of the engines on board the *Discoverer* may change as maintenance demands. Thus, Shell cannot be certain of the exact engines in either emission inventory. Rather, Shell is defining the known or expected emission units at the time of filing this EP Revision 2 and associated expected emission factors per group of the known or expected emission units. Applying these factors to a maximum projected use rate yields a maximum projected emission rate.

The vessel emission units will consist of diesel-fueled internal combustion (IC) engines and heaters, and incinerators. There are to be no hydrocarbon venting from the wells and no flaring. The only hydrocarbon contained on the drillship will be diesel fuel that may contribute to VOC emissions, with negligible hydrocarbon vapor emissions. Emissions from all sources are accounted for, although not all are individually identified. Sets of identical engines that can be collocated for impact modeling purposes are grouped. For the *Discoverer* emergency-use engines, with emissions only from periodic exercising, there is less emission unit specificity. The emergency-use engines on the auxiliary vessels are not individually defined as their emissions are small and are assumed to be represented in the maximum projected auxiliary vessel propulsion/generation emission inventories.

The candidate auxiliary vessels are provided in Table 1.

Table 1. Assumed Auxiliary Support Candidate Vessels

Category	Candidate Vessel	Included in EI
Ice Management 1	Fennica or similar	Yes
Ice Management 2[a]	Nordica or similar	Yes
Anchor Handler 1	Aiviq or similar	Yes
Anchor Handler 2[a]	Tor Viking or similar	Yes
Oil Spill Response Vessel (OSRV)	Nanuq or similar	Yes
Oil Spill Response – Tug/Barge (OSR-T/B)	Sea Robin/Klamath	Yes
Nearshore OSR Tug/Barge	Pt. Oliktok/Arctic Endeavour or similar	No
Offshore Supply Vessel 1	Sisuaq or similar	Yes
Offshore Supply Vessel 2	Supporter or similar	Yes
Science Vessel	Sisuaq or similar	Yes
Arctic Oil Storage Tanker	Affinity	Yes
Arctic Containment System		
Tug	Crowley Invader Tug	No
Barge	Arctic Challenger	No
Anchor Handler	Vidar Viking	No
Shallow Water Landing Craft	Arctic Seal or similar	No
Resupply Tug/Barge	Lauren Foss/Tuuq or similar	No
Support Tug	Ocean Wave or similar	No

[a] Occasional use in the exploration drilling program area.

The projected duties of each vessel and source group are described in the subsections below.

3.0 Emission Controls

This Shell exploration project is designed for efficient resource exploration, with a focus on minimizing air emissions. Substantial emission control equipment and practices are integrated into the program. These include the use of the use of ultra-low sulfur diesel (ULSD) fuel for all emission units on the *Discoverer* and all associated vessels, which considerably reduces the emissions of sulfur dioxide (SO_2). The *Discoverer* primary generators are also retrofitted with selective catalytic reduction (SCR) and catalyzed diesel particulate filters (CDPFs) to minimize nitrogen oxide (NO_X), particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOC) emissions. The ice management and anchor handler vessel propulsion and generation engines will also have SCR and oxidation catalysts/CDPFs for control of NO_X, PM, CO and VOC emissions. These emission controls surpass those used by any other current or past drilling project to Shell's knowledge. Again it is emphasized the AQRP emission inventory does not account for the use of these emission control systems in order to demonstrate that the project emissions are below the BOEM exemption thresholds.

4.0 Drilling Emissions

4.1 *Discoverer* Emission Units

The *Discoverer* is a drillship, converted for drilling in 1975 and substantially upgraded in 2007 and 2013. The *Discoverer* drilled in the Chukchi Sea for Shell during the 2012 open water season. It is equipped with a propulsion engine, electrically powered thrusters, generators for the electrical drilling motors, and other self-powered equipment. The self-powered equipment includes hydraulic pumps, cranes, boilers, an incinerator, and other (mostly emergency-related) small sources. There will be no flares and no hydrocarbon-venting sources except for minor amounts included with the drill cuttings.

Prior to mobilizing to the Chukchi Sea for the next open water drilling season, the *Discoverer* will be provisioned, with sufficient supplies required for the initial drilling operations. Together with the ice management and anchor handler vessels, consisting of one or two primary ice management vessels and an Arctic-class anchor handler/secondary ice management vessel, the rig will mobilize to the desired drill site. Anchors will be run and set by the anchor handler/ice management vessels either before or at the time of the *Discoverer*'s arrival at the drill site; the mooring lines will be attached and tensioned to position the *Discoverer* over the well location. Final positioning may be assisted with the ice management vessels. At this time, the *Discoverer* will become a stationary source and prepare to drill. De-mobilization is this process in reverse.

Once fully moored and stationary, the drilling can be initiated. Drilling of a new well will begin with the excavation or drilling of a mud-lined cellar (MLC), which is could be up to 30-foot diameter hole excavated to approximately 50 feet below the mud line. Rotation of this bit will involve hydraulic assistance from on-board hydraulic pumps. The MLC permits installation of the rig's Sub-sea Blowout Preventer (SSBOP) below the mud line to avoid damage by ice keels should ice floes force the drilling unit off the well. Next, a hole will be drilled for the next interval and a tube (casing) will be installed and cemented. Cementing the casing anchors in the hole and prevents annular formation fluid migration between formations or to the surface. Atop the casing is a guide base with receptacles for guidelines that facilitate reentry into the well.

After drilling, logging, and installing casing in the next interval, the SSBOP will be installed in the MLC. At this point, the OSR vessels generally must be in position and be prepared to deploy in the unlikely event of an unanticipated oil discharge. Additional intervals will be drilled, cased, and cemented as required to reach and evaluate the geologic objective. The remainder of the exploration process at each well would involve logging and casing.

Upon completion of the evaluation operations, the well will be properly secured or plugged and abandoned (P&A'd) using mechanical and/or cement plugs, or temporarily abandoned (T&A'd), which generally occurs upon completion of any of the interim operations of cementing the casing. After the well is abandoned, the SSBOP will be retrieved. The anchors can then be retrieved and the rig can depart the drill site. Except for emergency, the *Discoverer* will move from the drill site only after P&A'ing or T&A'ing a well.

The *Discoverer* may leave a drill site for a variety of reasons, including adverse ice and weather conditions, end of the drilling season, or desire to move to another drill site to start or finish a well previously T&A'd.

4.2 Generation

The well development involves the drilling, casing, cementing, logging, and setting of equipment in the MLC. Each activity requires a different level of electrical (and therefore generator engine) power consumption. High power consumption is estimated to occur in the MLC excavation and drilling, which occurs about half of the time as a stationary source. During this time, about three-quarters of each hour the bit turning consumes high power. One-quarter of each hour, the drill string is being lengthened, which consumes minimal power. Casing, cementing, and logging require minimal power.

Six Caterpillar 3512C generator sets comprise the current "Generation" source category. This system provides the primary power for the drilling as well as the ship utilities, and the number of units and load levels vary throughout the drilling process.

Each of the six generators is fitted with SCR and CDPF control devices to reduce the NO_X, PM, CO, and VOC emissions.

4.3 Propulsion

The *Discoverer* is self-powered with a single STX-MAN Model 6S42MC7, Marpol Tier II, 6,480-kW engine. This engine will be used to propel the *Discoverer* to the drill site, and to assist in holding position while the mooring is connected and tensioned. In extreme high winds, the engine may be used to assist the anchors in holding the vessel in position.

4.4 Seldom-Used IC Engines

4.4.1 Emergency Generator

The *Discoverer* has one 679-hp emergency generator for use in powering the basic drillship utilities when the primary power system is inoperable. It is capable of powering only domestic and worker safety devices and not the drilling equipment. There are no planned uses of the emergency generator except for weekly exercising, which involves operation for approximately 20 minutes at loads up to capacity. This unit is grouped with the "seldom-used" emission units.

4.4.2 Lifeboats and Diver Engines

The *Discoverer* has four lifeboats and two diver engines on board for emergency use. The only planned use of the lifeboats is monthly exercising per Coast Guard requirements. These units are grouped in the "seldom-used" emission units.

4.5 Small IC Engines

4.5.1 Hydraulic Power Units

The remainder of the diesel engines are used only occasionally for specialized and intermittent tasks. The hydraulic power units (HPUs) consist of two approximately 200-kW engines and are used primarily for assisting in the rotation of the up to 30-foot diameter bit for drilling the MLCs, which is expected to occur for about six days per well. They may also be occasionally used for other unspecified tasks. These are grouped with the "Small IC Engine" category.

4.5.2 Cranes

The *Discoverer* has two 450-kW engines that power the cranes, which in turn are installed on pedestals and rotate. These are used very intermittently to move materials around the deck and to on-load supplies from the offshore supply vessel. Their operating levels are highly variable depending on the load being moved. The use cycle consists of lifting a load, swinging the load, lowering the load, and idling while the load is disconnected, then swinging back to the position of a new load and idling as it is connected. The only activity consuming high power is the load lifting; the remainder of the cycle is at low to idle power level. These engines are grouped with the "Small IC Engine" category.

4.5.3 Cementing Units

There are two 250-kW cementing pumps, also grouped with the small IC engines. These cementing units are used intermittently for forcing a liquid slurry of cement and additives down the casing and into the annular space between the casing and the wall of the borehole, which can only occur when drilling has stopped and the drill pipe is pulled out of the hole. The cement units are also used intermittently as high-pressure pumps for hydrostatically testing various types of well equipment and drilling components such as the wellhead connections, the blowout preventer, and other connections.

4.6 Boilers

The *Discoverer* has two diesel-fueled boilers for providing domestic and workspace heating: one boiler for normal operation and the second as a safety backup.

4.7 Waste Incinerator

Domestic and other non-hazardous materials are to be incinerated as needed. This man-camp-style incinerator is a two-stage, batch-charged unit capable of burning 125 kg/hr of solid trash. Its incineration capacity is limited to 3 MMBtu/hr (850 kW) of heat. Its use rate is uncertain, but is assumed to be continuous at capacity.

4.8 Auxiliary Support Vessels

4.8.1 Ice Management and Anchor Handling Vessels

The ice management and anchor handling vessels are expected to consist of two leased ships: one ice management vessel and one anchor handler vessel. An additional ice management vessel and anchor handler, the same, or similar to which were used to provide support to the Beaufort Sea exploration drilling program in 2012, will be available to provide occasional support to the *Discoverer* and associated vessels during the next drilling season. These additional vessels likely will spend a portion of the season outside of the program area. Majority of the time, one ice management vessel and one anchor handler vessel will be near the drillship. However, at times there could be another ice management vessel used to assist for short periods of time in the anchoring process or management of heavy ice. The second anchor handler will be primarily dedicated to the relief well drilling located in Dutch Harbor but may enter the program area for anchor prelays and other duties as needed. One purpose of these vessels will be to manage the ice, which involves deflecting or in extreme cases fragmenting any ice floes that could impact the *Discoverer* when it is drilling. Removal of ice buildup on the bow of the *Discoverer* by "bow washing" is also a possibility. Bow washing involves backing the anchor handler close to the *Discoverer* and with its propeller wash, pushing the ice to one side or the other, thereby clearing the ice. The second purpose is to handle the *Discoverer* anchors during connection to and separation from the sea floor. The ice floe frequency and intensity is unpredictable and could range from no ice to ice sufficiently dense that the vessels have insufficient capacity to manage it and the *Discoverer* would need to disconnect from its anchors and move off-site. During the 2012 drilling season in the Chukchi ice management was required for parts of seven days. This is assumed to be representative of an open water drilling season in the Chukchi Sea. If thick, multi-year ice were to encroach, it will likely be necessary to terminate drilling and move the *Discoverer* to another location.

Ice management vessels will be equipped with SCR and oxidation catalysts/CDPFs to control the NO_X, PM, CO, and VOC emissions.

The air modeling assumes the ice management vessels will move in a radius of up to 10 miles from the *Discoverer*, with an anchor handler remaining closer to the *Discoverer* and an ice management vessel roaming upwind 20 or more miles to track the leading edge of any ice moving toward the *Discoverer*.

4.8.2 Oil Spill Response Vessels

The OSR vessels in the Chukchi consists of an OSR vessel with three 34-foot work boats, an OSR tug/barge and a Nearshore OSR tug/barge with three 34-foot work boats and one 47-foot Rozema skimmer. Two work boats will be used to tow containment booms, while a third will act as a backup, for crew changes, and for re-fueling. The OSR vessels are expected to be used in the unplanned and unlikely event of an oil discharge to the water. The vessels normally will remain within about two miles and downwind of the drillship. The work boats will remain on the deck of an OSR vessel and will only be in the water for training, drills, and response events. The OSR vessels will have on-water drills at a maximum frequency of once per day, and generally eight hours for each exercise. The Nanuq pilot estimates that the two small boats will be powered with both engines at approximately 50 percent. If the Nanuq is used, it will likely be anchored with power requirements for domestic use only, not including propulsion, and be at less than 10 percent power from one engine. In addition, the Nanuq will assist in booming during fuel transfers with estimated power of 30 percent. The work boats will also assist in booming during fuel transfers with estimated power of 50 percent for 12 hours. The Nearshore OSR tug/barge and its work boats emissions are not quantified here as these vessels are expected to remain near the Arctic Containment System (ACS) outside the lease sale area (Program Area). An onboard incinerator is estimated to be used up to an hour per day for the season. The emissions from the incinerator are not quantified here because of the negligible emissions attributed to its use.

4.8.3 Offshore Supply Vessels

There are expected to be three offshore supply vessels involved in the project: two OSVs that will shuttle between the *Discoverer* and port, which is expected to be Dutch Harbor; one of which (for air impact evaluation purposes) is assumed to be beside the *Discoverer* in DP mode; and one operating at a considerable distance from the *Discoverer*. Another may be more or less continuously within about two miles of the *Discoverer*, available to transfer materials to and from the *Discoverer* as needed and as a drill discharge monitor (the science vessel). This vessel is expected to be anchored for most of the time. Only two of these offshore supply vessels are normally expected to be near the *Discoverer* at any one time. Both emissions inventories assume two OSV vessels, one in DP mode and one shuttling back and forth. For the emission inventories, OSV operation in DP mode beside the *Discoverer* is assumed to occur continuously. However, actual operations of OSVs in DP mode will be substantially less. to a fraction of this assumption. An onboard incinerator is estimated to be used up to an hour per day for the season. The emissions from the incinerator are not quantified here because of the negligible emissions attributed to its use.

4.8.3.1 Science Vessel

A science vessel, responsible for discharge-monitoring and other science-related tasks will be located nearby for the purpose of sampling the drillings plume effluent on a frequency of less than once per week. This vessel is expected to also serve as an OSV, as described above. An onboard incinerator may be used but the emissions from the incinerator are not quantified here because of the expected infrequent use while in the Program Area.

4.8.4 Arctic Oil Storage Tanker

An Arctic oil storage tanker will reside near the *Discoverer*, expected to be within about a 10-mile radius for the purpose of refueling all the vessels. In the unlikely event of a well-control incident, it will also serve as a receiver of any discharged oil, skimmed by the OSR vessels. The tanker will be anchored for most of the season and may only move to refuel a vessel. Most refueling is expected to involve the other vessel moving to the tanker, with one, or more vessels providing booming support during fuel transfers. An onboard incinerator is estimated to be used up to an hour per day for the season. The emissions from the incinerator are not quantified here because of the negligible emissions attributed to its use.

4.8.5 Other Vessels

4.8.5.1 Arctic Containment System

An Arctic containment system is to be available near the Program Area. The ACS is to consist of a tug, barge and anchor handler. The ACS tug/barge will remain on location outside the lease sale area, located in Kotzebue Sound or Barrow in future years. An anchor handler may remain with the containment barge but may enter the Program Area for anchor prelays and other duties. Emissions while in port will be minimal and are not estimated because these areas are outside of the Program Area. The anchor handler emissions are also not estimated because these emissions are assumed to be included with the Ice Management/Anchor Handling Vessels, meaning only two anchor handlers will be near the drillship at any one time.

4.8.5.2 Shallow Water Landing Craft

A shallow water landing craft will on occasion be available within the Program Area, but may spend a portion of the open water drilling season outside of the Program Area near Kotzebue Sound or Barrow. These emissions have not been quantified for either inventory because the emissions are minimal and the vessel will primarily be located outside of the Program Area.

4.8.5.3 Resupply Tug/Barge and Support Tug

A resupply tug and barge pair is expected to be located within an area of Kotzebue Sound but will occasionally visit the drillship. A support tug is to remain outside the lease sale area most of the time, making occasional trips to the *Discoverer*. These emissions have not been quantified for either inventory because the emissions are minimal and the vessels will primarily be located outside of the Program Area.

4.9 On-Land Support Emissions

The on-land activities associated with the *Discoverer* exploration activities are likely to include support facilities in Barrow, with possible minor activities in Wainwright. The facilities in Barrow may include a man-camp, storage facilities, and an aircraft hangar, requiring heat and power. Transport of personnel and materials to and from the airport would be by means of automobiles, vans, or pickup trucks, fueled with diesel. Transport to and from the vessels will be by up to three helicopters, stationed in Barrow. Communications may be through existing communications center networks or leases from existing facilities. No industrial growth is anticipated.

4.10 Pre and Post-Drilling Emissions

4.10.1 Drilling Site Preparation and Decommissioning

The drill site preparation and decommissioning will involve placing and lifting the anchors of the *Discoverer*, at most a 48-hour process when there are no drilling activities. This involves at most the anchor handler and primary ice management vessels. The remainder of the site preparation and decommissioning activities includes transiting, which involves moving away (in different directions) from the drill site. In all, there would be at most two days of two ice management vessels operating within a five-mile radius of the drill site. The emissions during these non-drilling periods are not quantified.

4.10.2 Vessels Entering and Leaving the Drill Site

The *Discoverer* is expected to travel to the drill site from Dutch Harbor and on its own power. Once it arrives it will proceed to moor to its eight anchors. The anchoring process can take up to two days, involving the setting of the anchors, attaching to the anchors, and final tensioning. This is accomplished with the assistance of one or two of the ice management/anchoring handling vessels. The power level needed will depend on the task, which could be running the eight anchor cables or holding the *Discoverer* in position. Neither is expected to require more than 50 percent power in any single hour, and less over the full anchoring process. This process is reversed when drilling is completed for the well. In addition, a second set of eight anchors may be deployed to another drill site, which could require inspection after drilling at the first site has ended and before drilling at the second site has commenced. The project-wide power needed in these two-day maximum periods, when there is no drilling occurring, will be low in comparison to during the drilling process. The emissions during these non-drilling periods are not quantified.

4.10.3 On-Land Construction Activities

There may be adequate existing land support for the personnel and other construction activities needed for this project. However, if not, there could be expansion of a man-camp or a helicopter hangar in the Barrow area that require some construction activity, and the emissions from this construction would occur before the drilling commences. This possible activity is characterized as site preparation and installation of manufactured buildings. The site preparation could involve importing of gravel and minor grading. Normal fugitive dust mitigation will be employed, such as watering of dusty surfaces and roadways, and covering gravel trucks. Manufactured buildings would be used and building placement would be expeditious, involving only highway haul trucks and cranes. Because these are minor emitting activities which occur before the drilling program commences, the emissions are not quantified. Impacts will be small and local to the sites.

5.0 Emission Calculations

The regulated pollutants to be evaluated include particulate matter ($PM_{2.5}$ and PM_{10}), CO, nitrogen dioxide (NO_2), SO_2, lead (Pb), ozone (O_3), and greenhouse gases (GHG). Note that O_3 includes evaluation of pre-cursors, VOC and NO_X. Included in the analysis will be the evaluation of the formation of secondary aerosols, a component of $PM_{2.5}$.

5.1 Emission Unit Groups

Emission units, along with similar vessels have been grouped together for the air emission inventory.

Table 2 lists the emission unit groups for the *Discoverer*. Table 3 lists the auxiliary support vessel groupings.

Table 4 lists the onshore source groupings. The groupings show the aggregated nameplate ratings for each group, and candidate sources. The auxiliary support vessels only include those vessels within the program area that emissions have been estimated for.

Table 2. ***Discoverer*** **Emission Unit Groupings**

Emission Unit Group	Candidate Emission Unit(s)	Aggregate Nameplate Rating	
Generation	Caterpillar 3512C	6,000	kW
Propulsion	STX-MAN 6S42MC7	6,480	kW
Small IC Engines	Multiple Diesels	1,763	kW
Seldom-Used IC Engines	Multiple Diesels	645	kW
Heaters & Boilers	Clayton 200	16	MMBtu/hr
Incinerator	TeamTec GS500C	276	lb/hr

Table 3. Auxiliary Support Emission Unit Groupings

Duty	Candidate Vessels	Aggregate Nameplate Rating
Ice Management and Anchor Handling – Propulsion & Generation	Fennica, Nordica, Aiviq & Tor Viking	80,550 kW
Ice Management and Anchor Handling – Boilers	Fennica, Nordica, Aiviq & Tor Viking	24 MMBtu/hr
Ice Management and Anchor Handling – Incinerator	Fennica, Nordica & Aiviq [a]	584 lb/hr
Oil Spill Response	Nanuq, Ocean Wave Tug / Endeavor Barge[b], 3 Kvichak workboats	18,369 kW
Offshore Supply Vessels	Sisuaq & Supporter	16,042 kW
Science Vessel	Sisuaq or similar	8,357 kW
Arctic Oil Storage Tanker	Affinity	20,611 kW

[a] The Tor Viking does not contain an incinerator

[b] The Ocean Wave Tug/Arctic Endeavor Barge vessel combination was used for the emission inventory because it is larger than the Sea Robin Tug/Klamath barge. This is for emission modeling only.

Table 4. Onshore Support Emission Unit Groupings

Emission Unit	Nameplate Rating/Use/Fuel Consumption	
Helicopters	40	roundtrips/wk
Man Camp Generators	1,396	kW
Hangar/Storage Building Boiler	5	MMBtu/hr
Vehicles	200	gallons/wk

5.2 Short-term and Seasonal Use Limitations

Emissions are estimated by combining maximum projected source use with emission factors. Maximum projected source use is determined using the source grouping maximum operational power levels, in this case represented by maximum projected fuel consumption, and representative emission factors. Short-term (hourly) maximum projected emissions for the *Discoverer* and support vessels are estimated assuming nameplate ratings, modified by limitations established from a combination of safety policies, fuel efficiency policies, and good engine care policies. Seasonal use is assumed to be over a full 120–day maximum season. Usages are modified from the short-term usages using driller experience. The short-term and seasonal source group use limitations are provided in

Table 5 and Table 6.

The calculation of emissions is provided on two groups of tables provided in Attachments A and B. 0 provides the AQRP emission inventory, for the drillship and auxiliary support vessels, for the AQRP exemption formula comparison. **Error! Reference source not found.** provides the NEPA emission inventory representing the maximum projected emissions. Some calculations have been made to estimate a group average use.

Table 5. Short-term Limitations to Emission Unit Groups

Policy Limits on Emission Units/Group	Percent of Nameplate & Other	Reason for Limitation/Explanation
Diesel IC Engines	80%	Good maintenance practice maximum power level. Used for all IC engines.
Discoverer Small IC Engines	57% *	Cementing cannot operate simultaneously with drilling activity.
Discoverer Seldom-Used (including emergency) Engines	63% *	One engine (the largest) assumed to be running every hour. Exercise requirement.
OSV 1(DP vessel) & Science Vessel	50% *	Safety Policy, need for adequate power to pull away from *Discoverer* in emergency conditions.
OSV 2 (shuttle vessel)	65% *	Power level for efficient vessel cruising speed. Directive from operator to conserve fuel.
Arctic Oil Storage Tanker	32% *	Propulsion Engines operating at 30% power and 2 of the 3 generators operating at 80% power.
Sulfur Content of Diesel Fuel for all Marine Applications	Purchase 15 ppm, combust 100 ppm	By contract, ULSD fuel will be purchased during season. Because vessels are not limited to ULSD use during off season, maximum is considered to be 100 ppm.
Man Camp Generators	59% *	Three man camp generators: two operating at 80% and one operating at 80% for 15 minutes (the back-up generator).

* Further explained below

AQRP emission inventory short-term emissions are determined using the good maintenance practice of a maximum power level of 80 percent power. All boilers and incinerators are assumed at continuous use, 100 percent capacity. The short-term use limitations are explained below:

- Small IC Engines. The cementing engines cannot operate simultaneously with drilling activity. Since maximum drilling emissions are higher than cementing without drilling, the short-term emissions are calculated assuming that only the non-cementing engines are operating. The non-cementing IC engines total 1,263 kW, with the total group rating of 1,763 kW. All IC engines are operated at a maximum power level of 80 percent. The maximum power level for the group is:

$$\left(\frac{1{,}263\ kW}{1{,}763\ kW}\right) \times 80\% = 57\% \qquad (1)$$

- *Discoverer* Seldom-Used Engines. The largest engine is assumed to be running every hour. Therefore, the maximum power level for the group is:

$$679\ hp \div 1.34\ {}^{hp}/_{kW} \div 645\ kW \times 80\% = 63\% \qquad (2)$$

- OSVs. The stationary offshore supply vessel in DP mode operates at 50 percent power, and the shuttle offshore supply vessel cruises at 65 percent power. The average power level for the group is:

$$(50\% + 65\%) \div 2 = 58\% \qquad (3)$$

- Arctic Oil Storage Tanker. It is assumed that the propulsion engines will operate at 30 percent power plus 2 of the 3 generators will operate at 80 percent power. The remaining power, assumed to have minimal operation is the seldom-used equipment on board the tanker. The maximum power level for the group is:

$$30\% \times \frac{15{,}820\ kW}{20{,}611\ kW} + 80\% \times \frac{3{,}360\ kW\ ({}^{2}/_{3})}{20{,}611\ kW} = 32\% \qquad (4)$$

- Man Camp Generators. It is assumed that the man camp has three generators; two 448 kW primary generators and one 500 kW emergency backup generators. The emergency backup generator is to be operated 15 minutes per week for regular checks. The maximum hourly power level for the group is:

$$80\% \times \frac{448\ \times\ 2\ kW}{1{,}396\ kW} + 80\% \times \frac{15\ minutes}{60\ minutes} \times \frac{500\ kW}{1{,}396\ kW} = 59\% \qquad (5)$$

Table 6. Seasonal Limitations for Emission Unit Groups

Emission Unit/Group	Limit	Reason for Limitation/Explanation
Discoverer Generators	64% *	On average, ¼-hour lifting drill stem at 15% power and ¾-hour drilling at 80% power.
Discoverer Propulsion	2 days, operating at 80% power	2 days to propel the *Discoverer* during anchor and high-wind support.
Discoverer Small IC Engines	57% *	Cementing cannot operate simultaneously with drilling activity.
Discoverer Seldom-Used (including emergency) Engines	Less than 1% of the season*	Each engine will be exercised less than 1 hour per week based on Safety Policy Requirement.
Boilers	50%	Redundant capacity for heating. Safety Policy.
Ice Management Vessel 1 (performing ice management operation with ice)	80% power for 7 days (6% of time, while ice fragmenting), 30% for remaining time*	From 2012 drilling season, 7 partial days were spent managing ice.
Ice Management Vessel 2 (ice and anchor handling use)	80% power for 10 days (8% of time) and gone for remaining time *	Occasional use if vessel is free and there is a need for two ice management vessels simultaneously.
Anchor Handler 1 – Multiple Short-Term Duties near *Discoverer* (bow washing, transfer of personnel, oil-spill training, ice monitoring)	40% power level all season *	Safe operation in close proximity to *Discoverer* is at low power to avoid collision.
Anchor Handler 2	80%power for 15 days of the season *	Occasional use if vessel is free and there is a need for two anchor handler vessels simultaneously
OSR Vessel and Tug	26% *	20% power while anchored and an additional 5% representing a minimal need to shift locations. 30% power while booming for refueling.
OSR Work Boats	50% *	Power level during training exercises.
OSV 1 (DP vessel)	50% *	Safety Policy, need for adequate power to pull away from *Discoverer* in emergency conditions.
OSV 2 (shuttle vessel)	65%, 40 days of the season *	Power level for efficient vessel cruising speed. Directive from operator to conserve fuel.
Arctic Oil Storage Tanker	10% *	Propulsion Engines operating at 30% power and 2 of the 3 generators operating at 80% power.
Man Camp Generators	51% *	Three man camp generators: two operating at 80% and one operating at 80% for 15 minutes per week (the back-up generator). 24 weeks of operation.

* Further explained below

The AQRP emission inventory seasonal emissions are increased above those expected to actually occur under the NEPA emission inventory. The increases for the AQRP emission inventory result in the most conservative estimate of expected use of equipment while the facility seasonal emissions remain less than the exemption formula thresholds of 30 CFR 550.303(d). These calculations provide the most flexibility in operation under any proposed fuel limit that may be imposed under the AQRP.

The seasonal (long-term) use limitations are explained below.

- *Discoverer* Generation. Over the season, on average, ¼-hour will be spent lifting the drill stem at 15% power and ¾-hour drilling at 80% power. Therefore, the average seasonal use is:

$$15\% \times {}^{1}/_{4} + 80\% \times {}^{3}/_{4} = 64\% \qquad (6)$$

- Small IC Engines. The cementing engines cannot operate simultaneously with drilling activity and since maximum drilling emissions are higher than cementing without drilling, these long-term emissions are calculated at no load. The non-cementing IC engines total 1,263 kW, with the total group rating of 1,763 kW. All IC engines operated at a maximum power level of 80 percent. The average power level for the group is:

$$80\% \times \left(\frac{1{,}263\ kW}{1{,}763\ kW}\right) = 57\% \qquad (7)$$

- *Discoverer* Seldom-Used Engines. Each engine will be exercised less than 1 hour per 4 days.

- Ice Management and Anchor Handling Propulsion and Generation. Ice management vessel 1 will operate at 80 percent power for 7 days (6 percent of time, while ice fragmenting) and 30 percent power for the remaining 113 days (94 percent of time, moving around to track ice). Ice management vessel 2 will operate at 80 percent power for 10 days (8 percent of time) and will be gone from the project area for the remaining time. Anchor handler 1 will operate at an average of 40 percent power for the entire season. Anchor Handler 2 is assumed to be at 80 percent power for 15 days for additional prelay of anchors. Therefore, the average seasonal use is:

$$\left[\begin{array}{c}\left(80\% \times \frac{7\ days}{120\ days} + 30\% \times \frac{113\ days}{120\ days}\right) + \left(80\% \times \frac{10\ days}{120\ days}\right) + \\ 40\% + \left(80\% \times \frac{15\ days}{120\ days}\right)\end{array}\right] \div 4 = 22\% \qquad (8)$$

- Ice Management and Anchor Handling Boilers. All boilers are assumed at 50 percent capacity based on redundant capacity for heating. In addition, ice management vessel 2 is only anticipated to be within the project area for 10 days and anchor handler 2 is only anticipated to be within the project area for 15 days. The average seasonal use is:

$$\left[50\% + 50\% + \left(50\% \times \frac{10\ days}{120\ days}\right) + \left(50\% \times \frac{15\ days}{120\ days}\right)\right] \div 4 = 28\% \quad (9)$$

- Ice Management and Anchor Handling Incinerators. All 3 incinerators are assumed at 100 percent capacity. In addition, ice management vessel 2 is only anticipated to be within the project area for 10 days. The average seasonal use is:

$$\left[100\% + 100\% + \left(100\% \times \frac{10\ days}{120\ days}\right)\right] \div 3 = 69\% \quad (10)$$

- OSR. It is assumed that the OSR vessel (7,535 kW) and tug/barge (9,464 kW) will operate at 20 percent power while anchored. An additional 5 percent representing a minimal need to shift locations equals 25 percent. In addition, the OSR vessel will operate at 30 percent power while booming 30 days of the season. The OSR vessel work boats (1,370 kW) are assumed to operate at 50 percent power during training exercises and booming, 12 hours per day for 120 days. The average seasonal use is:

$$\left(25\% \times \frac{90\ days}{120\ days} + 30\% \times \frac{90\ days}{120\ days}\right) \times \frac{7{,}535\ \text{kW}}{18{,}369\ \text{kW}} + \left(25\% \times \frac{9{,}464\ \text{kW}}{18{,}369\ \text{kW}}\right) + \left(50\% \times \frac{12\ \text{hours}}{24\ \text{hours}} \times \frac{1{,}370\ \text{kW}}{18{,}369\ \text{kW}}\right) = 26\% \quad (11)$$

- OSVs. For the NEPA emission inventory it is assumed the OSV 1 (stationary vessel) will operate at 50 percent power for the entire season, and the OSV 2 (shuttle vessel) at 65 percent power for 40 days of the season. The average seasonal use is:

$$\left(50\% + 65\% \times \frac{40\ days}{120\ days}\right) \div 2 = 35\% \quad (12)$$

- Arctic Oil Storage Tanker. The Arctic oil storage tanker is anticipated to be anchored much of the time, with some travel to nearby vessels for refueling, about 6 days out of the season. It is assumed that the propulsion engines will operate at 30 percent power while traveling plus 2 of the 3 generators will operate at 80 percent power, continuously for the entire season. The remaining power, assumed to have minimal operation is the seldom-used equipment on board the tanker.

$$30\% \times \frac{15{,}820\ kW}{20{,}611\ kW} \times \frac{6\ days}{120\ days} + 80\% \times \frac{3{,}360\ kW\ ({}^{2}/_{3})}{20{,}611\ kW} = 10\% \quad (13)$$

- Science Vessel (which is an OSV). It is assumed that the science vessel will operate at 20 percent power while anchored half of the season, and at 50 percent power while traveling around the drill site for the other half of the season.

$$20\% \times \frac{60\ days}{120\ days} + 50\% \times \frac{60\ days}{120\ days} = 35\% \tag{14}$$

- Man Camp Generators. It is assumed that the man camp has three generators; two 448 kW primary generators and one 500 kW emergency backup generator. The emergency backup generator is to be operated 15 minutes per week for regular checks. The maximum daily power level for the group is:

$$\begin{gathered} 80\% \times \frac{448\ \times\ 2\ kW}{1{,}396\ kW} + \\ 80\% \times \frac{15\ minutes}{week} \times \frac{1\ hour}{60\ minutes} \times \frac{1\ day}{24\ hours} \times \frac{week}{7\ day} \times \frac{500\ kW}{1{,}396\ kW} = 51\% \end{gathered} \tag{15}$$

5.3 Sulfur Dioxide and Greenhouse Gas Emissions

SO_2 emissions are controlled through the use of ULSD fuel in all the diesel engines on the *Discoverer* and the auxiliary vessels. Shell has made a commitment to North Slope air quality to purchase and use ULSD during the drilling season. Emissions are calculated assuming 100 ppm sulfur content to account for the initial possible tank contamination from residual diesel fuel. SO_2 and GHG emissions are estimated directly from the fuel use. Minor emissions from the incinerators' use are included based on waste burned.

5.4 Emission Factors

Emission factors for some of the emission units on the *Discoverer* and ice management/anchor handling vessels are derived from the 2012 source testing of those sources. For the other vessels, the emission factors are from the EPA marine engine tier standards. For the onshore emission units, the emission factors are a mixture of other generic emission factors. The source testing emission factors are averaged over similar engines, so that for example, all the ice management vessel incinerator emission measurements are averaged and a single factor is used to represent emissions from all of those incinerators.

The six *Discoverer* generators are fitted with SCR and CDPF as emission control devices. These emission control devices require some warm-up time, generally less than one-half hour, to become effective. The NEPA emissions inventory accounts for this by averaging into the emission factor five engines in a controlled state and one operating uncontrolled. The *Discoverer* generators have been replaced with Caterpillar D3512c engines in 2013 and will be fitted with the same SCR and CDPF controls used for the previous Caterpillar D399 engines. The controlled emission factor is based on an estimated control efficiency of 50 percent per pollutant, where appropriate, applied to the applicable uncontrolled manufacturer data for the Caterpillar 3512c engine. The manufacturer maximum emission rate data are applied for the operation in an uncontrolled scenario. The combined NO_x factor used for the controlled emissions from the *Discoverer* Generations group is:

$$3.0\ {}^{g}/_{kW-hr} \times {}^{5}/_{6} + 5.9\ {}^{g}/_{kW-hr} \times {}^{1}/_{6} = 3.4\ {}^{g}/_{kW-hr} \qquad (16)$$

5.5 AQRP Emission Summary – Addressing BOEM AQRP

The evaluation of emissions consistent with the AQRP definitions of "facility" as provided in 30 CFR Part 550.302, includes AQRP emissions from the *Discoverer* drillship and auxiliary support vessels operating within 25 miles of the drillship for the full 120-day season. Shell has elected to represent emissions as if the emission controls are not present. These controls include SCR and CDPFs on the primary generators. Shell will in fact operate these controls throughout the drilling season. Use of ULSD is an emission control practice, although not as a physical control device. Shell does not provide a calculation of sulfur emissions as if some hypothetical higher-sulfur-content fuel were to be used because there is no well defined upper limit on the possible sulfur content of fuel used beyond the Alaska Seaward Boundary of three miles from shore. In addition, the maximum projected seasonal usage percentages have been increased above those expected to actually occur. Increases to the maximum projected operation and assuming uncontrolled emissions demonstrate that the facility has an exemption threshold of 63 miles. The distance from a drill site to the shoreline is estimated at 64 miles. Table 7 presents the estimated AQRP seasonal uncontrolled emissions. Attachment A provides the detailed emission calculation summaries.

Table 7. AQRP Seasonal Uncontrolled Emissions by Group

Emission Unit	NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	SO_2 ton/season
Discoverer					
Generation	112.38	3.05	24.76	24.76	6.59
Propulsion	2.47	0.07	1.71	0.45	0.12
Small IC Engines	30.78	1.12	27.98	7.27	1.94
Seldom-Used IC Engines	14.74	0.41	10.24	2.66	0.71
Boilers	3.64	0.05	0.42	0.06	1.87
Incinerator	0.64	1.37	2.15	19.87	0.50
SUBTOTAL	*164.65*	*6.07*	*67.26*	*38.89*	*11.72*
Ice Management & Anchor Handling (4 vessels)					
Propulsion & Generation	920.59	25.57	639.30	166.22	44.24
Boilers	4.58	0.19	0.06	0.09	2.85
Incinerator	1.81	5.21	6.27	42.05	1.05
SUBTOTAL	*926.98*	*30.98*	*645.63*	*208.36*	*48.14*
Oil Spill Response (Vessel, Tug & Barge, 3 work boats)					
All IC Engines (non-emergency)	251.92	7.00	174.94	45.49	12.11
SUBTOTAL	*251.92*	*7.00*	*174.94*	*45.49*	*12.11*
Offshore Supply (2 vessels)					
All IC Engines (non-emergency)	366.68	10.19	254.64	66.21	17.62
SUBTOTAL	*366.68*	*10.19*	*254.64*	*66.21*	*17.62*
Arctic Oil Storage Tanker					
All IC Engines (non-emergency)	117.78	3.27	81.79	21.27	5.66
SUBTOTAL	*117.78*	*3.27*	*81.79*	*21.27*	*5.66*
Science Vessel					
All IC Engines (non-emergency)	191.02	5.31	132.65	34.49	9.18
SUBTOTAL	*191.02*	*5.31*	*132.65*	*34.49*	*9.18*
ANNUAL EMISSIONS TOTAL	*2,019*	*63*	*1,357*	*415*	*104*
PROJECT DURATION TOTAL	*6,057*	*189*	*4,071*	*1,245*	*312*

The AQRP exemption equations, found in 30 CFR Part 550.303 (d), are provided below, where E is in units of tons per year and D is the distance from the proposed facility to the closest onshore area in units of statute miles.

For CO: $E = 3400\ D^{2/3}$

For TSP,[2] SO_2, NO_X, and VOC: $E=33.3D$

BOEM has instructed Shell to use the TSP equation for all forms of PM.

At 2,019 tons of NO_X, the minimum exemption distance is 60.6 statute miles.

5.6 NEPA Emission Summary

Table 8 presents the AQRP emission inventory maximum projected short-term emissions by group for the *Discoverer*, close support vessels, and on-land associated support emissions. These estimates do not include emissions from other associated vessels in as-yet undefined ports. The emissions from these other vessels are sufficiently distant from the project located out of the Program Area that their emissions will not interact with nor contribute to project impacts. Table 9 presents the estimated seasonal NEPA emission inventory emissions by group.

[2] Total Suspended Particulate

Table 8. Maximum Projected Short-term Emissions by Group [a]

Emission Unit	NO_X lb/hr	PM lb/hr	CO lb/hr	VOC lb/hr	SO_2 lb/hr	Pb lb/hr
Discoverer						
Generation	35.98	1.06	8.47	3.17	3.66	1.3E-3
Propulsion	82.29	2.29	57.14	14.86	3.95	1.4E-3
Small IC Engines	12.25	0.45	11.13	2.90	0.77	2.7E-4
Seldom-Used IC Engines	6.43	0.18	4.47	1.16	0.31	1.1E-4
Boilers	2.53	0.03	0.29	0.04	1.30	1.4E-4
Incinerator	0.44	0.95	1.49	13.80	0.35	2.9E-2
SUBTOTAL	*139.92*	*4.95*	*83.00*	*35.93*	*10.34*	*3.3E-2*
Ice Management & Anchor Handling (4 vessels)						
Propulsion & Generation	88.08	14.21	8.52	55.41	49.15	1.8E-2
Boilers	3.18	0.13	0.04	0.06	1.98	2.2E-4
Incinerator	1.26	3.62	4.35	29.20	0.73	6.2E-2
SUBTOTAL	*92.51*	*17.96*	*12.92*	*84.67*	*51.86*	*8.0E-2*
Oil Spill Response (Vessel, Tug & Barge, 3 work boats)						
All IC Engines (non-emergency)	233.26	6.48	161.99	42.12	11.21	4.0E-3
SUBTOTAL	*233.26*	*6.48*	*161.99*	*42.12*	*11.21*	*4.0E-3*
Offshore Supply (2 vessels)						
All IC Engines (non-emergency)	146.42	4.07	101.68	26.44	7.04	2.5E-3
SUBTOTAL	*146.42*	*4.07*	*101.68*	*26.44*	*7.04*	*2.5E-3*
Arctic Oil Storage Tanker						
All IC Engines (non-emergency)	103.78	2.88	72.07	18.74	4.99	1.8E-3
SUBTOTAL	*103.78*	*2.88*	*72.07*	*18.74*	*4.99*	*1.8E-3*
Science Vessel						
All IC Engines (non-emergency)	66.32	1.84	46.06	11.98	3.19	1.1E-3
SUBTOTAL	*66.32*	*1.84*	*46.06*	*11.98*	*3.19*	*1.1E-3*
Onshore Support						
Helicopters	0.20	0.04	1.25	1.50	0.43	-
Man Camp Generators	7.73	0.36	6.30	2.34	0.62	-
Hangar/Storage Building Boiler	0.49	0.04	0.41	0.02	0.41	2.5E-6
Vehicles	7.9E-3	7.9E-4	0.29	7.7E-3	1.2E-2	-
SUBTOTAL	*8.43*	*0.43*	*8.25*	*3.86*	*1.47*	*2.5E-6*
TOTAL	***791***	***39***	***486***	***224***	***90***	***1 2E-1***

[a] All emission factors, operational rates and calculations can be found in Attachment B.

Table 9. Maximum Projected Seasonal Emissions by Group [a]

Emission Unit	NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	SO_2 ton/season	Pb ton/season
Discoverer						
Generation	41.45	1.22	9.75	3.66	4.22	1.5E-3
Propulsion	1.97	0.05	1.37	0.36	0.09	3.4E-5
Small IC Engines	17.64	0.64	16.03	4.17	1.11	4.0E-4
Seldom-Used IC Engines	0.06	1.5E-3	0.04	0.01	2.7E-3	9.5E-7
Boilers	1.82	0.02	0.21	0.03	0.93	1.0E-4
Incinerator	0.64	1.37	2.15	19.87	0.50	4.2E-2
SUBTOTAL	*63.57*	*3.31*	*29.55*	*28.09*	*6.85*	*4.4E-2*
Ice Management & Anchor Handling (4 vessels)						
Propulsion & Generation	35.51	5.73	3.44	22.34	19.81	7.1E-3
Boilers	1.26	0.05	0.02	0.03	0.79	8.7E-5
Incinerator	1.26	3.62	4.35	29.20	0.73	6.2E-2
SUBTOTAL	*38.03*	*9.40*	*7.80*	*51.56*	*21.33*	*6.9E-2*
Oil Spill Response (Vessel, Tug & Barge, 3 work boats)						
All IC Engines (non-emergency)	107.12	2.98	74.39	19.34	5.15	1.8E-3
SUBTOTAL	*107.12*	*2.98*	*74.39*	*19.34*	*5.15*	*1.8E-3*
Offshore Supply (2 vessels)						
All IC Engines (non-emergency)	131.39	3.65	91.25	23.72	6.31	2.3E-3
SUBTOTAL	*131.39*	*3.65*	*91.25*	*23.72*	*6.31*	*2.3E-3*
Arctic Oil Storage Tanker						
All IC Engines (non-emergency)	46.38	1.29	32.21	8.38	2.23	7.9E-4
SUBTOTAL	*46.38*	*1.29*	*32.21*	*8.38*	*2.23*	*7.9E-4*
Science Vessel						
All IC Engines (non-emergency)	66.86	1.86	46.43	12.07	3.21	1.1E-3
SUBTOTAL	*66.86*	*1.86*	*46.43*	*12.07*	*3.21*	*1.1E-3*
Onshore Support						
Helicopter	0.28	0.05	1.80	2.16	0.62	-
Man Camp Generators	12.76	0.64	11.16	4.15	1.10	-
Hangar/Storage Building Boiler	0.35	0.03	4.88	0.01	0.29	1.8E-6
Vehicles	1.2E-2	1.2E-3	0.42	1.1E-2	0.02	-
SUBTOTAL	*13.41*	*0.72*	*18.27*	*6.33*	*2.03*	*1.8E-6*
ANNUAL EMISSIONS TOTAL	***467***	***23***	***300***	***149***	***47***	***1 2E-1***

[a] All emission factors, operational rates and calculations can be found in Attachment B.

Attachment A – AQRP Emission Inventory

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Discoverer OCS Source - Seasonal AQRP Emissions for each source group

	NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	SO_2 ton/season
Discoverer					
Generation	112 38	3 05	24 76	8 57	6 59
Propulsion	2 47	0 07	1 71	0 45	0 12
Small IC engines	30 78	1 12	27 98	7 27	1 94
Seldom-Used IC engines	14 74	0 41	10 24	2 66	0 71
Boilers	3 64	0 05	0 42	0 06	1 87
Incinerator	0 64	1 37	2 15	19 87	0 50
SUBTOTAL	*164.65*	*6.07*	*67.26*	*38.89*	*11.72*
Ice Management & Anchor Handling (4 vessels)					
Propulsion & Generation	920 59	25 57	639 30	166 22	44 24
Boilers	4 58	0 19	0 06	0 09	2 85
Incinerator	1 81	5 21	6 27	42 05	1 05
SUBTOTAL	*926.98*	*30.98*	*645.63*	*208.36*	*48.14*
Oil Spill Response (Vessel, Tug & Barge, 3 WB)					
All IC Engines (non-emergency)	251 92	7 00	174 94	45 49	12 11
SUBTOTAL	*251.92*	*7.00*	*174.94*	*45.49*	*12.11*
Offshore Supply (2 vessels)					
All IC Engines (non-emergency)	366 68	10 19	254 64	66 21	17 62
SUBTOTAL	*366.68*	*10.19*	*254.64*	*66.21*	*17.62*
Science Vessel					
All IC Engines (non-emergency)	191 02	5 31	132 65	34 49	9 18
SUBTOTAL	*191.02*	*5.31*	*132.65*	*34.49*	*9.18*
Arctic Oil Storage Tanker					
All IC Engines (non-emergency)	117 78	3 27	81 79	21 27	5 66
SUBTOTAL	*117.78*	*3.27*	*81.79*	*21.27*	*5.66*
TOTAL	**2,019**	**63**	**1,357**	**415**	**104**

Seasonal Pollutant Total

NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	SO_2 ton/season
2,019	63	1,357	415	104

BOEM EXEMPTION FORMULA 30 CFR 550 303

	NOx ton/year
Discoverer & Auxiliary Support	2,019

Formula:

E=33 3D NOx, TSP, SO_2, VOC

MINIMUM DISTANCE BASED ON EMISSIONS

	Based on: NOx
Discoverer & Auxiliary Support	60 6 statute miles

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FOR AQRP ANALYSIS ONLY

OPERATING ASSUMPTIONS

ACTIVITY LEVELS

Emission Units to permit	capacity		hourly max load % of capacity	per season max load % of capacity	days/season	Load Comments
Discoverer						
Generation	6,000	kW	80%	100%	120	
Propulsion	6,480	kW	80%	100%	2	Season: max use of Propulsion is estimated for 2 days
Small IC engines	1,763	kW	80%	100%	120	
Seldom-Used IC engines	645	kW	80%	100%	120	
Boilers	16	MMBtu/hr	100%	100%	120	
Incinerator	276	lb/hr	100%	100%	120	
Auxiliary Support - within 25 nm						
Ice Management & Anchor Handling (4 vessels)						
Propulsion & Generation	80,550	kW	80%	50%	120	
Boilers	24	MMBtu/hr	100%	100%	120	
Incinerator	584	lb/hr	100%	100%	120	
Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
All IC Engines (non-emergency)	18,369	kW	80%	60%	120	
Offshore Supply (2 vessels)						
All IC Engines (non-emergency)	16,042	kW	80%	100%	120	
Science Vessel						
All IC Engines (non-emergency)	8,357	kW	80%	100%	120	
Arctic Oil Storage Tanker						
All IC Engines (non-emergency)	20,611	kW	80%	25%	120	

ASSUMED AUXILIARY SUPPORT CANDIDATE VESSELS FOR EI	
Ice Management 1	Fennica
Ice Management 2	Nordica
Anchor Handler 1	Aiviq
Anchor Handler 2	Tor Viking
Oil Spill Response Vessel	Nanuq
Oil Spill Response - Tug/Barge	Ocean Wave/Arctic Endeavour
Offshore Supply Vessel 1	Sisuaq
Offshore Supply Vessel 2	Supporter
Science vessel	Sisuaq
Arctic Oil Storage Tanker	Affinity

ASSUMPTIONS			Reference
Diesel engine thermal efficiency	7,000	Btu/hp-hr	AP42 Table 3 3-1, 10/96
Diesel heating value	0 1312	MMBtu/gallon	Tesoro Nikiski, Email Royal Harris 4/20/11
Diesel density	7 00	lb/gal	Tesoro Nikiski, Email Royal Harris 4/20/11
Municipal solid waste HHV	9 95	MMBtu/short ton	Table C-1 to Subpart C of 40 CFR Part 98
Emission factors represent over 90% of the capacity power			

CONVERSIONS

1 34	hp/kW	2,000	lb/ton	32 07	wt S
0 7457	kW / hp	24	hr/day	64 06	wt SO2
1,000,000	Btu/MMBtu	168	hr/wk	2 00	wt conversion of S to SO2
453 592	g/lb	2 2	lb/kg	0 608	lb/hp-hr to kg/kW-hr
17 1	wk/season	1000	g/kg		

blue values are input, black values are calculated or linked

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EMISSIONS

	NOx		PM		CO		VOC		SO_2	
Emission Units	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**
Discoverer										
Generation	62	112	2	3	14	25	5	9	4	7
Propulsion	82	2	2	7E-2	57	2	15	4E-1	4	1E-1
Small IC engines	17	31	6E-1	1	16	28	4	7	1	2
Seldom-Used IC engines	8	15	2E-1	4E-1	6	10	1	3	4E-1	7E-1
Boilers	3	4	3E-2	5E-2	3E-1	4E-1	4E-2	6E-2	1	2
Incinerator	4E-1	6E-1	1E+0	1	1	2	14	20	3E-1	5E-1
SUBTOTAL	173	165	6	6	94	67	39	39	11	12
Auxiliary Support - within 25 nm										
Ice Management & Anchor Handling (4 vessels)										
Propulsion & Generation	1,023	921	28	26	710	639	185	166	49	44
Boilers	3	5	1E-1	2E-1	4E-2	6E-2	6E-2	9E-2	2	3
Incinerator	1	2	4	5	4	6	29	42	7E-1	1
Oil Spill Response (Vessel, Tug & Barge, 3 WB)										
All IC Engines (non-emergency)	233	252	6	7	162	175	42	45	11	12
Offshore Supply (2 vessels)										
All IC Engines (non-emergency)	204	367	6	10	141	255	37	66	10	18
Science Vessel										
All IC Engines (non-emergency)	106	191	3	5	74	133	19	34	5	9
Arctic Oil Storage Tanker										
All IC Engines (non-emergency)	262	118	7	3	182	82	47	21	13	6
SUBTOTAL	1,832	1,854	55	57	1,274	1,290	359	376	91	93
TOTAL	2,005	2,019	60	63	1,368	1,357	398	415	101	104

BOEM EXEMPTION FORMULA

MINIMUM DISTANCE BASED ON EMISSIONS	30 CFR 550 303	
	Based on: NOx	
Discoverer & Auxiliary Support	60 6	statute miles

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FUEL & WASTE CONSUMPTION

Emission Units	Capacity Values		MMBtu/hr	FUEL gal/hr	FUEL gal/day	FUEL gal/season	WASTE lb/hr	WASTE lb/day	WASTE lb/season
Discoverer									
Generation	6,000	kW	56	343	8,237	1,235,603			
Propulsion	6,480	kW	61	371	8,896	22,241			
Small IC engines	1,763	kW	17	101	2,420	362,997			
Seldom-Used IC engines	645	kW	6	37	886	132,834			
Boilers	16	MMBtu/hr	16	122	2,916	349,956			
Incinerator	276	lb/hr					276	6,624	794,880
	SUBTOTAL			973	23,356	2,103,630	276	6,624	794,880
Auxiliary Support - within 25 nm									
Ice Management & Anchor Handling (4 vessels)									
Propulsion & Generation	80,550	kW	756	4,608	110,587	8,294,031			
Boilers	24	MMBtu/hr	24	186	4,460	535,191			
Incinerator	584	lb/hr					584	14,016	1,681,920
Oil Spill Response (Vessel, Tug & Barge, 3 WB)									
All IC Engines (non-emergency)	18,369	kW	172	1,051	25,219	2,269,667			
Offshore Supply (2 vessels)									
All IC Engines (non-emergency)	16,042	kW	150	918	22,024	3,303,566			
Science Vessel									
All IC Engines (non-emergency)	8,357	kW	78	478	11,473	1,720,940			
Arctic Oil Storage Tanker									
All IC Engines (non-emergency)	20,611	kW	193	1,179	28,297	1,061,126			
	SUBTOTAL			8,419	202,059	17,184,520	584	14,016	1,681,920
	TOTAL			9,392	225,414	19,288,150	860	20,640	2,476,800

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NO_X EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	NO_X	5 9	g/kW-hr	0 18	lb/gal	Caterpillar 3512 Vendor Data
Discoverer Propulsion	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Small IC engines	NO_X	5 5	g/kW-hr	0 17	lb/gal	Average value from source testing, performed 3/28/2012-5/14/2012
Discoverer Seldom-Used IC engines	NO_X	7 2	g/kW-hr	0 22	lb/gal	Title 40 CFR 94 8, Table A-1 Marine Tier 2, Category 1
Discoverer Boilers	NO_X	20 8	lbs/k-gal	2 1E-2	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	NO_X	3 2	lb/ton	1 6E-3	lb/lb	Average value from source testing, performed 6/11/2012
IM/AH Propulsion & Generation	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
IM/AH Boiler	NO_X	17 1	lbs/k-gal	1 7E-2	lb/gal	Average value from source testing, performed 4/14/2012 - 4/23/2012 (3 vessels)
IM/AH Incineration	NO_X	4 3	lb/ton	2 2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OSR Propulsion & Generation	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Offshore Supply P & G	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Science Vessel Propulsion & Generation	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Arctic Oil Storage Tanker	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2

PM EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	PM	0 16	g/kW-hr	0 00	lb/gal	Caterpillar 3512 Vendor Data
Discoverer Propulsion	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Small IC engines	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Seldom-Used IC engines	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Boilers	PM	0 28	lbs/k-gal	2 8E-4	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	PM	6 90	lb/ton	3 5E-3	lb/lb	Average value from source testing, performed 6/11/2012
IM/AH Propulsion & Generation	PM	0 20	g/kW-hr	0 01	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
IM/AH Boiler	PM	0 71	lbs/k-gal	7 1E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/23/2012 (3 vessels)
IM/AH Incineration	PM	12 40	lb/ton	6 2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OSR Propulsion & Generation	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Offshore Supply P & G	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Science Vessel Propulsion & Generation	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Arctic Oil Storage Tanker	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2

CO EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	CO	1 3	g/kW-hr	0 04	lb/gal	Caterpillar 3512 Vendor Data
Discoverer Propulsion	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Small IC engines	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Seldom-Used IC engines	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Boilers	CO	2 4	lbs/k-gal	2 4E-3	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	CO	10 8	lb/ton	5 4E-3	lb/lb	Average value from source testing, performed 6/11/2012
IM/AH Propulsion & Generation	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
IM/AH Boiler	CO	0 23	lbs/k-gal	2 3E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/23/2012 (3 vessels)
IM/AH Incineration	CO	14 9	lb/ton	7 5E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OSR Propulsion & Generation	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Offshore Supply P & G	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Science Vessel Propulsion & Generation	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Arctic Oil Storage Tanker	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2

VOC EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	VOC	0 45	g/kW-hr	0 01	lb/gal	Caterpillar 3512 Vendor Data
Discoverer Propulsion	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Discoverer Small IC engines	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Discoverer Seldom-Used IC engines	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Discoverer Boilers	VOC	0 34	lbs/k-gal	3 4E-4	lb/gal	EPA AP-42, Table 1 3-3 ver 5-10, Commercial Boilers - Distillate Oil
Discoverer Incinerator	VOC	100	lb/ton	5 0E-2	lb/lb	EPA AP-42, Table 2 1-12, 10/96, without primary burner
IM/AH Propulsion & Generation	VOC	1 3	g/kW-hr	0 04	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
IM/AH Boiler	VOC	0 34	lbs/k-gal	3 4E-4	lb/gal	EPA AP-42, Table 1 3-3 ver 5-10, Commercial Boilers - Distillate Oil
IM/AH Incineration	VOC	100	lb/ton	5 0E-2	lb/lb	EPA AP-42, Table 2 1-12, 10/96, without primary burner
OSR Propulsion & Generation	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Offshore Supply P & G	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Science Vessel Propulsion & Generation	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Arctic Oil Storage Tanker	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)

SO_2 EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Combustion Sources	SO_2	100	ppm	1 1E-2	lb/gal	Stoichiometric Calculation
Incineration	SO_2	2 5	lb/ton	1 3E-3	lb/lb	EPA, AP42, Table 2 1-12, 10/96

Attachment B – NEPA Emission Inventory

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska	BY: S Pryor		
ENGINEERING CALCULATIONS	PROJECT NO: 180-23-1	PAGE: 1	OF: 2	SHEET: 1
	SUBJECT: NEPA Mass Emission Summary	DATE: October 11, 2013		

Discoverer OCS Source - Hourly Maximum NEPA Emissions for each source group

	NO_X lb/hr	PM lb/hr	CO lb/hr	VOC lb/hr	Pb lb/hr	SO_2 lb/hr
Discoverer						
Generation	35 98	1 06	8 47	3 17	1 3E-3	3 66
Propulsion	82 29	2 29	57 14	14 86	1 4E-3	3 95
Small IC engines	12 25	0 45	11 13	2 90	2 7E-4	0 77
Seldom-Used IC engines	6 43	0 18	4 47	1 16	1 1E-4	0 31
Boilers	2 53	0 03	0 29	0 04	1 4E-4	1 30
Incinerator	0 44	0 95	1 49	13 80	2 9E-2	0 35
SUBTOTAL	*139.92*	*4.95*	*83.00*	*35.93*	*3.3E-2*	*10.34*
Ice Management & Anchor Handling (4 vessels)						
Propulsion & Generation	88 08	14 21	8 52	55 41	1 8E-2	49 15
Boilers	3 18	0 13	0 04	0 06	2 2E-4	1 98
Incinerator	1 26	3 62	4 35	29 20	6 2E-2	0 73
SUBTOTAL	*92.51*	*17.96*	*12.92*	*84.67*	*8.0E-2*	*51.86*
Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
All IC Engines (non-emergency)	233 26	6 48	161 99	42 12	4 0E-3	11 21
SUBTOTAL	*233.26*	*6.48*	*161.99*	*42.12*	*4.0E-3*	*11.21*
Offshore Supply (2 vessels)						
All IC Engines (non-emergency)	146 42	4 07	101 68	26 44	2 5E-3	7 04
SUBTOTAL	*146.42*	*4.07*	*101.68*	*26.44*	*2.5E-3*	*7.04*
Science Vessel						
All IC Engines (non-emergency)	66 32	1 84	46 06	11 98	1 1E-3	3 19
SUBTOTAL	*66.32*	*1.84*	*46.06*	*11.98*	*1.1E-3*	*3.19*
Arctic Oil Storage Tanker						
All IC Engines (non-emergency)	103 78	2 88	72 07	18 74	1 8E-3	4 99
SUBTOTAL	*103.78*	*2.88*	*72.07*	*18.74*	*1.8E-3*	*4.99*
On-shore Support						
Helicopter	0 20	0 04	1 25	1 50	-	0 43
Man Camp Generators	7 73	0 36	6 30	2 34	-	0 62
Hangar/Storage Building Boiler	0 49	0 04	0 41	0 02	2 5E-6	0 41
Vehicles	7 9E-3	7 9E-4	0 29	7 7E-3	-	1 2E-2
SUBTOTAL	*8.43*	*0.43*	*8.25*	*3.86*	*2.5E-6*	*1.47*
TOTAL	**791**	**39**	**486**	**224**	**1.2E-1**	**90**

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska		BY: S Pryor	
AIR SCIENCES INC. DENVER • PORTLAND	PROJECT NO: 180-23-1	PAGE: 2	OF: 2	SHEET: 1
ENGINEERING CALCULATIONS	SUBJECT: NEPA Mass Emission Summary		DATE: October 11, 2013	

Discoverer OCS Source - Seasonal Maximum NEPA Emissions for each source group

	NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	Pb ton/season	SO_2 ton/season
Discoverer						
Generation	41 45	1 22	9 75	3 66	1 5E-3	4 22
Propulsion	1 97	0 05	1 37	0 36	3 4E-5	0 09
Small IC engines	17 64	0 64	16 03	4 17	4 0E-4	1 11
Seldom-Used IC engines	0 06	1 5E-3	0 04	0 01	9 5E-7	2 7E-3
Boilers	1 82	0 02	0 21	0 03	1 0E-4	0 93
Incinerator	0 64	1 37	2 15	19 87	4 2E-2	0 50
SUBTOTAL	*63.57*	*3.31*	*29.55*	*28.09*	*4.4E-2*	*6.85*
Ice Management & Anchor Handling (4 vessels)						
Propulsion & Generation	35 51	5 73	3 44	22 34	7 1E-3	19 81
Boilers	1 26	0 05	0 02	0 03	8 7E-5	0 79
Incinerator	1 26	3 62	4 35	29 20	6 2E-2	0 73
SUBTOTAL	*38.03*	*9.40*	*7.80*	*51.56*	*6.9E-2*	*21.33*
Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
All IC Engines (non-emergency)	107 12	2 98	74 39	19 34	1 8E-3	5 15
SUBTOTAL	*107.12*	*2.98*	*74.39*	*19.34*	*1.8E-3*	*5.15*
Offshore Supply (2 vessels)						
All IC Engines (non-emergency)	131 39	3 65	91 25	23 72	2 3E-3	6 31
SUBTOTAL	*131.39*	*3.65*	*91.25*	*23.72*	*2.3E-3*	*6.31*
Science Vessel						
All IC Engines (non-emergency)	66 86	1 86	46 43	12 07	1 1E-3	3 21
SUBTOTAL	*66.86*	*1.86*	*46.43*	*12.07*	*1.1E-3*	*3.21*
Arctic Oil Storage Tanker						
All IC Engines (non-emergency)	46 38	1 29	32 21	8 38	7 9E-4	2 23
SUBTOTAL	*46.38*	*1.29*	*32.21*	*8.38*	*7.9E-4*	*2.23*
On-shore Support						
Helicopter	0 28	0 05	1 80	2 16	-	0 62
Man Camp Generators	12 76	0 64	11 16	4 15	-	1 10
Hangar/Storage Building Boiler	0 35	0 03	4 88	0 01	1 8E-6	0 29
Vehicles	1 2E-2	1 2E-3	0 42	1 1E-2	-	0 02
SUBTOTAL	*13.41*	*0.72*	*18.27*	*6.33*	*1.8E-6*	*2.03*
TOTAL	**467**	**23**	**300**	**149**	**1.2E-1**	**47**

Seasonal Pollutant Total

NO_X ton/season	PM ton/season	CO ton/season	VOC ton/season	Pb ton/season	SO_2 ton/season	CO_2e ton/season
467	23	300	149	1 2E-1	47	93,134

Air Sciences Inc.	PROJECT TITLE: Shell OCS Alaska			BY: S Pryor
	PROJECT NO: 180-23-1	PAGE: 1	OF: 6	SHEET: 2
ENGINEERING CALCULATIONS	SUBJECT: Discoverer Chukchi Project-NEPA Inventory			DATE: October 11, 2013

OPERATING ASSUMPTIONS

ACTIVITY LEVELS

Emission Units	capacity		hourly max load % of capacity	per season max load % of capacity	days/season	Load Comments
Discoverer						
Generation	6,000	kW	80%	64%	120	Season: 15% use for 1/4 and 80% for 3/4 = 64%
Propulsion	6,480	kW	80%	80%	2	Season: max use of Propulsion is estimated for 2 days
Small IC engines	1,763	kW	57%	57%	120	Season: emissions represented by generation (no Cementing)
Seldom-Used IC engines	645	kW	63%	63%	0 7	Hour: eGen only operating at 80% capacity, Season: 1 hr/wk
Boilers	16	MMBtu/hr	100%	50%	120	Season: expected max use of Boilers is 50%
Incinerator	276	lb/hr	100%	100%	120	no operational restrictions preventing 100% use
Auxiliary Support - within 25 nm						
Ice Management & Anchor Handling (4 vessels)						
Propulsion & Generation	80,550	kW	80%	22%	120	Season: calculations and assumptions available on Support Vessels Sheet
Boilers	24	MMBtu/hr	100%	28%	120	Season: calculations and assumptions available on Support Vessels Sheet
Incinerator	584	lb/hr	100%	69%	120	Season: calculations and assumptions available on Support Vessels Shee
Oil Spill Response (Vessel, Tug & Barge, 3 WB)						
All IC Engines (non-emergency)	18,369	kW	80%	26%	120	Season: calculations and assumptions available on Support Vessels Sheet
Offshore Supply (2 vessels)						
All IC Engines (non-emergency)	16,042	kW	58%	36%	120	Season: calculations and assumptions available on Support Vessels Sheet
Science Vessel						
All IC Engines (non-emergency)	8,357	kW	50%	35%	120	Season: calculations and assumptions available on Support Vessels Sheet
Arctic Oil Storage Tanker						
All IC Engines (non-emergency)	20,611	kW	32%	10%	120	Season: calculations and assumptions available on Support Vessels Sheet
On-shore Support						
Helicopter	40	roundtrips per week			120	See Helicopter Sheet
Man Camp Generators	1,396	kW	59%	51%	168	See Onshore Sheet, 2 Diesel fired Gens at 80%, 1 as back up operated 15 min/wk
Hangar/Storage Building Boiler	5	MMBtu/hr	100%	50%	120	Natural Gas fired Boiler - heat input
Vehicles	200	gal/wk			123	Based on 3/4 ton diesel on-road truck, see Vehicle Sheet

ASSUMED AUXILIARY SUPPORT CANDIDATE VESSELS FOR EI

Ice Management 1	Fennica
Ice Management 2	Nordica
Anchor Handler 1	Aiviq
Anchor Handler 2	Tor Viking
Oil Spill Response Vessel	Nanuq
Oil Spill Response - Tug/Barge	Ocean Wave/Arctic Endeavour
Offshore Supply Vessel 1	Sisuaq
Offshore Supply Vessel 2	Supporter
Science vessel	Sisuaq
Arctic Oil Storage Tanker	Affinity

ASSUMPTIONS			Reference
Diesel engine thermal efficiency	7,000	Btu/hp-hr	AP42 Table 3 3-1, 10/96
Diesel heating value	0 1312	MMBtu/gallon	Tesoro Nikiski, Email Royal Harris 4/20/11
Diesel density	7 00	lb/gal	Tesoro Nikiski, Email Royal Harris 4/20/11
Municipal solid waste HHV	9 95	MMBtu/short ton	Table C-1 to Subpart C of 40 CFR Part 98
Emission factors represent over 90% of the capacity power			

CONVERSIONS

1 34	hp/kW	2,000	lb/ton	32 07	wt S
0 7457	kW / hp	24	hr/day	64 06	wt SO2
1,000,000	Btu/MMBtu	168	hr/wk	2 00	wt conversion of S to SO2
453 592	g/lb	2 2	lb/kg	0 608	lb/hp-hr to kg/kW-hr
17 1	wk/season	1000	g/kg		

blue values are input, black values are calculated or linked

EMISSIONS

	NOx		PM		CO		VOC		Pb	
Emission Units	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**
Discoverer										
Generation	36	41	1	1	8	10	3	4	1E-3	2E-3
Propulsion	82	2	2	5E-2	57	1	15	4E-1	1E-3	3E-5
Small IC engines	12	18	4E-1	6E-1	11	16	3	4	3E-4	4E-4
Seldom-Used IC engines	6	6E-2	2E-1	2E-3	4	4E-2	1	1E-2	1E-4	9E-7
Boilers	3	2	3E-2	2E-2	3E-1	2E-1	4E-2	3E-2	1E-4	1E-4
Incinerator	4E-1	6E-1	1E+0	1	1	2	14	20	3E-2	4E-2
SUBTOTAL	140	64	5	3	83	30	36	28	3E-2	4E-2
Auxiliary Support - within 25 nm										
Ice Management & Anchor Handling (4 vessels)										
Propulsion & Generation	88	36	14	6	9	3	55	22	2E-2	7E-3
Boilers	3	1	1E-1	5E-2	4E-2	2E-2	6E-2	3E-2	2E-4	9E-5
Incinerator	1	1	4	4	4	4	29	29	6E-2	6E-2
Oil Spill Response (Vessel, Tug & Barge, 3 WB)										
All IC Engines (non-emergency)	233	107	6	3	162	74	42	19	4E-3	2E-3
Offshore Supply (2 vessels)										
All IC Engines (non-emergency)	146	131	4	4	102	91	26	24	3E-3	2E-3
Science Vessel										
All IC Engines (non-emergency)	66	67	2	2	46	46	12	12	1E-3	1E-3
Arctic Oil Storage Tanker										
All IC Engines (non-emergency)	104	46	3	1	72	32	19	8	2E-3	8E-4
SUBTOTAL	642	390	33	19	395	252	184	115	9E-2	8E-2
On-shore Support										
Helicopter	2E-1	3E-1	4E-2	5E-2	1	2	1	2	-	-
Man Camp Generators	8	13	4E-1	6E-1	6	11	2	4	-	-
Hangar/Storage Building Boiler	5E-1	4E-1	4E-2	3E-2	4E-1	5	2E-2	1E-2	2E-6	2E-6
Vehicles	8E-3	1E-2	8E-4	1E-3	3E-1	4E-1	8E-3	1E-2	-	-
SUBTOTAL	8	13	4E-1	7E-1	8	18	4	6	2E-6	2E-6
TOTAL	791	467	39	23	486	300	224	149	1E-1	1E-1

EMISSIONS continued

	SO_2		GHG	
Emission Units	**lb/hr**	**ton/season**	**lb/hr**	**ton/season**
Discoverer				
Generation	4	4	7,351	8,468
Propulsion	4	9E-2	7,939	191
Small IC engines	8E-1	1	1,547	2,228
Seldom-Used IC engines	3E-1	3E-3	621	5
Boilers	1	9E-1	2,602	1,874
Incinerator	3E-1	5E-1	280	403
SUBTOTAL	10	7	20,339	13,168
Auxiliary Support - within 25 nm				
Ice Management & Anchor Handling (4 vessels)				
Propulsion & Generation	49	20	98,682	39,781
Boilers	2	8E-1	3,980	1,582
Incinerator	7E-1	7E-1	592	592
Oil Spill Response (Vessel, Tug & Barge, 3 WB)				
All IC Engines (non-emergency)	11	5	22,504	10,334
Offshore Supply (2 vessels)				
All IC Engines (non-emergency)	7	6	14,126	12,676
Science Vessel				
All IC Engines (non-emergency)	3	3	6,399	6,450
Arctic Oil Storage Tanker				
All IC Engines (non-emergency)	5	2	10,012	4,475
SUBTOTAL	78	38	156,295	75,891
On-shore Support*				
Helicopter	4E-1	6E-1	858	1,236
Man Camp Generators	6E-1	1	1,251	2,214
Hangar/Storage Building Boiler	4E-1	3E-1	816	588
Vehicles	1E-2	2E-2	25	37
SUBTOTAL	1	2	2,950	4,075
TOTAL	90	47	179,584	93,134

SO_2 EMISSIONS

		ton/season
Combustion Sources	SO_2	46
Incineration	SO_2	1
TOTAL		47

GHG EMISSIONS

		ton/season
Combustion Sources	CO_2	91,829
Combustion Sources	CH_4	4
Combustion Sources	N_2O	7E-1
Incineration	CO_2	974
Incineration	CH_4	3E-1
Incineration	N_2O	5E-2
All Sources	CO_2e	93,134

FUEL & WASTE CONSUMPTION

Emission Units	Capacity Values	MMBtu/hr	FUEL gal/hr	gal/day	gal/season	WASTE lb/hr	lb/day	lb/season
Discoverer								
Generation	6,000 kW	56	343	8,237	790,786			
Propulsion	6,480 kW	61	371	8,896	17,793			
Small IC engines	1,763 kW	17	72	1,734	208,024			
Seldom-Used IC engines	645 kW	6	29	696	497			
Boilers	16 MMBtu/hr	16	122	2,916	174,978			
Incinerator	276 lb/hr					276	6,624	794,880
SUBTOTAL			937	22,479	1,192,077	276	6,624	794,880
Auxiliary Support - within 25 nm								
Ice Management & Anchor Handling (4 vessels)								
Propulsion & Generation	80,550 kW	756	4,608	110,587	3,715,035			
Boilers	24 MMBtu/hr	24	186	4,460	147,735			
Incinerator	584 lb/hr					584	14,016	1,168,000
Oil Spill Response (Vessel, Tug & Barge, 3 WB)								
All IC Engines (non-emergency)	18,369 kW	172	1,051	25,219	965,090			
Offshore Supply (2 vessels)								
All IC Engines (non-emergency)	16,042 kW	150	660	15,830	1,183,778			
Science Vessel								
All IC Engines (non-emergency)	8,357 kW	78	299	7,171	602,329			
Arctic Oil Storage Tanker								
All IC Engines (non-emergency)	20,611 kW	193	467	11,220	417,902			
SUBTOTAL			7,270	174,486	7,031,868	584	14,016	1,168,000
On-shore Support*								
Helicopter		5	40	962	115,404			
Man Camp Generators	1,396 kW	7	58	1,231	206,799			
Hangar/Storage Building Boiler		5	38	915	54,886			
Vehicles		0 2	1	28	3,429			
SUBTOTAL			138	3,135	380,518			
TOTAL			8,345	200,100	8,604,463	860	20,640	1,962,880

*gallon measurements are in diesel equivalent

EMISSION FACTORS

NO_X EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	NO_X	3 4	g/kW-hr	0 10	lb/gal	5 engines SCR controlled, 1 engine uncontrolled due to start-up/variable loads[a]
Discoverer Propulsion	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Small IC engines	NO_X	5 5	g/kW-hr	0 17	lb/gal	Average value from source testing, performed 3/28/2012-5/14/2012
Discoverer Seldom-Used IC engines	NO_X	7 2	g/kW-hr	0 22	lb/gal	Title 40 CFR 94 8, Table A-1 Marine Tier 2, Category 1
Discoverer Boilers	NO_X	20 8	lbs/k-gal	2 1E-2	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	NO_X	3 2	lb/ton	1 6E-3	lb/lb	Average value from source testing, performed 6/11/2012
IM/AH Propulsion & Generation	NO_X	0 62	g/kW-hr	1 9E-2	lb/gal	Average SCR controlled source test value, performed 4/13/2012 - 5/9/2012 (4 vessels)
IM/AH Boiler	NO_X	17 1	lbs/k-gal	1 7E-2	lb/gal	Average value from source testing, performed 4/14/2012 - 4/23/2012 (3 vessels)
IM/AH Incineration	NO_X	4 3	lb/ton	2 2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OSR Propulsion & Generation	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Offshore Supply P & G	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Science Vessel Propulsion & Generation	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Arctic Oil Storage Tanker	NO_X	7 2	g/kW-hr	0 22	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
[a] Discoverer Generation	NO_X					
		1 engine uncontrolled at		5 9	g/kW-hr	Caterpillar 3512 Vendor Data
		5 engines controlled at		3 0	g/kW-hr	SCR Controlled with 50% reduction efficiency
SCR NOx reduction efficiency	50%					Estimate

PM EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	PM	0 10	g/kW-hr	3 1E-3	lb/gal	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads[a]
Discoverer Propulsion	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Small IC engines	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Seldom-Used IC engines	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Boilers	PM	0 28	lbs/k-gal	2 8E-4	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	PM	6 90	lb/ton	3 5E-3	lb/lb	Average value from source testing, performed 6/11/2012
IM/AH Propulsion & Generation	PM	0 10	g/kW-hr	3 1E-3	lb/gal	Average value from source testing, performed 4/13/2012 - 5/9/2012 (4 vessels)
IM/AH Boiler	PM	0 71	lbs/k-gal	7 1E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/23/2012 (3 vessels)
IM/AH Incineration	PM	12 4	lb/ton	6 2E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OSR Propulsion & Generation	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Offshore Supply P & G	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Science Vessel Propulsion & Generation	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Cate_or_ 1 - Tier 2
Arctic Oil Storage Tanker	PM	0 20	g/kW-hr	6 2E-3	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
[a] Discoverer Generation	PM					
		1 engine uncontrolled at		0 16	g/kW-hr	Caterpillar 3512 Vendor Data
		5 engines controlled at		0 08	g/kW-hr	CDPF Controlled with 50% reduction efficiency
CDPF PM reduction efficiency	50%					Estimate

CO EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	CO	0 80	g/kW-hr	2 5E-2	lb/gal	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads[a]
Discoverer Propulsion	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Small IC engines	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Seldom-Used IC engines	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Discoverer Boilers	CO	2 4	lbs/k-gal	2 4E-3	lb/gal	Average value from source testing, performed 6/10/2012-6/11/2012
Discoverer Incinerator	CO	10 8	lb/ton	5 4E-3	lb/lb	Average value from source testing, performed 6/11/2012
IM/AH Propulsion & Generation	CO	0 06	g/kW-hr	1 8E-3	lb/gal	Average value from source testing, performed 4/13/2012 - 5/9/2012 (4 vessels)
IM/AH Boiler	CO	0 23	lbs/k-gal	2 3E-4	lb/gal	Average value from source testing, performed 4/14/2012 - 4/23/2012 (3 vessels)
IM/AH Incineration	CO	14 9	lb/ton	7 5E-3	lb/lb	Average value from source testing, performed 4/16/2012 - 5/10/2012 (3 vessels)
OSR Propulsion & Generation	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Offshore Supply P & G	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Science Vessel Propulsion & Generation	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
Arctic Oil Storage Tanker	CO	5 0	g/kW-hr	0 15	lb/gal	40 CFR 94 8 Table A-1 Marine Category 1 - Tier 2
[a] Discoverer Generation	CO					
		1 engine uncontrolled at		1 30	g/kW-hr	Caterpillar 3512 Vendor Data
		5 engines controlled at		0 65	g/kW-hr	CDPF Controlled with 50% reduction efficiency
CDPF CO reduction efficiency	50%					Estimate

EMISSION FACTORS, cont'd

VOC EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Discoverer Generation	VOC	0 30	g/kW-hr	9 2E-3	lb/gal	5 engines CDPF controlled, 1 engine uncontrolled due to start-up/variable loads[a]
Discoverer Propulsion	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Discoverer Small IC engines	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Discoverer Seldom-Used IC engines	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Discoverer Boilers	VOC	0 34	lbs/k-gal	3 4E-4	lb/gal	EPA AP-42, Table 1 3-3 ver 5-10, Commercial Boilers - Distillate Oil
Discoverer Incinerator	VOC	100	lb/ton	5 0E-2	lb/lb	EPA AP-42, Table 2 1-12, 10/96, without primary burner
IM/AH Propulsion & Generation	VOC	0 39	g/kW-hr	1 2E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1) - 70% control b
IM/AH Boiler	VOC	0 34	lbs/k-gal	3 4E-4	lb/gal	EPA AP-42, Table 1 3-3 ver 5-10, Commercial Boilers - Distillate Oil
IM/AH Incineration	VOC	100	lb/ton	5 0E-2	lb/lb	EPA AP-42, Table 2 1-12, 10/96, without primary burner
OSR Propulsion & Generation	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Offshore Supply P & G	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Science Vessel Propulsion & Generation	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)
Arctic Oil Storage Tanker	VOC	1 3	g/kW-hr	4 0E-2	lb/gal	EPA 40 CFR 89 112 Table 1 EPA Nonroad CI engines (Tier 1)

[a] Discoverer Generation	VOC			
		1 engine uncontrolled at	0 45 g/kW-hr	Caterpillar 3512 Vendor Data
		5 engines controlled at	0 23 g/kW-hr	CDPF Controlled with 50% reduction efficiency
CDPF VOC reduction efficiency	50%			Estimate
[b] IM/AH CDPF VOC reduction efficiency		70%		OxyCat control eff for VOCs based on Kulluk Statement of Basis for use of CDPFs (Sec 2 3)

GHG EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference	Multiplier
Combustion Sources	CO_2	73 96	kg/MMBtu	21 3	lb/gal	40 CFR Part 98, Subpart C, Table C-1 (Distillate Fuel Oil No 2)	1
Combustion Sources	CH_4	3 0E-3	kg/MMBtu	8 7E-4	lb/gal	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Petroleum)	21
Combustion Sources	N_2O	6 0E-4	kg/MMBtu	1 7E-4	lb/gal	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Petroleum)	310
Incineration	CO_2	90 7	kg/MMBtu	1 0	lb/lb	40 CFR Part 98, Subpart C, Table C-1 (Municipal Solid Waste)	1
Incineration	CH_4	3 2E-2	kg/MMBtu	3 5E-4	lb/lb	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Municipal Solid Wa	21
Incineration	N_2O	4 2E-3	kg/MMBtu	4 6E-5	lb/lb	40 CFR Part 98, Subpart C, Table C-2 (Fuel Type: Municipal Solid Wa	310

SO_2 EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit	Reference
Combustion Sources	SO_2	100	ppm S	1 1E-2	lb/gal	Stoichiometric Calculation
Incineration	SO_2	2 5	lb/ton	1 3E-3	lb/lb	EPA AP42 Table 2 1-12 10/96

Pb EMISSION FACTORS

Source	Pollutant	EF	unit	EF	unit
Internal Combustion Engines	Pb	2 9E-5	lb/MMBtu	3 8E-6	lb/gal
Heaters & Boilers	Pb	9	lb/10^{12} Btu	1 2E-6	lb/gal
Incineration	Pb	0 213	lb/ton	1 1E-4	lb/lb

Source	Reference
Internal Combustion Engines	L & E Air Emissions from Sources of Lead and Lead Compounds, EPA 454/R-98-006, May 1998, Section 5 2 2, Distillate oil-fired gas turbines
Heaters & Boilers	AP42, Table 1 3-10 Emission Factors For Trace Elements From Distillate Fuel Oil Combustion Sources
Incineration	EPA, AP42, Table 2 1-2, EF for Modular Excess Air Combustors, uncontrolled

Appendix P

Adaptive Approach to Ice Management In Areas Occupied by Pacific Walruses

Adaptive Approach to Ice Management in Areas Occupied by Pacific Walruses

The corner post of the adaptive management approach to managing ice in areas occupied by Pacific walruses will be monitoring of both ice and marine mammals, including walruses, such that sufficient lead time is provided to afford consultation and planning. During the period of operations Shell will conduct a robust program of ice and weather monitoring and forecasting. A team of ice specialists will work daily with synthetic aperture radar images purchased for the purpose to produce high resolution maps of ice floes within the project areas (Chukchi and Beaufort Seas) (Figure 1). The results of these analyses and forecasts are posted daily to the Shell Ice and Weather Advisory Center (SIWAC). The SIWAC information is available by permission at www.siwac.com.

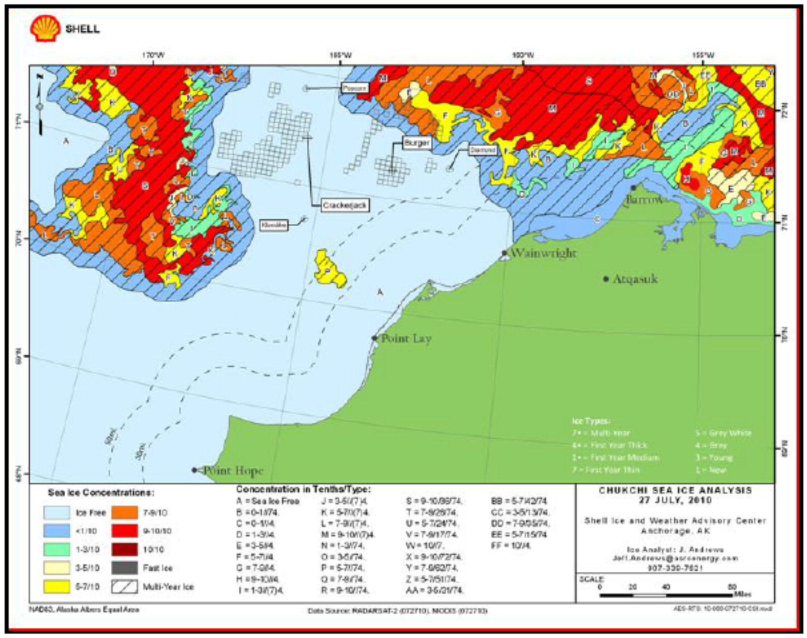


Figure 1: High resolution ice map from the SIWAC program depicting ice distribution and characteristics

Weather forecasts are supported by a network of industry funded and deployed met-ocean buoys, coastal weather reporting installations, and regular observations following standardized protocols from all Shell vessels operating in the theater. Professional meteorologists analyze these data and update NOAA weather models to provide real time support of operations and localized weather forecasts.

Satellite imagery of ice conditions is also supplemented by observations from vessels. When conditions indicate the need, the primary ice management vessel will scout ice in the vicinity of drilling operations. Professional ice pilots will assess ice conditions and provide detailed descriptions and real time consultation to the ice team. Through ice tracking and weather forecasting, the likelihood that Shell would be surprised by changing ice conditions and forced to take action without appropriate consultation and planning is low.

Walrus distribution data will be derived from three different sources. Marine mammal observers (PSOs) will be aboard every vessel engaged in the Shell drilling program and will provide daily reports of walrus and other marine mammal observations. These observations will be reported to U.S. Fish & Wildlife Service (FWS) on a daily basis. Due to the critical activities of the primary ice management vessel, five PSOs will be aboard this vessel and will provide two persons on duty coverage 24 hours per day. Since this vessel is most likely to be operating in close proximity to the ice, the PSOs and vessel operators will be most highly trained in walrus avoidance and mitigation requirements. Observations will also be aided by the installation of Big-Eye binoculars on board these vessels. The data from these vessels will be reported at least daily.

In addition to the observations of vessel based PSOs, Shell will operate aerial overflights in both the nearshore (within 25 miles of shore), alongshore, and offshore. The overflights will be conducted utilizing a Twin Otter aircraft flying at 1,000 feet elevation during surveys. To limit exposure to the risks of flying fixed wing aircraft far offshore, no PSOs will be on board during the offshore (Figure 2) Chukchi Sea overflights. High resolution still frame cameras will capture overlapping images during transit surveys. Still frame photography will be supplemented by HD video. This sensor package is being evaluated for applicability in unmanned aerial system (UAS), which is the preferred platform for aerial monitoring in the future. The imagery from these offshore overflights will be processed upon retrieval of the images when the aircraft lands in Barrow.

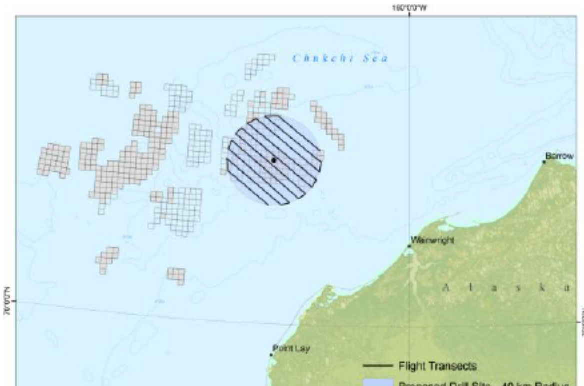


Figure 2: Proposed survey grid for offshore aerial overflights.

When the offshore drilling area cannot be accessed, the nearshore/alongshore (n/a) flights will be conducted, weather permitting (Figure 3). There is also the possibility that the n/a flights would be shifted to higher priority, in the case of needs for observations of possible haulouts. Priority for operation of offshore v. n/a flights will be established through consultation with trust agencies, including FWS, and stakeholders. When they are operated, the n/a overflights will be conducted with both photographic equipment, as utilized on the offshore flights, and PSOs. This dual sensing capability will enable the comparison of the two survey methods and the development, if necessary, of correction factors.

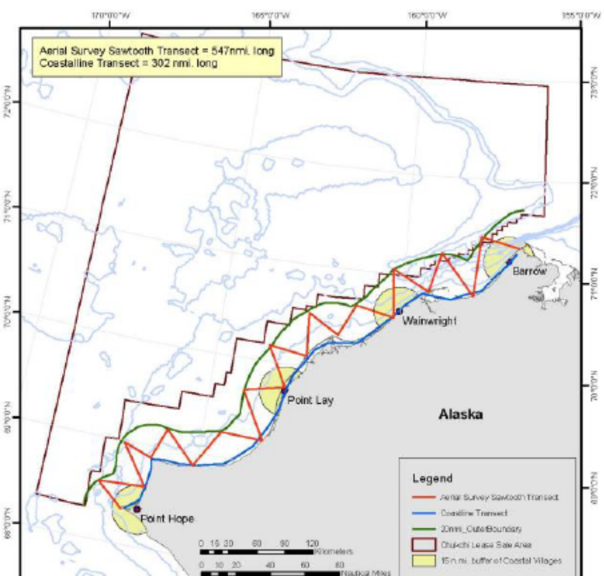


Figure 3 Proposed survey grid for nearshore/alongshore aerial surveys.

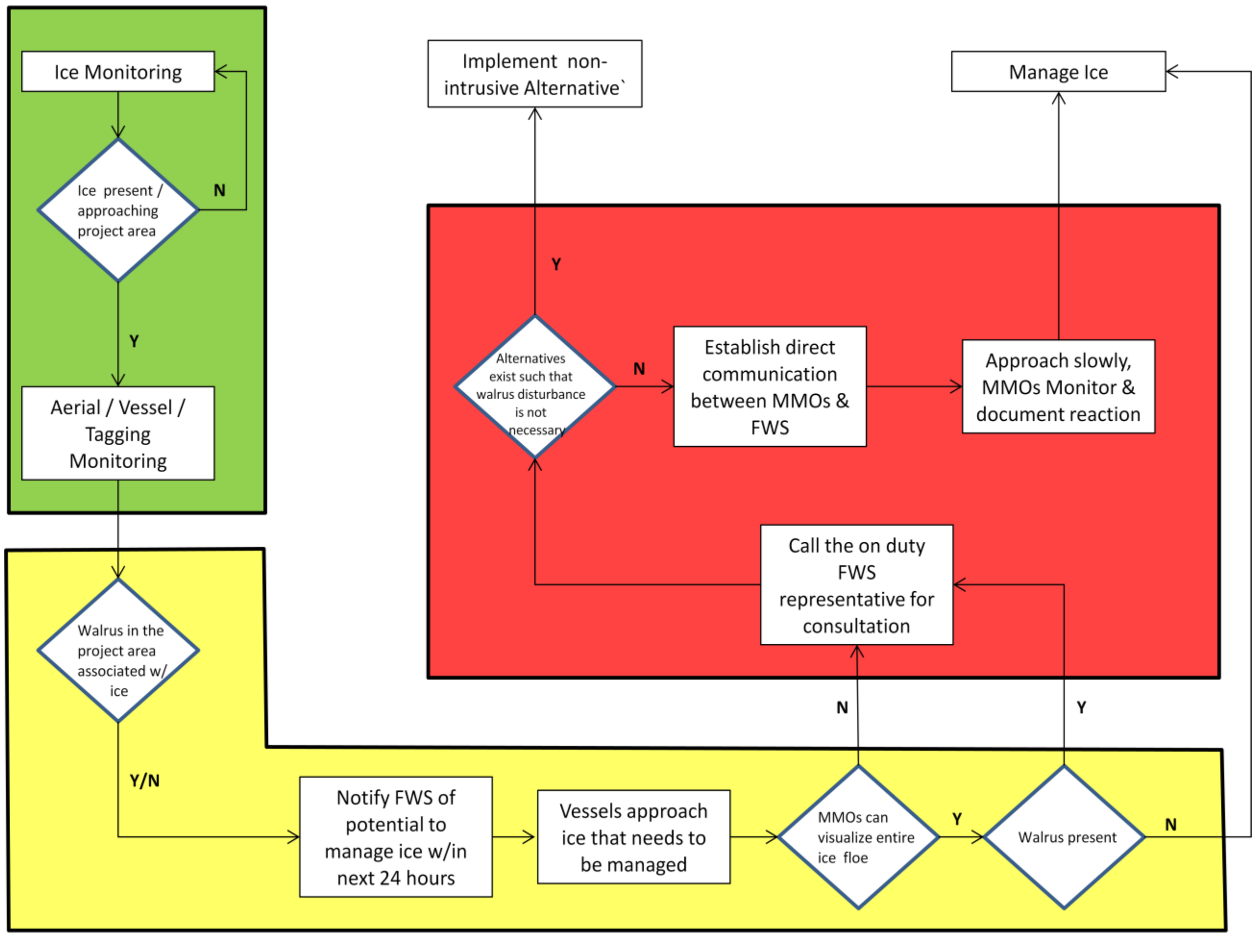
An additional source of information that will be utilized to forecast the potential for presence of walruses in the project area will be the data from USGS tagged animals. At a minimum, Shell will utilize data posted to the USGS walrus tracking website. We will also endeavor to work closely with USGS, such that we have access to data prior to its being posted on the website.

Utilizing these three data sources, that provide accurate indications of walrus distribution in combination with ice maps and forecasts, Shell will be able to generate daily assessments of the potential need to manage ice and the potential for such activities to interact with walruses. On the basis of these daily assessments, risk can be assessed as green (no immediate need to manage ice and/or no walrus are present in the project area), yellow (possibility exists for ice management), and red (active ice management will be required and potential exists for impacts to walrusesRisk level will be developed by Shell through consultation between ice & weather monitoring and marine mammal monitoring, both of which report to the Science Lead, and with the wells group).

The daily risk level will be communicated to USFWS by email as a part of the daily report. The flow chart in Figure 4 presents the process that will be used to rank risks and initiate consultation both within Shell and between Shell and USFWS. The Adaptive Approach functions as follows:

1. Ice and weather forecasting will evaluate the potential risk to vessels and the drilling process on the basis of proximity of ice to the drilling operation and factors influencing ice movement.
    a. If the area of operation is ice free or there is a low probability that ice could impact vessels and drilling operations the risk level is green and monitoring continues.
    b. If ice is in close proximity, or otherwise potentially threatening vessels and drilling operations, walrus distribution information will be considered. Walrus distribution information will be treated conservatively. There may be times during the season (e.g. late October) when the potential for walruses within the project area is extremely low and risk level could be assessed as green. Otherwise, the difficulty of knowing where all concentrations are, given incomplete monitoring capabilities, leads to the assumption that they may be present. In such cases, the risk level would be elevated to yellow.
2. At yellow risk levels USFWS would be notified by email and updates will be provided by telephone, or in person, during regular business hours. When at yellow risk levels, ice management vessels will provide scouting reports that evaluate ice conditions and the presence and distribution of walruses. PSOs on board these vessels will provide around the clock monitoring and will endeavor to assess the potential to disturb walruses through ice management activities.
    a. If ice management is needed and IF the entire ice floe and surrounding areas can be visualized and no walruses are hauled out on the ice, ice management may proceed with care.
    b. If walruses are present and hauled out and, if ice management is needed, the risk level will be elevated to red.
3. At red risk levels (ice presents an imminent threat to vessels and/or drilling operations and walruses are present in areas where ice management is needed) the on duty compliance representative for Shell will notify a designated USFWS representative by calling a duty phone t engage in real-time consultation.
    a. The Shell drilling supervisor will be engaged to evaluate the status of drilling operations and the potential for implementation of ice avoidance measures that may include cessation of drilling activities and moving off hole in extreme cases. If such alternatives are available and can be implemented, these procedures will be implemented

Figure 3 Flow chart of risk levels based upon ice, weather, and walrus monitoring.



b. Real-time communications will be established with the lead MMO on the ice management vessel(s) to assess the proximity and status of walruses hauled out on ice floes that need to be managed. Descriptions of the situation will be shared with the consultation team.
c. If the team agrees that ice management can go forward, the vessel will approach the ice floe slowly in an effort to avoid causing a stampede. Video cameras and still cameras will be used to document procedures and results to enhance the understanding of the risks posed by ice management activities.
d. Real time consultation will continue as long as ice management is required, or until the consultation team agrees that procedures are going forward successfully.
e. A post action report will be filed with USFWS within 24 hours. To the extent that communications will allow the transfer of still frame and video, photographic documentation will be included.

At present the nominal plan is for both Shell and USFWS to maintain a 24 hour duty phone for the purpose of consultation. If risk levels are in the green, email notification will be the principle mode of communication. At risk levels of yellow email notifications will be made and telephone, or in person, consultations will occur during business hours. If the risk level becomes red, however, Shell will notify the designated duty individual within the Service and initiate direct consultation. If real-time consultation cannot be established, and if ice management cannot be avoided to protect vessels and critical drilling operations, Shell will proceed as per the above flow chart exercising all due care to avoid impacts to walruses.