Imperial Oil

ExxonMobil

bp

Beaufort Sea Exploration Joint Venture Drilling Program

PROJECT DESCRIPTION

Submitted to:
the Environmental Impact Screening Committee

Submitted by:
Imperial Oil Resources Ventures Limited

September 2013
Calgary, Alberta

BEAUFORT SEA EXPLORATION
JOINT VENTURE

Drilling Program

Project Description

Imperial Oil Resources Ventures Limited

September 2013

Acknowledgements

This Project Description has been prepared with the assistance of SL Ross Environmental Research Ltd. and Golder Associates Ltd. with contributions by IMG-Golder Corporation.

BEAUFORT SEA EXPLORATION
JOINT VENTURE DRILLING PROGRAM
PROJECT DESCRIPTION

TABLE OF CONTENTS

Contents

CONTENTS

BEAUFORT SEA EXPLORATION
JOINT VENTURE DRILLING PROGRAM
PROJECT DESCRIPTION

LIST OF ILLUSTRATIONS

LIST OF FIGURES

LIST OF TABLES

COVER LETTER

BEAUFORT SEA EXPLORATION
JOINT VENTURE DRILLING PROGRAM
PROJECT DESCRIPTION

Imperial Oil Resources Ventures Limited
237 Fourth Avenue South West
P.O. Box 2480, Station "M"
Calgary, Alberta Canada, T2P 3M9

Sherry Becker
Beaufort/East Coast Opportunity
Manager, Exploration

Tel. (403) 237-2623
Fax. (403) 237-4447

September 9, 2013

Mr. Darrell Christie
Environmental Impact Screening Coordinator
Environmental Impact Screening Committee
107 Mackenzie Road, Suite 204
PO Box 2120, Inuvik, NT X0E 0T0

Dear Mr. Christie:

Re: Imperial Oil Resources Ventures Limited
Application to the Environmental Impact Screening Committee
for the Beaufort Sea Exploration Joint Venture Drilling Program

---

Imperial Oil Resources Ventures Limited (Imperial) hereby requests the Environmental Impact Screening Committee (EISC), under the Inuvialuit Final Agreement (IFA) environmental impact screening and review process, to conduct a screening of Imperial's proposed Beaufort Sea Exploration Joint Venture Drilling Program (the exploration program or the program).

To meet the requirements of the EISC's *Environmental Impact Screening Guidelines* of June 29, 2012, Imperial has:

- submitted an electronic project summary questionnaire to the EISC registry site
- prepared the enclosed Project Description

The content and format of the Project Description is consistent with Appendix F, Project Description Content Guide.

Imperial requests that the review of the exploration program proceed directly to Phase 2 of the screening process, as it is a development as defined by the IFA and not exempt from screening.

As operator of the exploration program, Imperial and its co-venturers in the Beaufort Sea Exploration Joint Venture (ExxonMobil Canada Ltd. and BP Exploration Operating Company Limited) believe that the program described in the Project Description can be carried out in a safe and environmentally responsible manner. Furthermore, the joint venture partners believe that the program will provide positive benefits for Inuvialuit and northern residents.

Imperial looks forward to working with the EISC and assisting the committee, as required, in reaching a screening decision. If you have any questions or requests please contact the undersigned.

Sincerely,

(original signed by)

Sherry Becker
Beaufort/East Coast Opportunity Manager
Beaufort Sea Exploration Joint Venture

Enclosures

The title of the proposed development described in this Project Description for review by the Environmental Impact Screening Committee is the Beaufort Sea Exploration Joint Venture Drilling Program.

For information concerning the proposed development or this Project Description document contact:

Sherry Becker
Beaufort/East Coast Opportunity Manager
Beaufort Sea Exploration Joint Venture

Imperial Oil Resources Ventures Limited
237 Fourth Avenue South West
P.O. Box 2480, Station “M”
Calgary, Alberta T2P 3M9

Bus.: 403-237-2623
Fax: 403-237-4447

Email: beaufortsea.project@esso.ca

4.1.1 REGULATORY APPROVALS

The proposed Beaufort Sea Exploration Joint Venture Drilling Program (the exploration program or the program) consists of drilling one or more exploration wells within exploration licence (EL) 476 or EL 477. The ELs are located within the Canadian sector of the Beaufort Sea, more specifically in the Inuvialuit Settlement Region (ISR) in the Northwest Territories (NWT).

The major approval milestones for offshore wells in the ISR, as required in the *Canada Oil and Gas Operations Act* (COGOA) and under the Inuvialuit Final Agreement (IFA) include:

- this Project Description (PD) to be filed with the Inuvialuit Environmental Impact Screening Committee (EISC) and the National Energy Board (NEB)
- an Environmental Impact Statement (EIS), if required, to be filed with the Inuvialuit Environmental Impact Review Board (EIRB)
- a drilling operations authorization (OA) application to be filed with the NEB
- a benefits plan to be filed with Aboriginal Affairs and Northern Development Canada (AANDC) and provided to the NEB
- a well approval (WA) application to be filed with the NEB
- other ancillary applications or licences required for the exploration program

Table 4-1, summarizes the regulatory approvals required for the program. An overview of the regulatory approval process is shown in Figure 4-1.

Table 4-1: Program Required Regulatory Approvals

No.	Approval	Jurisdiction	Legislation	Contact	Planned Submittal Date	Expected Approval Date	Date Approval Required	Description and Notes
1	Screening by the Environmental Impact Screening Committee (EISC)	EISC	• *Western Arctic (Inuvialuit) Claims Settlement Act* • Inuvialuit Final Agreement (IFA)	EISC – Darrell Christie, EISC Coordinator AANDC – Conrad Baetz, Manager, North Mackenzie District	July 2013	September 2013 (two months to review and possibly refer to the EIRB)	September 2013	• The EISC will determine if the program should be referred to the EIRB. • The NEB will also receive the Project Description. The NEB might provide comment during the EISC screening and might elect to conduct an additional assessment.
2	Potential review by the Environmental Impact Review Board (EIRB) or the National Energy Board (NEB)	EIRB and NEB	• *Western* Arctic *(Inuvialuit) Claims Settlement Act* • IFA • EIRB and NEB Memorandum of Understanding	EIRB – Elizabeth Snider, EIRB Chair AANDC – Conrad Baetz, Manager, North Mackenzie District NEB – Céline Sirois Technical Leader, Environment	Early 2014	December 2014 (one year to review)	December 2014	• The Environmental Impact Statement (EIS) will be submitted to the EIRB. The EIRB will conduct a public review in accordance with the IFA and a public hearing is a possibility. • There is an opportunity for common terms of reference with the NEB if a coordinated assessment is possible. If a coordinated assessment is not possible, the EIS will be submitted to the NEB along with the drilling operations authorization (OA). • The NEB will consider the EIRB's report and recommendations during its CEAA, 2012 determination and its consideration of the drilling OA.
3	*Canadian Environmental Assessment Act, 2012* (CEAA, 2012) determination Note: based on proposed amendments to the *Regulations Designating Physical Activities*, April 19, 2013	NEB	• the CEAA, 2012 • Canada *Oil and Gas Operations Act* (COGOA) under the jurisdiction of the NEB • EIRB and NEB Memorandum of Understanding	NEB – Céline Sirois, Technical Leader, Environment	December 2014	December 2015 (one year)	December 2015	• There is an opportunity for common terms of reference with the EIRB, if a coordinated assessment is possible. • An NEB public hearing is a possibility in addition to an EIRB's hearing. • The NEB must wait for the EISC and EIRB recommendations before it makes its determination.

Table 4-1: Program Required Regulatory Approvals (cont'd)

No.	Approval	Jurisdiction	Legislation	Contact	Planned Submittal Date	Expected Approval Date	Date Approval Required	Description and Notes

4	Drilling operations authorizations (OA)	NEB	• COGOA under the jurisdiction of the NEB
			• the *NEB's Filing Requirements for Offshore Drilling in the Canadian Arctic*, December 2011
				NEB – Hearing Manager (to be determined)	December 2014	December 2015 (one year)	December 2015	• A drilling OA would be required before a funding commitment in Q1 2016.
								• The application must include a description of the drilling program including:
								  • management
								  • evidence of financial responsibility
								  • an approved benefits plan
								• A certificate of fitness for each drilling and accommodation installation, which is a condition before authorization.

5	Canada Benefits Plan	Aboriginal Affairs and Northern Development Canada (AANDC)	• Section 5.2 of the COGOA	AANDC – Michel Chenier, Director, Policy and Research	Q1 2015	Q3 2015 (six months)	Q4 2015	• The Canada Benefits Plan must be approved before the NEB provides a drilling OA. • The plan describes the operator's policies and activities for involving Canadian and local business, and for employment and training of Canadians and northerners.

6	Section 35 – authorization to alter fish habitat	Fisheries and Oceans Canada (DFO)	• *Fisheries Act*	DFO – Julie Dahl, Manager, Central and Arctic Region	Q1 2017 (if dredging is required)	Q1 2019 (two years, if required)	Q1 2019 (if three months of dredging during the open-water season is required)	• Specific program components to evaluate are:
								  • potential dredging activities in Tuktoyaktuk Harbour
								  • installation of docks, harbours or moorings
								  • set down of anchors
								  • disposal of dredged material
								  • noise and vessel traffic
								• Authorization under the *Fisheries Act* will likely still be needed.

7	Disposal at sea permit (for dredged material)	Environment Canada (EC)	• *Canadian Environmental Protection Act* (CEPA)	EC – Mark Dahl, Senior Ocean Disposal Officer	Q1 2018 (if dredging is required)	Q1 2019 (one year, if required)	Q1 2019 (if three months of dredging during the open-water season is required)	• A permit is required for disposing dredged material at sea.

Table 4-1: Program Required Regulatory Approvals (cont'd)

No.	Approval	Jurisdiction	Legislation	Contact	Planned Submittal Date	Expected Approval Date	Date Approval Required	Description and Notes
8	Approval for potential dredging activities in Tuktoyaktuk Harbour	Transport Canada (TC)	• *Navigable Waters Protection Act*	TC – Matt Klaverkamp, Acting Manager Navigable Waters Protection	Q3 2018 (if dredging is required)	Q4 2018 (three months, if dredging is required)	Q1 2019 (if three months of dredging during the open-water season is required)	• Approval is required if dredging work is undertaken. • The application will include a description of the proposed site, its design, construction and management and operation of the work. • Approval will be required for disposing of dredged material.
9	Certificates of fitness	TC and NEB	• *Canada Oil and Gas Certificate of Fitness Regulations* • COGOA	NEB – Chief Safety Officer TC – Craig Miller, Manager Marine Safety	Q2 2019	Q4 2019 (six months)	December 2019	• Required for vessels and equipment. • The NEB will determine if the drilling installation and accommodation: • is designed, constructed, transported and installed in accordance with regulations • is fit for purpose • will continue to satisfy the requirements for the period of validity
10	Drilling unit, icebreaker and supply vessel approvals	TC	• *Arctic Waters Pollution Prevention Act* • *Canada Shipping Act* • *Navigable Waters Protection Act* • *Coasting Trade Act* • *Marine Transportation Security Act* and regulations, Part 2	TC – Craig Miller, Manager Marine Safety TC – Lavina Harding, Manager Marine Security	Q3 2017 To be determined	Q1 2019 (18 months) To be determined	Q4 2019 To be determined	• An early application with significant schedule float is recommended. Approvals will be obtained by prime contractors. • Required approvals for each vessel include: • an arctic pollution prevention certificate (not mandatory, but strongly encouraged) • Canadian maritime documents addressing personnel competency, maritime safety and maritime pollution prevention • a coasting trade licence for foreign vessels or non-duty paid vessels • inspection of a vessel operator's international ship safety certificate or for a Canadian vessel, a Canadian vessel security certificate and shipping approval once the flag state is known for all Safety of Life at Sea (SOLAS) or non-SOLAS vessels interfacing with the marine drill site

Table 4-1: Program Required Regulatory Approvals (cont'd)

No.	Approval	Jurisdiction	Legislation	Contact	Planned Submittal Date	Expected Approval Date	Date Approval Required	Description and Notes
11	Water licence	Northwest Territories Water Board (NWTWB)	• *Northwest Territories Water Act* and regulations Sec. 4-8	NWTWB – Executive Director (to be determined) AANDC – Conrad Baetz, Manager, North Mackenzie District	Q4 2018	Q2 2019 (six months)	Q1 2020	• Required for withdrawing water for potable water use and for disposal at the shore-based facility. • Devolution in the NWT will transfer governance of land and water from the federal government to the GNWT. Transfer of responsibility is expected to happen in the spring of 2014. Confirmation of whether the water licence would be issued by the GNWT or NWTWB and AANDC will be obtained.
12	Other approvals required for onshore staging activities, such as land use permits	Land use permits - Inuvialuit Land Administration (ILA) GNWT - Department of Environment and Natural Resources (GNWT-ENR) Waste – ENR has jurisdiction over waste management in the NWT	• IFA • *North West Territories Environmental Protection Act*	Land – ILA, Mike Harlow, Chief Land Administrator (if on Inuvialuit private lands) or AANDC – Conrad Baetz, Manager, North Mackenzie District if on Crown land in the ISR – Catherine Conrad, Director, Northern Affairs Organization Waste: GNWT-ENR, Todd Paget	To be determined with contractor	To be determined with contractor	To be determined before start of onshore activities	• Onshore activities will occur through contracted parties. Imperial will work with contractors to ensure that proper regulatory approvals are in place. If sites and services are not in full compliance, compliant alternatives will be used. • Devolution in the NWT will transfer governance of land and water from the federal government to the GNWT. Transfer of responsibility is expected to happen in the spring of 2014, which might impact Crown land administration. • For waste, joint engagement in conjunction with the Canadian Wildlife Services and TC will occur.
13	Well approval (WA)	NEB	• *Canada Oil and Gas Drilling and Production Regulations* • COGOA	NEB – Patrick Smyth, Chief Conservation Officer	Feb. 1, 2020 (120 days before the latest drilling start date, May 1, 2020)	March 1, 2020 (one month)	Start drilling in 2020 season	• A WA is required before drilling starts. • A WA will be submitted no less than 21 days before the date the operator plans to spud the well. • The operator must start drilling within 120 days after the WA is granted. Imperial might apply for the WA well before the 120 day deadline.

Table 4-1: Program Required Regulatory Approvals (cont'd)

No.	Approval	Jurisdiction	Legislation	Contact	Planned Submittal Date	Expected Approval Date	Date Approval Required	Description and Notes
13	Well Approval (WA) (cont'd)							This would be done to give Imperial time to address any concerns the NEB might have before the program drilling starts. This would help Imperial avoid having program equipment or resources sit idle if there is a delay in the permit being granted.
14	Significant Discovery Licence (SDL)	AANDC	• *Canadian Petroleum Resources Act*	AANDC – Mimi Fortier, Director General	To be determined	To be determined	To be determined	• If a discovery of hydrocarbons is made, Imperial could apply to the NEB and AANDC for an SDL.

Note:
AANDC = Aboriginal Affairs and Northern Development Canada
CEAA, 2012 = *Canadian Environmental Assessment Act, 2012*
CEPA = *Canadian Environmental Protection Act*
COGOA = *Canada Oil and Gas Operations Act*
DFO = Fisheries and Oceans Canada
EC = Environment Canada
EIRB = Environmental Impact Review Board
EIS = Environmental Impact Statement
EISC = Environmental Impact Screening Committee
GNWT-ENR = Government of the Northwest Territories - Department of Environment and Natural Resources
IFA = Inuvialuit Final Agreement
ILA = Inuvialuit Land Administration
ISR = Inuvialuit Settlement Region
NEB = National Energy Board
NWTWB = Northwest Territories Water Board
OA = operations authorization
SDL = significant discovery licence
TC = Transport Canada
WA = well approval

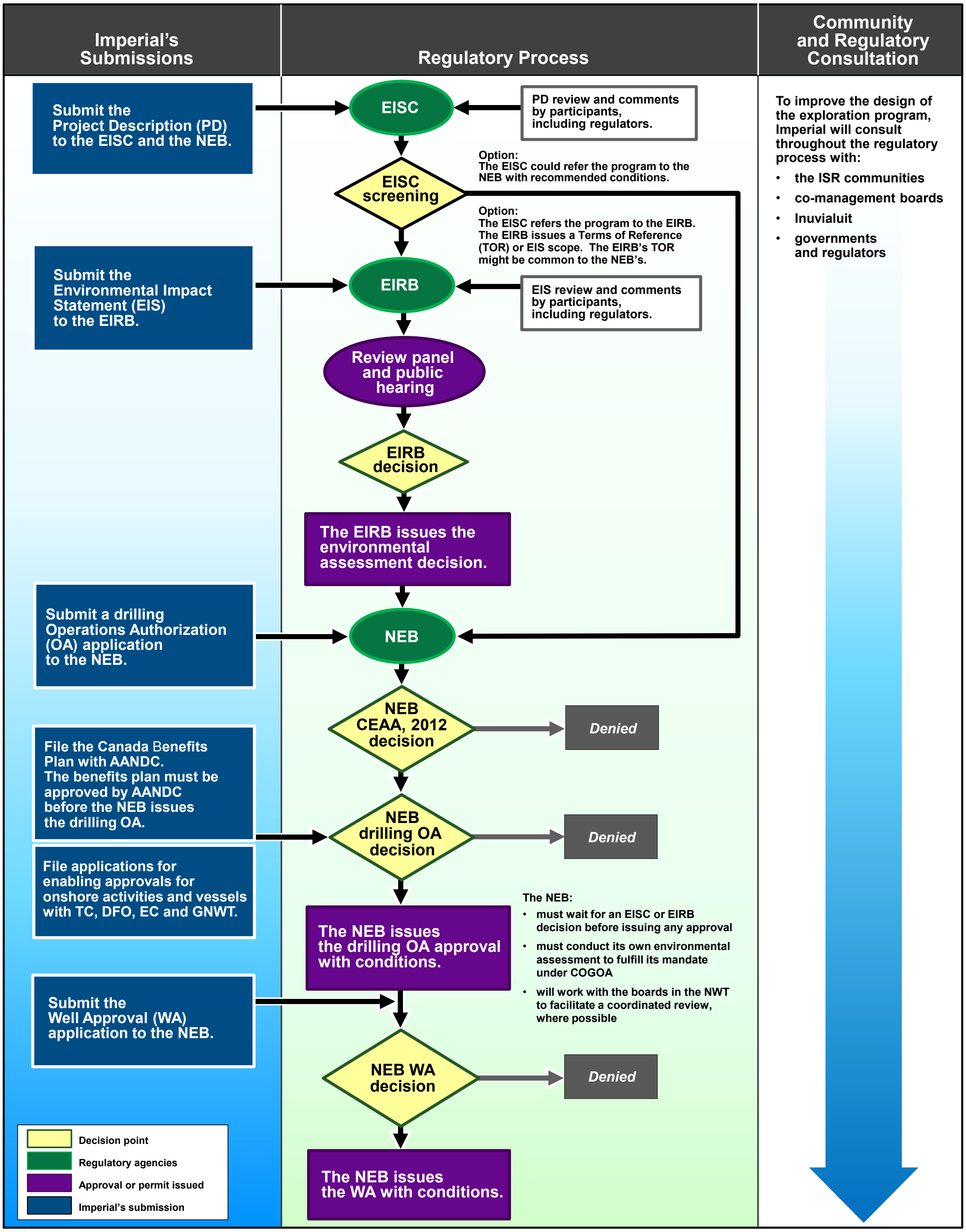


Figure 4-1: Overview of the Regulatory Approval Process

4.1.2 REGULATORY AUTHORITIES

The primary agency providing enabling approvals for the program is the NEB. There are also a number of other regulatory agencies with interest in the approval process, including:

- Fisheries and Oceans Canada (DFO)
- Environment Canada (EC)
- Transport Canada (TC)
- the Canadian Coast Guard (CCG) concerning vessel specifications

Imperial has met with representatives from most of the interested agencies to discuss their interests. This section provides a brief description of the relevant agencies and their interest in the program. For an outline of the comments and questions received from agencies to date, see Section 13, Co-Management, Inuvialuit Organizations and Government Engagement Consultation.

4.1.2.1 National Energy Board

The NEB is an independent federal agency established by the Parliament of Canada to regulate international and interprovincial aspects of the oil, gas and electric utility industries. The NEB is accountable to Parliament through the Minister of Natural Resources Canada (NRCan).

Legislation governing offshore oil and gas drilling in the Beaufort Sea has been developed by federal regulators, including the NEB, and is continuously updated and improved in response to industry activities that have been conducted for more than 40 years. The key piece of legislation administered by the NEB is the COGOA.

In response to the *Deepwater Horizon* (Macondo) accident in 2010, the NEB conducted an Arctic Offshore Drilling Review (AODR) in 2011. The purpose of the AODR was to gather information from stakeholders concerning drilling in the Arctic. That data was used to assist the NEB in evaluating and formulating its policies and requirements, particularly regarding same season relief well (SSRW) capability. Imperial participated in the AODR, which included responding to two rounds of information requests and participating in public hearings held in Inuvik. In December 2011, the NEB concluded its review and issued two documents:

- Review of Offshore Drilling in the Canadian Arctic, which summarized the AODR

- *Filing Requirements for Offshore Drilling in the Canadian Arctic*, an updated set of filing requirements that incorporated lessons learned from the AODR

Imperial will submit an application for a drilling OA to the NEB under the *Canada Oil and Gas Drilling and Production Regulations* and in accordance with the NEB's *Filing Requirements for Offshore Drilling in the Canadian Arctic*.

The amended *Canadian Environmental Assessment Act, 2012* (CEAA, 2012) includes the *Regulations Designating Physical Activities*, commonly called the projects list. This document lists physical activities that require an environmental assessment under the new CEAA, 2012. Currently, it is proposed that offshore exploration wells be added to the projects list. If this change is sanctioned, this program would require an environmental assessment under the CEAA, 2012. The NEB would be responsible for the environmental assessment and would make a CEAA determination after considering the EISC and EIRB recommendations. The NEB would also be required to consider environmental impacts under its jurisdiction and to consider the program under the COGOA and its applicable regulations. If, after considering all the relevant recommendations, and making the CEAA determination, and if the NEB approved of the program, the NEB would issue an OA with a list of conditions that the program must adhere to.

After an OA has been submitted and approved by the NEB, the program proponents would submit an application for a WA to the NEB. Well approvals fall under the *Canada Oil and Gas Drilling and Production Regulations* and must meet the NEB's filing requirements.

4.1.2.2 The EISC and EIRB

The EISC is an advisory committee that conducts environmental screening of development activities proposed for onshore or offshore areas of the ISR. The EISC and EIRB's responsibilities are mandated by the IFA. Although the EISC and EIRB are not federal regulatory agencies, the IFA requires the NEB to wait for an EISC or EIRB decision before issuing any regulatory authorization.

If the EISC determines that a detailed environmental impact assessment and public review of a proposed development project or program is required, then the EISC would refer the project or program to the EIRB (under the IFA) and to the NEB (under the COGOA). Imperial would then file an EIS, which would be completed using methods developed to meet the requirements of:

- the EIRB (under the IFA)
- the NEB (under the COGOA and CEAA, 2012)

The EIRB decides whether a project or program should proceed and, if so, under which specific terms and conditions. In making its decision the EIRB considers the need for:

- wildlife compensation
- mitigation
- remedial measures

4.1.2.3 Environment Canada

It is the responsibility of EC to preserve and enhance the quality of the natural environment of the nation, conserve Canada's renewable resources including wildlife, preserve and protect Canada's water resources, forecast weather and environmental change, enforce rules relating to boundary waters, and coordinate environmental policies and programs for the Government of Canada. Under the

4.1.2.3 Environment Canada (cont'd)

Canadian Environmental Protection Act, EC is the lead agency responsible for ensuring that the cleanup of hazardous waste and oil spills is adequate.

Specific to this exploration program, EC is interested in understanding potential effects on:

- birds
- polar bears, for the Canadian Wildlife Service (CWS)
- pollution prevention

Environment Canada would also be responsible for issuing a Disposal at Sea Permit for dredged material, if dredging is required by the program.

In addition to EC, two agencies that also report to the Minister of Environment and which will have an interest in the program are:

- the Canadian Environmental Assessment Agency
- Parks Canada, which manages the Canadian National Parks system

4.1.2.4 Fisheries and Oceans Canada

Fisheries and Oceans Canada is responsible for developing and implementing policies and programs in support of Canada's social, economic, ecological and scientific interests in Canada's oceans and fresh waters. A key piece of legislation for which the DFO is responsible for is the *Fisheries Act*. In June 2012, amendments to the *Fisheries Act* received royal assent. The changes to the act focused on protecting the productivity of recreational, commercial and Aboriginal fisheries. Within this context, the DFO would evaluate the program's potential effects on:

- marine mammals
- fish
- fish habitat
- marine invertebrates

The DFO would also be responsible for issuing an approval specific to dredging work, if necessary.

The CCG, an operating agency within the DFO, helps the DFO meet its responsibility of ensuring that Canada's waterways are safe and accessible.

4.1.2.5 Transport Canada

Transport Canada is responsible for Canada's federal transportation policies and programs. It ensures that air, marine, road and rail transportation are safe, secure, efficient and managed in an environmentally responsible manner. Transport Canada is also responsible for enforcing several Canadian acts and regulations, including the:

- *Navigable Waters Protection Act*

- *Transportation of Dangerous Goods Act*
- *Canada Transportation Act*
- *Canada Shipping Act, 2001*
- *Marine Transportation Security Act*

Imperial will seek a number of permits and approvals from TC for the drilling unit, vessels and equipment operation, including:

- an arctic pollution prevention certificate
- Canadian maritime documents addressing personnel competency, maritime safety and maritime pollution prevention
- a coasting trade licence for foreign vessels or non-duty paid vessels

Transport Canada will also have a role in approving dredging activities in Tuktoyaktuk Harbour, if required.

4.1.2.6 Aboriginal Affairs and Northern Development Canada

The AANDC is one of the federal government departments responsible for meeting the Government of Canada’s legal obligations and commitments to Aboriginal people (First Nations, Inuit and Métis) and for fulfilling the federal government’s constitutional responsibilities in the North. The AANDC works in partnership with northern and Aboriginal agencies and people to:

- govern the allocation of Crown lands to the private sector for oil and gas exploration
- set and collect royalties
- issue ELs
- issue significant discovery licences (SDLs)
- approve benefit plans, which define oil and gas operators' policies and activities to maximize employment, business and training prospects for residents of the North

The NEB cannot make its regulatory decision regarding oil and gas exploration and production activities pursuant to the COGOA (e.g., issue a drilling OA) until the Minister of AANDC has approved or waived the requirement of approval of a benefits plan.

4.1.2.7 Government of the Northwest Territories

The Government of the Northwest Territories (GNWT) currently administers the following acts:

- the *Environmental Protection Act*
- the *Spill Contingency Planning and Reporting Regulations*
- the *NWT Wildlife Act*

4.1.2.7 Government of the Northwest Territories (cont'd)

A key interface with the GNWT is through the Department of Environment and Natural Resources (GWNT-ENR). The GNWT is currently in the final stage of devolution negotiations with the federal government. Devolution will transfer the responsibility for public land, water and resource management from the federal government to the GNWT. The devolution process is expected to be finalized in the spring of 2014. As part of the devolution process, the GNWT and participating Aboriginal agencies have agreed to work together on land management and natural resource stewardship.

4.1.2.8 Northwest Territories Water Board

The Northwest Territories Water Board's jurisdiction is the ISR within the NWT and is limited to use of inland water (fresh water) and disposal of waste that might come into contact with water. The need for water licences required for the proposed program will be further defined as government responsibilities are finalized along with the program's plans for onshore staging activities.

5.1.1 PURPOSE OF THE PROPOSED DEVELOPMENT

The purpose of the proposed development is to drill one or more exploration wells within EL 476 (Ajurak) or EL 477 (Pokak) in the Beaufort Sea to:

- determine if hydrocarbons are present in one or more geological structures
- determine the composition of any hydrocarbons found
- identify the boundaries of the prospects to apply for an SDL
- identify the potential for future exploration or development drilling
- determine if there is a potential for commercial production

5.1.2 PROPONENT

Imperial Oil Resources Ventures Limited (Imperial), on behalf of the Beaufort Sea Joint Venture, is the proponent of the Beaufort Sea Exploration Joint Venture Drilling Program.

In 2010, a Joint Operating Agreement was reached between Imperial, ExxonMobil Canada Ltd. (ExxonMobil) and BP Exploration Operating Company Limited (BP). The Joint Operating Agreement provides for a cross-conveyance of Ajurak and Pokak, with ownership as follows:

- Imperial – 25%
- ExxonMobil – 25%
- BP – 50%

Imperial is the designated operator of the joint venture.

5.1.3 EXPLORATION LICENCES

In 2007, AANDC issued EL 446 (Ajurak) to:

- Imperial – 50%
- ExxonMobil – 50%

In 2008, AANDC issued EL 449 (Pokak) to BP.

In July 2012, the Minister of AANDC issued replacement EL numbers to Imperial and BP. The new EL numbers are:

5.1.3 EXPLORATION LICENCES (cont'd)

- EL 476 for Imperial's Ajurak, with an expiry date of July 31, 2019
- EL 477 for BP's Pokak, with an expiry date of September 30, 2020

5.1.4 OPERATING CONDITIONS AT AJURAK AND POKAK

The Ajurak and Pokak ELs are located in the Canadian sector of the Beaufort Sea about 175 km north-northwest of Tuktoyaktuk, Northwest Territories, within the ISR (see Figure 5-1). These ELs are located in water depths ranging from 60 to 1,500 m.

In 2008 and 2009, 3-D seismic programs were conducted by Imperial and BP. From 2009 to 2011, Imperial, ExxonMobil and BP undertook three years of field data collection studies in collaboration with ArcticNet in the Ajurak and Pokak areas.

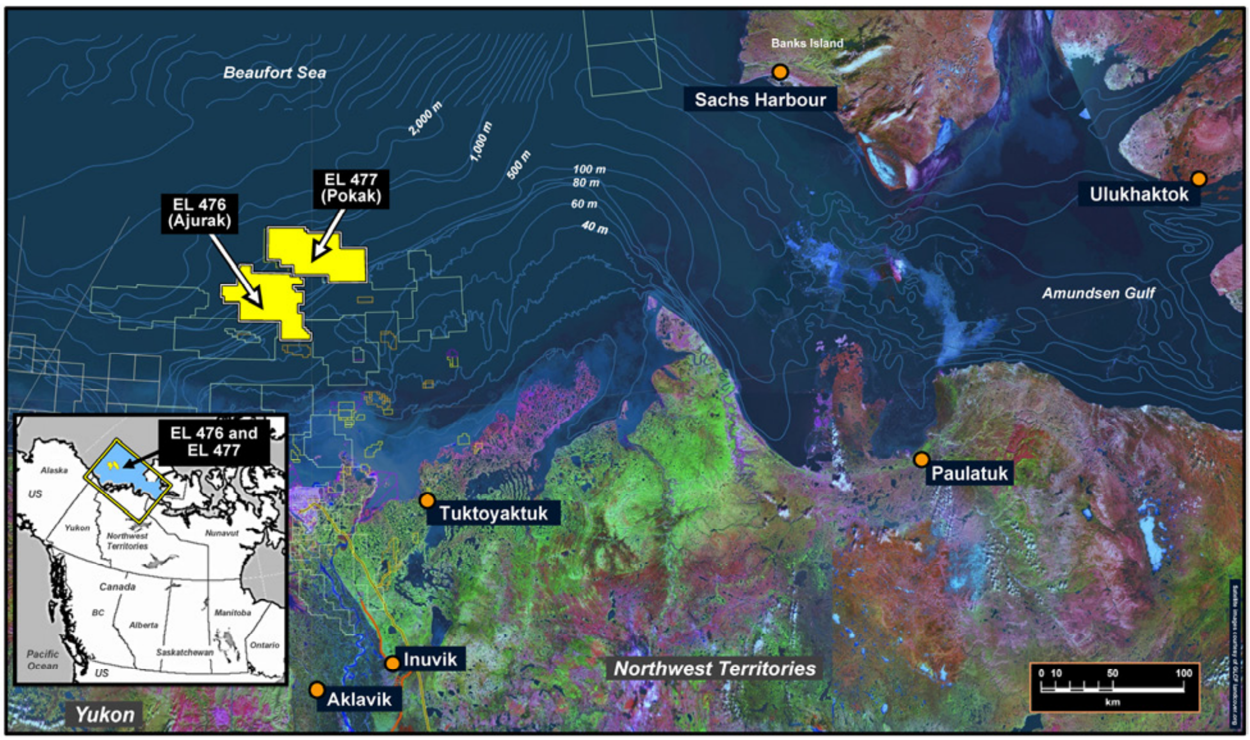


Figure 5-1: Regional Map of the Beaufort Sea with ELs and Six ISR Communities

Historical data indicates that the period of manageable ice conditions in the proposed development area is on average about 120 days, from May to November.

Imperial will use Inuvialuit expertise and traditional knowledge of the region, particularly their understanding of sea state, ice conditions and wildlife. Imperial will incorporate the scientific and traditional information of the region into their design and operating specifications to ensure that the drilling program is safe and environmentally responsible.

5.1.5 BEAUFORT SEA DRILLING PROGRAM

The drilling program for the Beaufort Sea might involve a series of activities over a given time period, including:

- obtaining initial and final regulatory approvals
- satisfying pre-operating regulatory conditions
- procuring materials and equipment to drill one or more wells, including the drilling unit and support vessels
- preparing a shore-based facility
- mobilizing to the work area
- drilling for multiple seasons, with drilling suspension at the end of each season
- conducting formation evaluations based on drilling data collected
- conducting abandonment and decommissioning activities

The major equipment components of an offshore drilling operation will include:

- a drilling unit and related equipment
- marine support vessels

5.1.6 POTENTIAL DRILLING SCHEDULE

For planning purposes, a potential drilling program schedule has been developed. This potential schedule allows for one or more wells to be spudded in EL 477 during the 2020 open-water season before the expiry of EL 477 (see Figure 5-2). This schedule is based on the following events occurring in a timely and effective manner:

- timely regulatory reviews and approvals, including:
  - EISC and NEB screening decisions
  - environmental assessment public review, if required
  - the NEB reviewing the drilling OA application and providing acceptable conditions
- the joint venture’s decision to commit in the 2016 to 2018 time period to a drilling system, including support vessels
- the final NEB WA

5.1.6 POTENTIAL DRILLING SCHEDULE (cont'd)

- mobilization to the Beaufort Sea and the start of drilling by 2020 (i.e., spudding the well)

It is assumed that any well drilled in Ajurak or Pokak would require at least two years to complete. Depending on weather and ice conditions at the time, the drilling window for a single well could require up to four seasons to complete. The seasonal drilling operations would be conducted using a single drilling unit.

Notwithstanding the potential program schedule, there is a possibility of an earlier spud date and more than one drilling location.

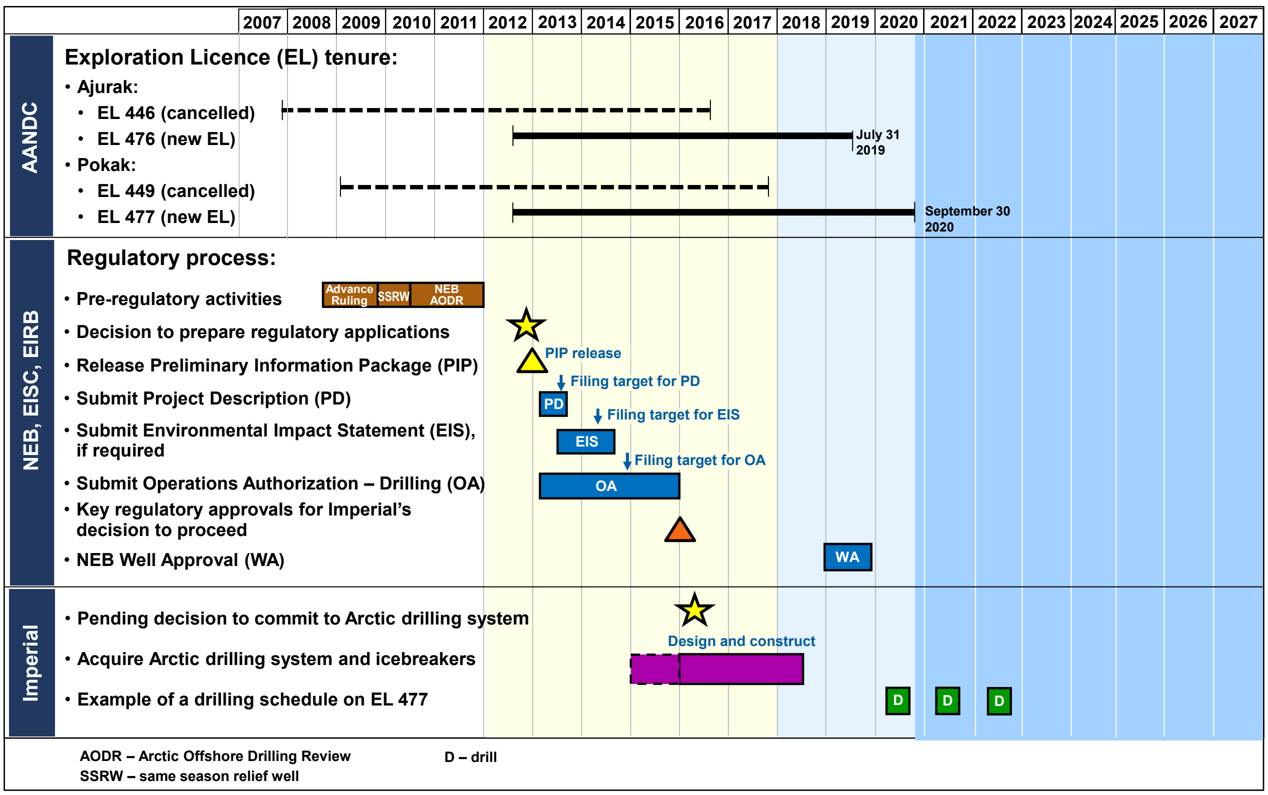


Figure 5-2: Example of a Potential Drilling Program Schedule

5.1.7 PHASES OF ACTIVITY

The scope and duration of the drilling activities would vary in any given year depending on:

- ice conditions in the Beaufort Sea at the start and end of the season
- day-to-day ice incursions at the drill site
- the annual drilling progress to well depths that are appropriate for well suspension

5.1.7.1 Years 2013 to 2015

The focus between 2013 and 2015 will be on:

- conducting community consultation and engagement with Inuvialuit, regulators and the public
- completing an environmental screening and assessment, and a public review, if required
- developing an early design and performing relevant technical studies
- performing additional field studies, including seeking opportunities for collaboration with other oil and gas explorers in the Arctic
- preparing and submitting a benefits plan to the AANDC
- preparing and submitting a drilling OA application to the NEB

5.1.7.2 Year 2016

The lead time required to spud a well or wells in 2020 requires that a decision to drill be made in 2016. Factors that would affect this decision include:

- the joint venture's confidence that a well or wells can be drilled in a safe and environmentally responsible manner
- the level of support by Inuvialuit for an exploration program
- acceptable conditions from the NEB regarding the program's drilling OA
- resolution of the SSRW equivalency requirement
- availability of an Arctic drilling system within the required time frame
- availability of proven technology and resources to meet the expected operating conditions
- the necessary financial commitment from the joint venture

5.1.7.3 Pre-Spud Activities in 2016 to 2019

If a decision is made to drill one or more wells in EL 476 or EL 477, many activities would need to be completed before spudding a well in 2020, including:

- finalizing well locations
- applying for and receiving a WA from the NEB
- establishing contracts for the drilling unit, icebreakers and support vessels
- developing infrastructure, such as a shore-based facility, aviation and communications, as required
- ordering drilling supplies and equipment

5.1.7.3 Pre-Spud Activities in 2016 to 2019 (cont'd)

- providing information on potential employment and business opportunities, including opportunities for Inuvialuit communities
- training the program workforce
- testing equipment and conducting drills, including appropriate emergency response drills
- executing other program plans and commitments, such as:
  - a Waste Management Plan (WMP)
  - a Wildlife Protection Plan
  - an Ice Management Plan (IMP)
  - regulatory requirements
  - company commitments
- potentially pre-installing a mooring system on the seafloor to secure the drilling unit in subsequent seasons
- potentially mobilizing equipment, fuel and supplies into the Beaufort Sea

5.1.7.4 Post-Drilling Activities (2022+)

If no further drilling is planned after the exploration well or wells have been drilled, the shore-based facility will be returned to its pre-program condition. All remaining supplies, equipment and fuel would be shipped out of the ISR, unless other arrangements are made.

If it was decided that further geological prospects warranted new exploration, the process would begin again to:

- conduct a possible seismic program
- obtain the necessary regulatory approvals
- begin drilling a new exploration well

5.1.8 MANAGEMENT AND EXPERIENCE

The drilling program design would draw on Imperial's and ExxonMobil's experience from 90 years of working safely and responsibly during drilling and production activities in the Arctic and global experience in operating in harsh offshore environments.

Other wells drilled worldwide have experienced the conditions that a Beaufort Sea drilling program might encounter, including:

- ice conditions
- oceanographic conditions (e.g., wave heights and currents)
- weather
- temperature
- water depth

- surficial geology
- reservoir pressure

The drilling program will be designed and implemented using all relevant Imperial and ExxonMobil standards and in compliance with regulatory requirements.

To reduce the risk of incidents and mitigate potential effects on the environment, certain aspects of the planning process will undergo a detailed risk assessment. The program will be prepared using Imperial's Operations Integrity Management System (OIMS) and ExxonMobil Development Company (EMDC) drilling's OIMS for drilling-related activities, which both use a systematic approach to managing risks and preventing incidents.

5.1.9 WELL CONTROL

Imperial's primary approach to well control is prevention.

Procedures will be developed to prevent a single point of failure leading to a catastrophic event. These procedures will ensure that:

- wells are designed for the range of risk expected
- equipment is inspected and maintained
- operators are trained
- tests and drills are conducted to verify personnel competency
- adequate barriers and redundancy are in place and tested to safely execute the work

Overbalanced fluids will be used to provide the primary barrier against well flow. Specialized pressure hunt teams and tools will be used on the drilling rig to:

- analyze well data for signs of abnormal pressure
- make the necessary adjustments to mud weight to ensure overbalance
- select casing setting depths to ensure that wellbore integrity can be maintained

The well will be monitored at all times to detect signs of well flow. If well flow is detected, personnel will have been trained and certified to quickly activate the secondary barrier (i.e., the blowout preventer) to stop the well flow and properly manage the well control event to restore the primary barrier (i.e., overbalanced fluid).

5.1.10 CONTINGENCY PLANS

Contingency planning describes how Imperial would respond to a non-routine event that could compromise safety or the environment. Contingency plans are formulated to provide the necessary plans for immediate and long-term response

5.1.10 CONTINGENCY PLANS (cont'd)

to incidents. For a Beaufort Sea drilling program, contingency plans will be developed for emergency response and oil spill response.

The optimal response to restore well control is well specific. Surface intervention would be the primary means of regaining well control and the fastest method to put in place. Other effective same-well intervention methods include activating the subsea BOP stack, which is typically the first option for regaining well control.

5.1.11 DRILLING UNIT

There are many types of drilling systems used around the world today, including:

- jack-up rigs
- moored semi-submersible drilling units
- drillships

For the water depths and conditions likely to be experienced in the Beaufort Sea, a floating drilling unit is the system of choice.

A key requirement of any drilling system is its ability to maintain its position (referred to as stationkeeping) at the well site location. The two most common stationkeeping methods used today are:

- moored drilling systems that use anchors attached to the seafloor
- dynamic positioning (DP) using a computer-controlled system to automatically maintain the drilling unit's position and heading by using its own propellers and thrusters

Dynamic positioning allows for operations in deep water where mooring is not feasible because of water depth.

Whatever drilling unit is selected for use in the Beaufort Sea, the most important factor is that it be fit for purpose and use proven technologies appropriate for the most severe conditions that could be experienced.

5.1.12 MARINE SUPPORT VESSELS

Multiple vessels will be required to support the drilling program, including:

- icebreaking support vessels
- ice-strengthened supply vessels
- ice-strengthened fuel tankers
- an ice-strengthened wareship

All of these vessels will be powered by diesel engines burning low sulphur diesel. No nuclear-powered vessels will be used. Each vessel might also have one or more boilers that will also burn low sulphur diesel to generate heat for the vessel's living compartments and other spaces. Each vessel would have multiple roles.

5.1.12.1 Icebreaking Support Vessels

Most drilling unit options in the Arctic would require icebreaking support. Several icebreaking support vessels will be used. Each vessel will be capable of performing one or more of the following functions:

- breaking ice to clear a path for a drilling unit into and out of the Beaufort Sea at the beginning and end of each drilling season
- breaking ice a considerable distance from the drilling unit (ice management)
- breaking ice to clear a path into and out of the Beaufort Sea for fuel tankers or a wareship, if these vessels are used
- breaking ice and providing ice management for fuel tankers or a wareship while they are in the licence areas, if these vessels are used
- carrying fuel, drilling materials and other supplies for the drilling unit
- carrying, installing and retrieving the pre-set anchors used to moor the drilling unit at the drilling site, if required
- deploying and retrieving a remotely operated vehicle to support well work operations
- carrying and refuelling helicopters for personnel transfer and ice reconnaissance
- supporting source control operations in the unlikely event of loss of well control
- supporting oil spill response operations, including applying dispersants and skimming oil from the water surface
- providing emergency response for the drilling unit, including firefighting and evacuating the drilling unit's crew

Icebreaking support vessels will be of various sizes, but will likely be too big to enter Tuktoyaktuk Harbour. These vessels would normally remain in or near the EL areas, except when escorting the drilling unit, fuel tankers or wareship (if used) into and out of the Beaufort Sea.

These vessels will be designed:

- for breaking and ramming ice
- in accordance with Canadian regulations and international standards, including the International Association of Classification Societies Ltd. (IACS) Unified Requirements for Polar Ships
- to operate independently for an extended duration

5.1.12.2 Ice-Strengthened Supply Vessels

Depending on the final strategies for logistics, waste management, oil spill response and well control, several ice-strengthened supply vessels might be used to perform one or more of the following functions:

- carry fuel, drilling materials and other supplies from Tuktoyaktuk to the drilling unit and icebreaking support vessels
- carry waste products from the drilling unit and icebreaking support vessels to Tuktoyaktuk for shipment out of the ISR
- carry drilling unit and icebreaking support vessel crew members to and from Tuktoyaktuk
- support source control operations in the unlikely event of loss of well control
- support oil spill response operations, including deploying containment booms

These vessels would be designed to enter and operate out of Tuktoyaktuk Harbour and would be smaller in size than the icebreaking support vessels described previously. Ice-strengthened supply vessels would be:

- capable of operating independently throughout the drilling season in the ice conditions expected between Tuktoyaktuk and the licence areas
- designed in accordance with Canadian regulations and international standards, including the IACS Unified Requirements for Polar Ships

5.1.12.3 Ice-Strengthened Fuel Tankers

Depending on the exploration drilling program’s final logistics strategy, ice-strengthened fuel tankers might be used over the course of each drilling season to supply some or all of the diesel fuel and other supplies required by:

- the drilling unit
- icebreaking support vessels
- ice-strengthened supply vessels

The number and size of fuel tankers could vary from a single large tanker to multiple small tankers, or a combination of both.

Fuel tankers would be too large to enter Tuktoyaktuk Harbour and would remain in or near the licence areas, except when transiting into and out of the Beaufort Sea.

The fuel tankers used would likely:

- have double hulls
- be designed in accordance with Canadian regulations and international standards including the IACS Unified Requirements for Polar Ships

- be capable of independent operations in the ice conditions expected between the port of departure and the licence area throughout the drilling season, except at the beginning and ends of the season when it is expected that escort by one of more of the icebreaking support vessels would be required
- be specially configured for ship-to-ship transfer of fuel to smaller vessels, such as the icebreaking support vessels and ice-strengthened supply vessels

5.1.12.4 Ice-Strengthened Wareship

Depending on the final strategies for logistics, waste management, spill response, and well control, an ice-strengthened wareship might be used to perform one or more of the following functions:

- carry fuel, drilling materials and other supplies for the drilling unit and support vessels
- receive waste products from the drilling unit and support vessels for storage and shipment out of the licence areas
- support helicopter operations
- provide a location to conduct or support maintenance work needed for the drilling unit and support vessels
- support for source control operations in the unlikely event of loss of well control
- support for oil spill response operations, including carrying containment booms and dispersant

The wareship, if used, would be too large to enter Tuktoyaktuk Harbour and would normally remain in or near the licence area, except when transiting into and out of the Beaufort Sea at the beginning and end of each season. After arriving at the beginning of the season, the wareship would remain in an ice-free section of the licence area and move only as necessary to avoid ice. The icebreaking support vessels and ice-strengthened supply vessels (if used) would offload fuel and other supplies from the wareship both for their own needs and to transfer fuel to the drilling unit.

5.1.13 SUPPORT FACILITIES

Deepwater drilling operations typically require a deep-draft port for operations support. Because there is no deep-draft port in the Beaufort Sea, an offshore wareship might be used.

Various land-based facilities and services might be needed to support offshore drilling operations, including:

- a shore-based facility, which might include:
    - accommodations

5.1.13 SUPPORT FACILITIES (cont'd)

  - staging sites and storage areas
  - a dock area

- transportation services (i.e., air and land) for moving supplies and personnel
- emergency equipment storage
- a potable water supply
- waste management services

5.1.14 SHORE-BASED FACILITY

The offshore drilling program could require the support of a shore-based facility, most likely located in Tuktoyaktuk, which is about 125 km from the potential drilling location in EL 476 or EL 477. The shore-based facility would be leased from one or more of the existing commercial locations.

5.1.14.1 Onshore Accommodations

Onshore accommodation could be required for:

- shore-based facility personnel, if such a facility were established for the program
- personnel transiting to and from the offshore drill site
- personnel evacuated from the offshore drill site in an emergency

The accommodation requirements will be determined at a later date.

5.1.14.2 Staging Sites and Storage Areas

It is not expected that a lot of equipment would be stored at the shore-based facility.

Infrastructure at the shore-based facility to support the drilling operations might include:

- a staging site and storage area for equipment and materials
- a heated warehouse
- offices and communication services

5.1.14.3 Dock Area

Some dock construction and upgrading might be required to handle the loading and unloading of supplies and personnel. To allow shallow-draft vessels to enter and exit Tuktoyaktuk Harbour, dredging might be required near the dock area and at some locations inside the harbour. The dock area would require equipment to handle small tools and lightweight containers.

5.1.15 OPPORTUNITIES

Imperial and ExxonMobil personnel would typically occupy and/or provide oversight to the senior positions on the drilling unit, support vessels and at the shore-based facility. Most of the workforce for a Beaufort Sea drilling program would consist of individuals hired by contractors working under service agreements with Imperial and ExxonMobil.

Work would be awarded based on an assessment of whether a proposal provides the best total value, including:

- safety and environmental performance
- technical and operational capabilities
- Inuvialuit and Canadian content
- cost competitiveness
- the ability to deliver work within Imperial’s schedule requirements

Imperial’s intent is to provide opportunities for Inuvialuit companies by:

- notifying Inuvialuit suppliers of potential opportunities as early as possible
- preparing work packages that encourage Inuvialuit companies to bid on the work or align with other companies in joint ventures to manage larger work packages

If an Inuvialuit company secures a contract, Imperial will assist the successful bidder to:

- achieve first-class safety and environmental performance
- provide training and development opportunities
- verify that the company has all the required procedures and policies in place to do the work safely and successfully
- deliver timely and high-quality results, which would put the company in good standing for future work opportunities in the Beaufort Sea region or at the national and international level

Identifying specific jobs and contracting services at this time in the planning cycle would be premature. If the joint venture partners decide in 2016 to proceed with drilling, the job identification effort will be further defined. The first areas of employment opportunities will be for positions to provide long lead time services, such as new-build vessels, if required, and upgrading the shore-based facility at Tuktoyaktuk, if required.

5.1.16 ACCOUNTABILITY

Imperial and ExxonMobil will fill key management and technical positions with qualified personnel for the proposed Arctic and offshore operations. These personnel would have the authority and responsibility to make decisions that ensure operations are performed in a safe and environmentally responsible

5.1.16 ACCOUNTABILITY (cont'd)

manner. Imperial will take responsibility and oversight of their contractors' actions and activities.

In the unlikely event of an incident that could affect the livelihood of local residents, damage to the environment or Inuvialuit culture and lifestyle, Imperial's solid financial status and the compensation procedures it has in place, including fair and timely wildlife compensation, would ensure:

- appropriate compensation for individuals or local businesses
- restoration of the environment, as quickly as possible

5.2.1 VALUED ECOSYSTEM COMPONENTS

While all components of the environment are important, it is neither practical nor necessary to assess the potential effects of the program on every component. This PD focuses on the valued ecosystem components (VECs) that have the greatest value and sensitivity and, therefore, have the greatest degree of sensitivity to program-related activities.

The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. The VECs identified are surrogates to focus or structure the environmental effects assessment, with an understanding that effects on other related components of the environment would be similar.

The VECs were identified through a relevant literature review, local knowledge of the potentially affected area, the results of baseline studies, previous environmental assessment experience and from lists of generally accepted VECs among discipline experts (i.e., VECs known to be strong indicators of change). The VECs selected for this assessment and the rationale for their inclusion are listed in Table 5-1.

Table 5-1: Selected VECs

VEC	Description	Rational for Selection
Atmospheric environment	• Includes ambient air quality and ambient noise levels (expressed in A-weighted decibels or dBA).	• Requirement to comply with the *Guideline for Ambient Air Quality Standards in the Northwest Territories*. • The potential for health implications. • Noise levels are likely to increase as a result of program activities.
Benthos	• Includes benthic invertebrates living on the seafloor (epifauna) or within the sediment of the seafloor (infauna) in the local study area (LSA), benthic macrophytes (seaweeds) occurring in Tuktoyaktuk Harbour and benthic habitat in the LSA.	• Ecological importance in the regional study area (RSA). • Potentially affected by proposed program activities.
Coastal landscapes	• Shoreline and seafloor erosion or alteration because of dredging or vessel transit. • Fouling of shoreline habitats.	• Shoreline morphologic changes are possible because of program activities. • Erosion of the shoreline might increase risk to existing coastal populations (i.e., Tuktoyaktuk). • Oil spills during storm surges could result in fouling large areas of coastal plain and vegetation.

Table 5-1: Selected VECs (cont'd)

VEC	Description	Rational for Selection
Community wellness	• Community health and wellness includes determinants that can have an effect on economic, physical, mental and social well-being.	• Importance of community wellness in the ISR.
Human health	• Health of individuals in the ISR harvesting country foods.	• Public concern that program activities could influence the health of the populations in and around Tuktoyaktuk and other local communities.
Marine and anadromous fish	• Includes marine and anadromous fish and fish habitat occurring in the RSA, including broad whitefish, lake whitefish, round whitefish, inconnu, Dolly Varden, Arctic cisco, least cisco, Bering cisco, Arctic char, Pacific herring, Arctic cod, rainbow smelt, fourhorn sculpin, Arctic flounder, starry flounder, blackline prickleback and northern wolffish.	• Identified as important during traditional knowledge studies and during consultation activities. • Ecological, social, cultural and commercial importance in the RSA. • Biological indicators for marine and terrestrial ecosystem health. • Mackenzie River and estuary supports spawning, rearing and feeding areas. • Potentially affected by proposed program activities. • Includes several species listed in the federal *Species at Risk Act* (SARA).
Marine avifauna	• Includes: • seabirds • waterfowl • shorebirds • raptors • passerines occurring in the RSA • protected migratory bird areas, important bird areas and other critical habitat areas for marine avifauna	• Identified as important during traditional knowledge studies and during consultation activities. • Ecological, social, cultural and commercial importance in the RSA. • Biological indicators for marine and terrestrial ecosystem health. • Potentially affected by proposed program activities. • Includes several federal SARA-listed species. Migratory and non-migratory species protected by federal and territorial legislation. • Identified as important by regulators and in the Beaufort Sea Petroleum and Environmental Management Tool (PEMT).
Marine mammals	• Includes: • beluga whales • bowhead whales • ringed seals • polar bears • protected marine mammal zones and critical habitat areas (e.g., foraging ground and migratory corridors)	• Identified as important during traditional knowledge studies and during consultation activities. • Ecological, social, cultural and commercial importance in the RSA. • Biological indicators for marine and terrestrial ecosystem health. • Potentially affected by proposed program activities. • Includes federally SARA-listed species. • Program activities would take place in, or adjacent to, recognized beluga management zones. • Identified as important by regulators and in the PEMT (AECOM 2010).

Table 5-1: Selected VECs (cont'd)

VEC	Description	Rational for Selection
Terrestrial wildlife	• Includes: • barren-ground caribou • Peary caribou • grizzly bear • wolf • Arctic fox	• Importance as Inuvialuit resources (nutrition, clothing, cultural). • Territorial and federally protected species listings (i.e., SARA listing). • Ecological, social, cultural and commercial importance in RSA. • Biological indicators for terrestrial ecosystem health (keystone species). • Potentially effected by program activities. • Identified as important by regulators (i.e., Peary Caribou identified in the PEMT). • Identified as important during traditional knowledge studies.
Traditional land and resource use	• Considers harvesting of marine mammals, marine birds, fish and terrestrial wildlife.	• Program activities might affect traditional harvesting activities. • An EISC requirement.
Note: LSA = local study area PEMT = Petroleum and Environmental Management Tool RSA = regional study area SARA = *Species at Risk Act*		

5.2.2 IDENTIFICATION OF POTENTIAL PROGRAM ACTIVITY INTERACTIONS

Before predicting and assessing effects that are likely to occur, the potential for program activities to interact with VECs were determined and likely interactions identified (see Table 5-2). These interactions and associated effects have been identified based on a general understanding of the existing environment, and the experience of technical specialists, supported by existing information and data collected from past studies. Both direct and indirect interactions have been identified. A direct interaction occurs when the VEC is affected by a program component or activity. An indirect interaction occurs when one VEC is affected by a change in another VEC (e.g., beluga whales and resource harvesting).

Table 5-2: VEC and Program Activity Interaction

Program Activity	Description	Atmospheric environment	Benthos	Coastal Landscapes	Community Wellness *	Human Health	Marine and Anadromous Fish	Marine Avifauna	Marine Mammals	Terrestrial Wildlife	Traditional Land and Resource Use
Routine											
Mobilization/Demobilization/Support or Resupply											
Vessel transit and presence	• Vessel movements to and from the drill site • Vessel movement to the Beaufort Sea • Drilling unit presence	X			X	X		X	X		
Aircraft support	• Aircraft flights to and from the shore-based facility	X			X	X	X		X		
Transfer of supplies and consumables	• Land-to-ship transfers • Ship-to-ship transfers	X			●						
Routine discharges	• Ballast water • Wastewater and greywater • Cooling water		●	●	●	●		●	●		
Drilling Program											
Site preparation and construction	• Drill site preparation	X	X						●		
Icebreaking and management	• Ice management for the drilling program • Ice management for supply transits	X				X	X		X		
Drilling	• Well spud • Well drilling • Cuttings disposal • Well completion • Suspension and abandonment	X	X	X	●	X			X		
Well testing	• Flaring, vertical seismic profiling and surveys	X		X	X	X			X		
Onshore Support											
Shore-based facility preparation and operation	• Shore-based facility upgrades • Ongoing operations • Storage of supplies and materials	●				X	X			●	
Dock construction	• Upgrade of dock infrastructure	X	X	X	X	●			X	●	
Harbour dredging (might not be undertaken)	• Removal and disposal of material	X	X	X	●	●		X	X	●	
Waste disposal	• Disposal of ship-generated waste and shore-based facility waste				●	●	●			●	

Table 5-2: VEC and Program Activity Interaction (cont'd)

Program Activity	Description	Atmospheric environment	Benthos	Coastal Landscapes	Community Wellness *	Human Health	Marine and Anadromous Fish	Marine Avifauna	Marine Mammals	Terrestrial Wildlife	Traditional Land and Resource Use
Non-Routine											
Tier 3 spills	• Subsea blowouts • Blowout during open water • Blowout during fall	X	X	X	X	X	X	X	X	X	
Tier 1 spills	• Spills during open-water fuelling • Spills from vessel collisions • Onshore spills	X	X	X	X	X			X	X	

Note:
* The program as a whole has the potential to affect community wellness (both positively and negatively). This will be addressed separately in the assessment.
● = interaction is negligible and is not assessed further
X = likely effect to be assessed

5.3.1 ROUTINE ACTIVITIES

An assessment of the significance of the effects of routine program activities is provided in:

- Table 14-4, for vessel transit and presence
- Table 14-6, for aircraft support
- Table 14-7, for transfer of supplies and consumables (resupply)
- Table 14-8, for drill site preparation
- Table 14-9, for icebreaking and ice management
- Table 14-10, for drilling
- Table 14-11, for well testing
- Table 14-12, for shore-based facility preparation and operation
- Table 14-13, for dock construction
- Table 14-14, for dredging

Once mitigation is applied, the effects of the program activities are assessed as not significant.

5.3.2 NON-ROUTINE EVENTS

An assessment of the significance of effects of non-routine events is provided in:

- Table 14-19, for a minor spill
- Table 14-20, for a major spill

Once mitigation is applied, the effects of a minor spill are assessed as not significant.

Once mitigation is applied, the effects of a major spill are assessed as not significant, except for:

- effects on marine avifauna
- traditional land and resource use

5.4.1 PREVENTION AND MITIGATION OF ROUTINE ACTIVITIES

Some prevention measures apply at all stages of the program's life cycle. In general, these measures are tied to best practice and use of best available technology, including:

- maintaining a continual on-site environmental compliance presence during all program phases and activities, in accordance with Imperial's OIMS and with EMDC drilling's OIMS for all drilling-related activities
- establishing an environmental compliance and cultural awareness training program for program personnel
- conducting permit compliance training with all employees
- conducting periodic safety, security, health and environment (SSHE) compliance assessments

Table 5-3 lists the mitigation measures developed for the program's routine activities. These measures include best practices for oil and gas development projects that account for the unique Arctic environment. In addition to the VEC-specific mitigation measures, Imperial will develop and implement an Environmental Protection Plan (EPP) that provides specific procedures and protocols to address all program-related activities, such as site preparation, drilling, other offshore operations and transits to, or from, Tuktoyaktuk Harbour.

5.4.2 PREVENTION AND MITIGATION OF NON-ROUTINE ACTIVITIES

To prevent and respond to fuel spills Imperial will:

- maintain adequate oil spill response equipment and personnel to respond to terrestrial and marine spills
- train personnel in acceptable refuelling procedures and establish specified refuelling locations
- use secondary containment at temporary fuel storage and transfer locations, including using drip pans and liners, which will be mandatory, in accordance with Imperial's policies and procedures
- implement an Oil Spill Response Plan (OSRP) that covers incidents at sea and onshore, including information on:
    - spill kits (i.e., number, type, contents and location)
    - crew spill response training and vessel spill response certification

5.4.2 PREVENTION AND MITIGATION OF NON-ROUTINE ACTIVITIES (cont'd)

- spill response communication plans and contact information
- the Oil Record Book, as required under the MARPOL 73/78 International Convention for the Prevention of Pollution from Ships

- implement management plans:
  - a Safety Plan
  - an IMP
  - an Emergency Response Plan (ERP)

For information on oil spill response, including a subsea release or oil that is drifting or moving on the surface, see section 16.3, Management Plans.

Table 5-3: Mitigation Measures for Routine Program Activities

VEC	Mitigation Measures
Coastal landscapes, including water quality and sediment quality related to dredging	• Develop and implement a comprehensive Dredging Management Plan for dredging activities that might be required alongside the dock or pier in Tuktoyaktuk Harbour at the shore-based facility, at the entrance to the harbour or along the fairway (marine resupply corridor) to deeper water offshore. This plan will include mitigation identified during a separate and comprehensive environmental assessment of dredging that Imperial will conduct, if another party does not perform the dredging and Imperial decides to perform the dredging itself. The Dredging Management Plan will include performance criteria, and incorporate suggestions and recommendations from northern residents and other stakeholders, including regulators, as appropriate. This plan will also cover selection of equipment appropriate for areas or locations that need to be dredged with minimal disturbance. • Mitigation measures include: • Accurately marking the areas to be dredged on large-scale charts before starting dredging so all dredging will take place inside the perimeter of these marked areas. This will allow for accurate vessel positioning during dredging. • Installing a silt curtain to contain or control resuspended sediments, and contribute to meeting the performance criteria developed for dredging. • Taking additional steps to prevent or limit resuspension of contaminated material if it is determined that sediment near the dock or pier at the shore-based facility is contaminated with hydrocarbons or metals from non-program operations. • Disposing of all sediment (spoil) removed during dredging at an approved offshore location in accordance with applicable regulations and permits. Spoil placement will be monitored with a measurement program that is based on the volume of material to be dredged. Samples for analysis will be collected before, during and after the spoil is placed in the disposal area. • Have a qualified environmental monitor on site during program activities. • Operate program vessels in a manner that will avoid spills to the marine environment. • Perform dredging (if required) during the marine/estuarine fisheries winter work window for the area, where practicable (i.e., July 1 to October 1 and December 1 to February 15). Subject to agreement by applicable regulatory agencies and the implementation of appropriate controls, some work might need to occur outside of these windows to accommodate the construction schedule and sequencing. • Follow best management practices for dredging operations, as applicable, as identified by the International Association of Dredging Companies and the International Finance Corporation. Additional related guideline information is also provided by the International Maritime Organization (IMO) London Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter (and the 1996 protocol) and the guidelines developed for the disposal of dredged materials at sea.

Table 5-3: Mitigation Measures for Routine Program Activities (cont'd)

VEC	Mitigation Measures
Marine avifauna	• Identify the areas where birds congregate (i.e., for feeding, breeding and rearing, and moulting), including protected areas or key subsistence harvesting locations or other sensitive bird habitat locations and avoid these areas where possible. • Ensure that vessels maintain operational protocols for maximum speeds and standard courses, where possible, to reduce potential bird strikes or other negative effects. Icebreaking activities at the drill site and along supply routes might require rapid changes in speed and course to respond to changing ice conditions, as necessary for safe operations. • Shield or reduce external lights at night to limit the effect of program-related light sources, where possible. • Ensure that birds that might land on vessels are left undisturbed, where practical, and provide training to program personnel on how to handle injured or resting birds. Only personnel who have a CWS handling permit would perform this task. • Establish and implement an Air Operations Plan to provide minimum operational altitudes and speeds, and other safe operating procedures and protocols (including mapping sensitive bird habitat locations along potential program flight paths) to minimize potential interactions with birds. • Conduct flaring only when necessary for well testing, in accordance with regulatory requirements and industry guidelines. • Operate all program vessels operating in Tuktoyaktuk Harbour at reduced speeds.
Marine mammals	• Implement a Marine Mammal Management Plan that includes marine mammal monitoring (to be undertaken by qualified observers) for all vessel-related activities. Establish safe vessel operations protocols (including safety perimeters, speed and course restrictions, and suspension of work requirements) to avoid marine mammals and sensitive marine mammal habitats along the marine resupply corridor route and at the drill site, whenever possible. These actions will reduce the likelihood of a vessel strike that leads to injury or mortality. • Establish and implement an Air Operations Plan to provide minimum operational altitudes and speeds and other operating procedures and protocols (including mapping locations of sensitive marine mammal habitats and locations along potential flight paths) to minimize potential interactions with marine mammals. This plan will cover inbound and outbound fixed-wing aircraft and helicopter operations carrying passengers or cargo to or from the fleet offshore. • Establish and implement an ERP that provides procedures and protocols for addressing all accidents, spills or items of a similar nature to ensure that appropriate measures are in place to mitigate the potential effects of an accidental release or malfunction affecting marine mammals, including follow-up protocols to investigate and determine root causes and identify lessons learned. • Develop and implement a program-specific Polar Bear Interaction and Management Plan that includes procedures and protocols for polar bear interactions.
Offshore water quality and sediment quality during drilling	• If ballast water discharge is necessary, it would be governed by a Ballast Water Management Plan that will be developed and implemented for program vessels. The plan would be developed and implemented in accordance with the IMO convention on exchange of ballast water and associated sediment. • Separate drilling fluid from cuttings during drilling operations. The cleaned or washed cuttings will be placed in a designated area on the seafloor by pumping them down a delivery system below the sea surface. Residual fluid on the separated cuttings will be measured as part of the disposal process. As part of the Environmental Effects Monitoring Plan, a seafloor sampling program will be developed to monitor the dispersal and distribution of cuttings on the seafloor and the effects of burial on the benthic community in the affected area. • Develop and implement a program-specific WMP in accordance with the NEB's *Offshore Waste Treatment Guidelines* and other federal regulations or guidelines that

Table 5-3: Mitigation Measures for Routine Program Activities (cont'd)

VEC	Mitigation Measures
Offshore water quality and sediment quality during drilling (cont'd)	apply in Canadian waters, and federal or territorial regulations or guidelines that apply onshore. • Maintain records of all program-related discharges. • Provide program personnel with opportunities for continuous improvement and training in the handling and disposal of waste in compliance with the requirements of Imperial's OIMS and EMDC drilling's OIMS for drilling-related activities.
Traditional land and resource use	• Ensure that the information collected during the traditional knowledge process is incorporated into the program design and operations. Continue the public consultation process to identify any new areas of significance or historic importance, ensuring that community confidentiality is maintained during the reporting process. • Implement a wildlife compensation program that would cover damages or loss of equipment, loss or reduction of income, loss or reduction of wildlife harvest and any adverse changes to the quality of the harvest. Compensation could include relocation or replacement costs for equipment, provision of wildlife products or a cash settlement. • Prohibit hunting by program personnel. Provide cultural resource sensitivity training and traditional harvesting sensitivity training to program personnel, as required. Imperial will consult with communities about who should be trained, when the training should happen, and how hunters and trappers committee (HTC) members or other residents will be part of this process. • Minimize potential program effects on traditional land use and harvesting activities by avoiding sensitive locations and ensuring that operations are timed to limit any potential overlap with traditional harvesting activities or land use. • Avoid all areas identified as being of archaeological or cultural significance along the shoreline at, or near, the entrance to Tuktoyaktuk Harbour. It is unlikely that new traditional resources will be discovered by program personnel, but if this occurs, the appropriate authorities will be notified immediately. • Establish and implement a Northern Communications Plan for the program to communicate and inform local communities of program-related developments, ensuring a flow of information to the communities in a timely and efficient manner. This plan will include a process for liaising with the HTC in Tuktoyaktuk, and HTCs in other communities, as required. Avoid scheduling public meetings and information sharing sessions at times when community members are hunting, fishing or engaged in other harvesting activities.
Wildlife and habitat	• Establish vessel and aircraft operations routes and schedules designed to minimize wildlife disturbance. • Establish and enforce vehicle and vessel speed limits within the program area. • Institute a no hunting policy for program personnel. • Prepare and implement a Wildlife Interaction Plan and a program-specific Polar Bear Interaction and Management Plan. The Wildlife Interaction Plan will provide measures to address potential interactions with terrestrial wildlife at the shore-based facility and encounters with marine mammals and birds within the proposed marine resupply corridor and the EL areas. • Design and operate the shore-based facility to reduce effects on wildlife, marine seabirds and mammals, including effects related to nesting or denning sites. • Ensure that all program-related waste is disposed of properly and in accordance with regulatory requirements and industry best practice, including using wildlife-proof waste collection containers. Waste will be stored at the shore-based facility pending disposal at an approved facility. • Prohibit feeding wildlife.

**BEAUFORT SEA EXPLORATION
JOINT VENTURE DRILLING PROGRAM
PROJECT DESCRIPTION**

OVERVIEW

6.1.1 PURPOSE OF THE PROPOSED DEVELOPMENT

The purpose of the proposed development is to drill one or more exploration wells within EL 476 (Ajurak) or EL 477 (Pokak) in the Beaufort Sea to:

- determine if hydrocarbons are present in one or more geological structures
- determine the composition of any hydrocarbons found
- identify the boundaries of the prospects to apply for an SDL
- identify the potential for future exploration or development drilling
- determine if there is a potential for commercial production

6.1.2 EXPLORATION LICENCES

In 2007, AANDC issued EL 446 (Ajurak), now EL 476, to:

- Imperial – 50%
- ExxonMobil – 50%

In 2008, Imperial conducted a 3-D marine seismic program over the Ajurak licence area to identify potential geological prospects and possible drilling locations.

In 2008, AANDC issued EL 449 (Pokak), now EL 477, to BP. In 2009, BP conducted a 3-D seismic program over the Pokak area.

In 2010, a Joint Operating Agreement was reached between Imperial, ExxonMobil and BP. The Joint Operating Agreement provides for a cross-conveyance of Ajurak and Pokak, with ownership as follows:

- Imperial – 25%
- ExxonMobil – 25%
- BP – 50%

Imperial is the designated operator of the joint venture.

The geographic coordinates of the EL areas are shown in:

- Table 6-1, for EL 476
- Table 6-2, for EL 477

Table 6-1: Geographic Coordinates for EL 476

Latitude *	Longitude *	Section
71° 00′ N	136° 30′ W	1-7
	136° 00′ W	1-5, 11-15, 21-25, 31-35, 41-45, 51-58, 61-68, 71-78, 81-88, 91-98
	135° 30′ W	1-5, 11-15, 21-25, 31-35, 41-45, 51-55, 61-65, 71-75, 81-85, 91-95
	135° 00′ W	51-53, 61-64, 71-74, 81-84, 91-94
70° 50′ N	136° 30′ W	4-10, 14-20, 24-30, 34-40, 44-50, 54-60, 66-70
	136° 00′ W	1-100
	135° 30′ W	1-100
	135° 00′ W	54-58, 64-68, 71-78, 81-89, 91-100
70° 40′ N	136° 00′ W	7-10, 17-20, 27-30, 37-40, 47-50, 57-60, 67-70, 77-80, 87-90, 97-100
	135° 30′ W	1-40, 47-50, 57-60, 67-70, 77-80, 87-90, 97-100
	135° 00′ W	21, 22, 31-33, 41-44, 51-100
70° 30′ N	135° 30′ W	10, 20, 30, 40
	135° 00′ W	30, 40, 50, 60, 70, 80, 90, 100
Note: 205,321 hectares, more or less. * = North American Datum 1927		

Table 6-2: Geographic Coordinates for EL 477

Latitude *	Longitude *	Section
71° 00′ N	134° 00′ W	12-20, 22-30, 32-40, 42-50, 52-60, 62-70, 72-80, 82-90, 92-100
	134° 30′ W	2-10, 12-20, 22-30, 32-40, 42-50, 52-60, 65-70, 75-80, 85-90, 95-100
	135° 00′ W	5-10, 15-20, 25-30, 35-40, 45-50, 55-60, 65-70, 75-80, 85-90, 95-100
	135° 30′ W	8-10, 18-20, 28-30, 38-40, 48-50, 60, 70, 80, 90, 100
71° 10′ N	134° 00′ W	11-14, 21-24, 31-34, 41-44, 51-54, 61-64, 71-74, 81-84, 91-94
	134° 30′ W	1-4, 11-100
	135° 00′ W	1-100
	135° 30′ W	1-100
71° 20′ N	135° 00′ W	41, 51-52, 61-62, 71-72, 81-82, 91-92
	135° 30′ W	1-2, 11-12, 21-22, 31-32, 41-42, 51-52, 61-62, 71-72, 81-82, 91-92
Note: 202,380 hectares, more or less. * = North American Datum 1927		

6.1.3 NEB ARCTIC OFFSHORE DRILLING REVIEW

As a result of the *Deepwater Horizon* accident in 2010 in the Gulf of Mexico, the NEB convened the AODR. Imperial actively participated in the review, including responding to questions from the NEB, and in the Inuvik roundtable meeting in September 2011.

In December 2011, the NEB published the findings of the AODR, including filing requirements for offshore drilling in the Canadian Arctic. In its report the NEB reaffirmed its commitment to goal-based regulation. The report also included a provision for the flexibility to propose equivalent alternatives to SSRW capability.

Imperial will develop a plan for SSRW equivalency for submission to the NEB as part of the:

- drilling OA
- well-specific drilling WA

At this early stage in the development of the drilling program, Imperial is undertaking the necessary technical and engineering studies to fully address the subject. Consequently, only a high-level discussion is provided in this document.

6.1.4 EXTENSION OF EXPLORATION LICENCE TERMS

Because of the time required conducting the AODR, all holders of active ELs in the Beaufort Sea lost some of the time available for conducting exploration activities before the licences would expire. To compensate for the lost time, in July 2012, the Minister of AANDC issued replacement EL numbers to all affected Beaufort Sea EL holders.

For the joint venture the changes in EL numbers are:

- EL 446 (Ajurak) was replaced by EL 476, with an expiry date of July 31, 2019
- EL 449 (Pokak) was replaced by EL 477, with an expiry date of September 30, 2020

6.1.5 OPERATING CONDITIONS AT AJURAK AND POKAK

The Ajurak and Pokak ELs are located in the Canadian sector of the Beaufort Sea about 125 km north-northwest of Tuktoyaktuk, NWT, within the ISR (see Figure 6-1 and Figure 6-2). These ELs are located in water depths ranging from 60 to 1,500 m (see Figure 6-3).

From 2009 to 2011, Imperial, ExxonMobil and BP undertook three years of field studies in collaboration with ArcticNet in the Ajurak and Pokak licence areas. The results of those studies, in addition to other past academic and government scientific research and ongoing field work under the federal Beaufort Regional Environmental Assessment (BREA) program, are discussed in Section 10, Description of the Biophysical Environment.

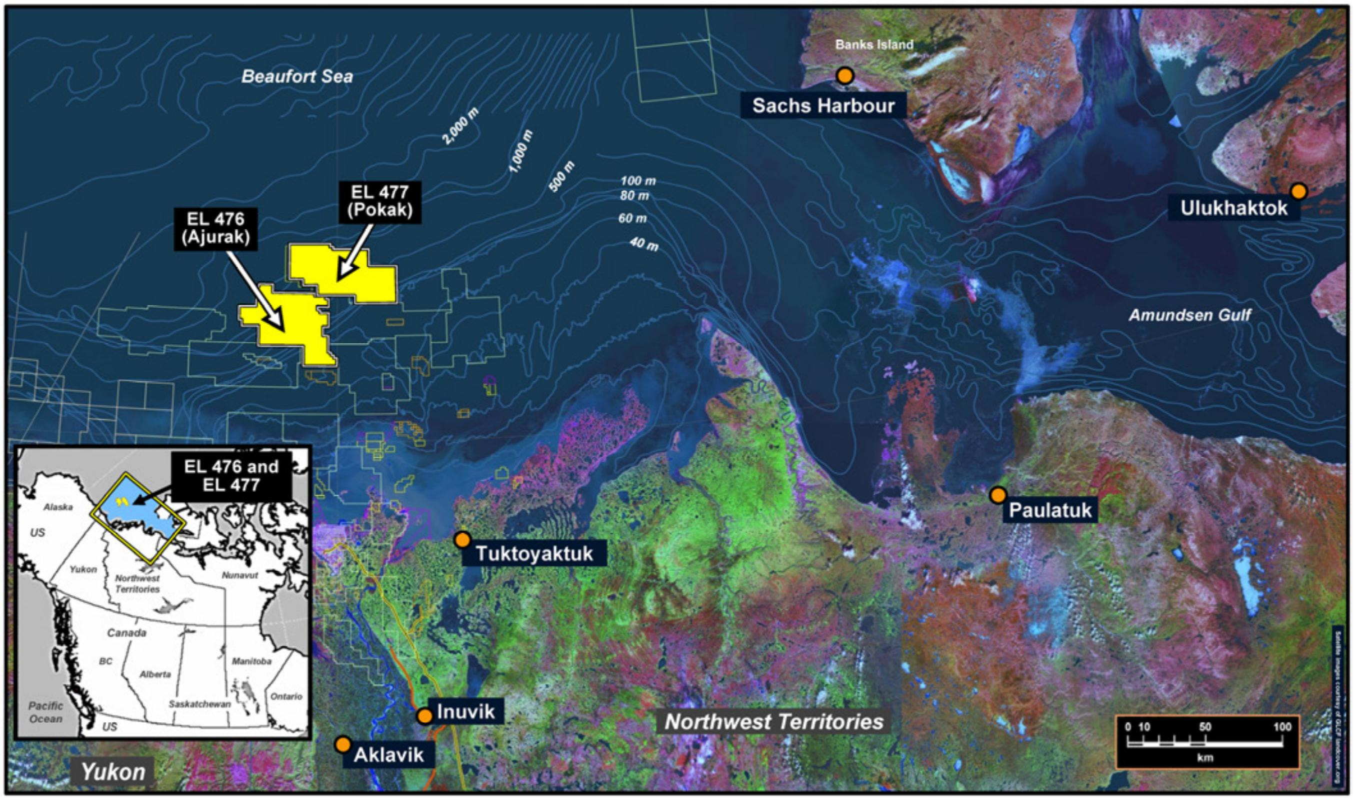


Figure 6-1: Regional Map of the Beaufort Sea with ELs and Six ISR Communities

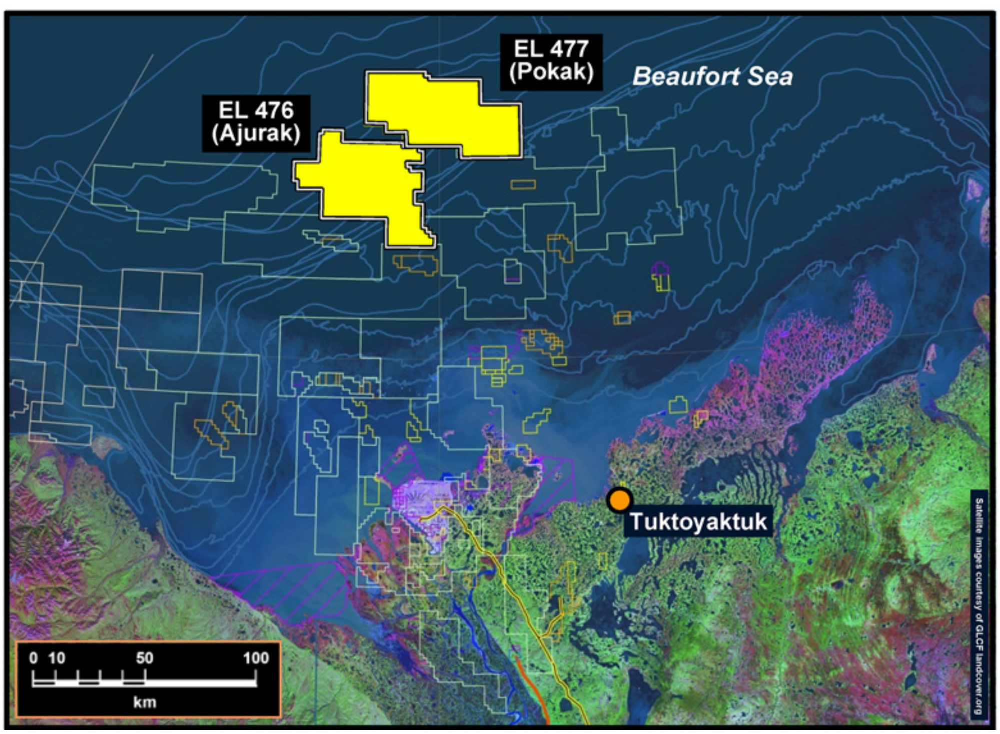


Figure 6-2: Program Area with EL 476 and EL 477

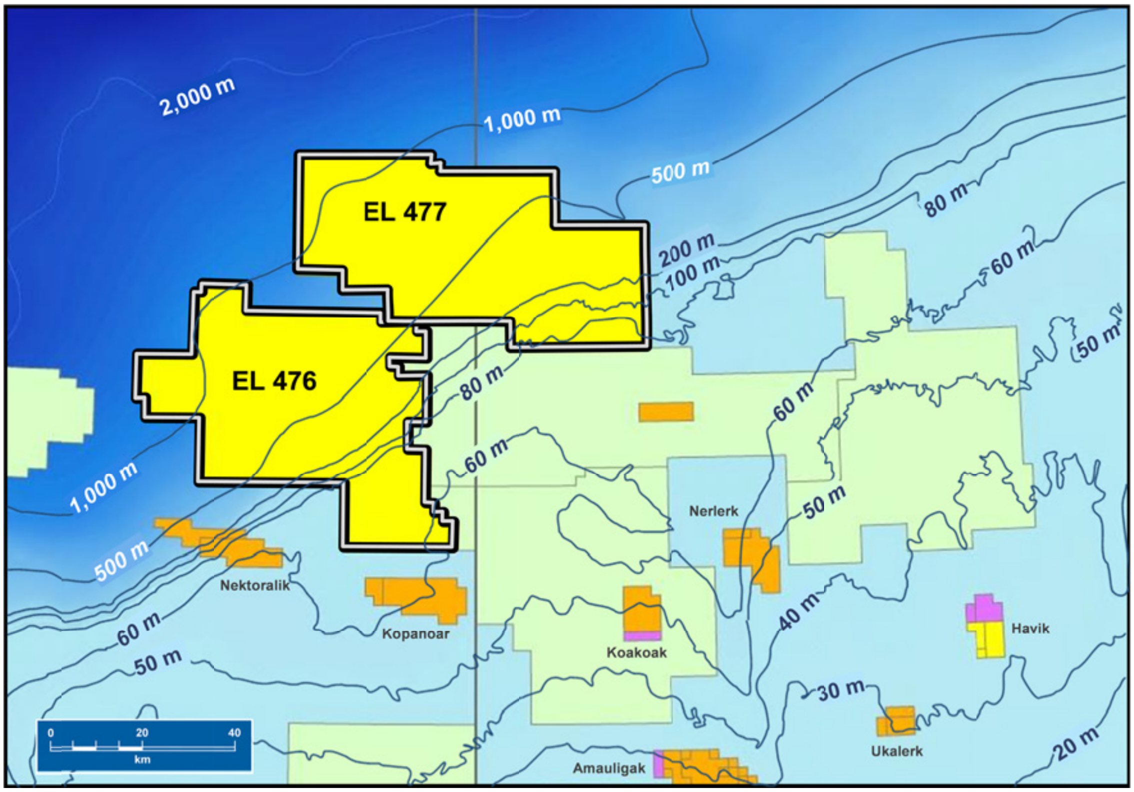


Figure 6-3: Bathymetry Near EL 476 and EL 477

Historical data indicates that the period of manageable ice conditions in the proposed development area is on average about 120 days, from May to November. The period for working conditions in the Beaufort Sea is shown in Figure 6-4.

To acquire more detailed information about the operating conditions in the area, Imperial expects to continue field studies in the coming years, and where appropriate or valuable, would work in conjunction with other scientific expeditions conducted by:

- academic institutions
- government research scientists, such as the Geological Survey of Canada, which would conduct studies of seafloor slope stability

In addition, Imperial will use Inuvialuit expertise and traditional knowledge of the region, particularly their understanding of sea state, ice conditions and wildlife.

Imperial will incorporate scientific data and traditional knowledge for the region into its design and operating specifications for the program to ensure that the drilling program is safe and environmentally responsible.

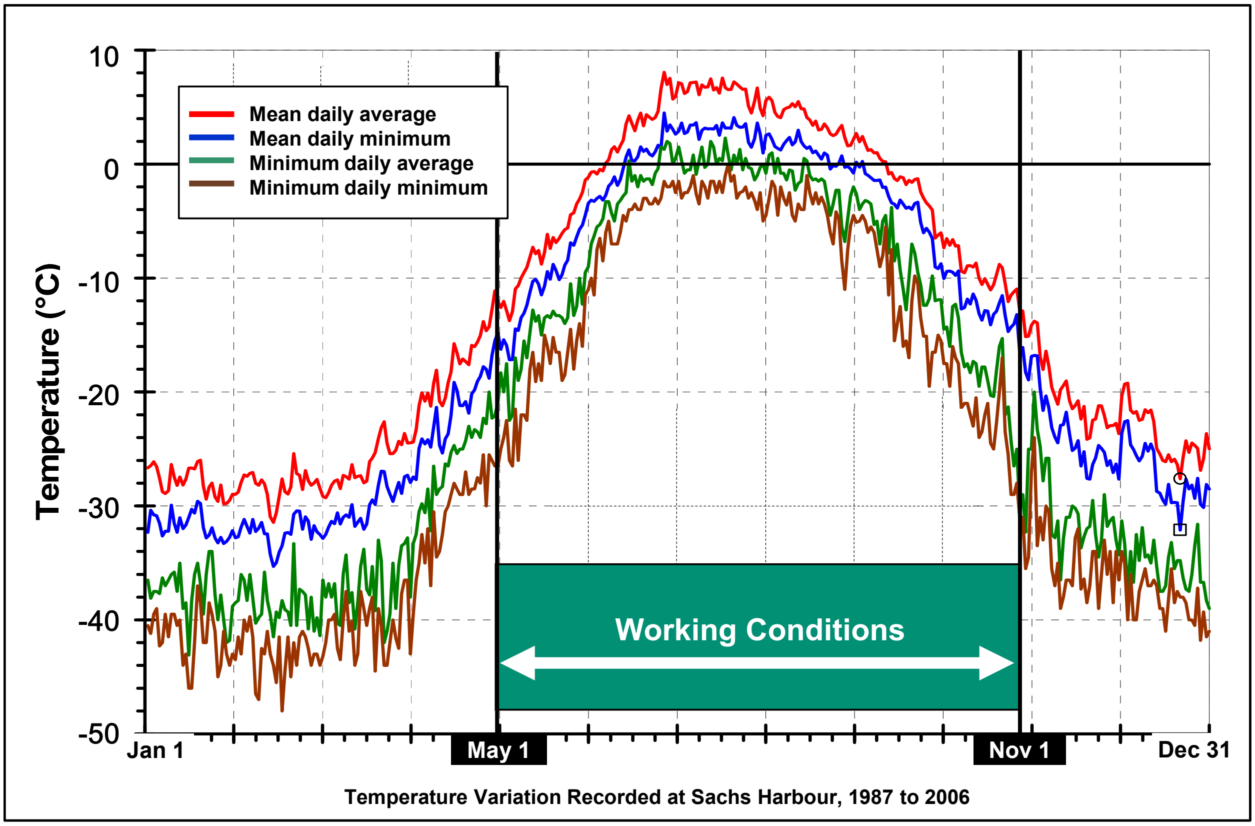


Figure 6-4: Arctic Working Conditions Based on Temperature

6.2.1 BEAUFORT SEA DRILLING PROGRAM

The drilling program for the Beaufort Sea might involve a series of activities over a given time period, including:

- obtaining initial and final regulatory approvals
- satisfying pre-operating regulatory conditions
- procuring materials and equipment to drill one or more wells, including the drilling unit and support vessels
- preparing a shore-based facility
- mobilizing to the work area
- drilling for multiple seasons, with drilling suspension at the end of each season
- conducting formation evaluations based on drilling data collected
- conducting abandonment and decommissioning activities

6.2.2 POTENTIAL DRILLING SCHEDULE

For planning purposes, a potential drilling program schedule has been developed. This potential schedule allows for one or more wells to be spudded in EL 477 during the 2020 open-water season before the expiry of EL 477 (see Figure 6-5). This schedule is based on the following events occurring in a timely and effective manner:

- regulatory reviews and approvals, including:
    - EISC and NEB screening decisions
    - environmental assessment public review, if required
    - the NEB reviewing the drilling OA application and providing acceptable conditions
- the joint venture's decision to commit in the 2016 to 2018 time period to a drilling system, including support vessels
- the issuance of the NEB WA
- mobilization to the Beaufort Sea and the start of drilling by 2020 (i.e., spudding the well)

6.2.2 POTENTIAL DRILLING SCHEDULE (cont'd)

It is assumed that any well drilled in the Ajurak or Pokak licence areas would require at least two years to complete. Depending on weather and ice conditions at the time, the drilling window for a single well could require up to four drilling seasons to complete. The seasonal drilling operations would be conducted using a single drilling unit.

Notwithstanding the potential program schedule, there is a possibility of an earlier spud date and more than one drilling location.

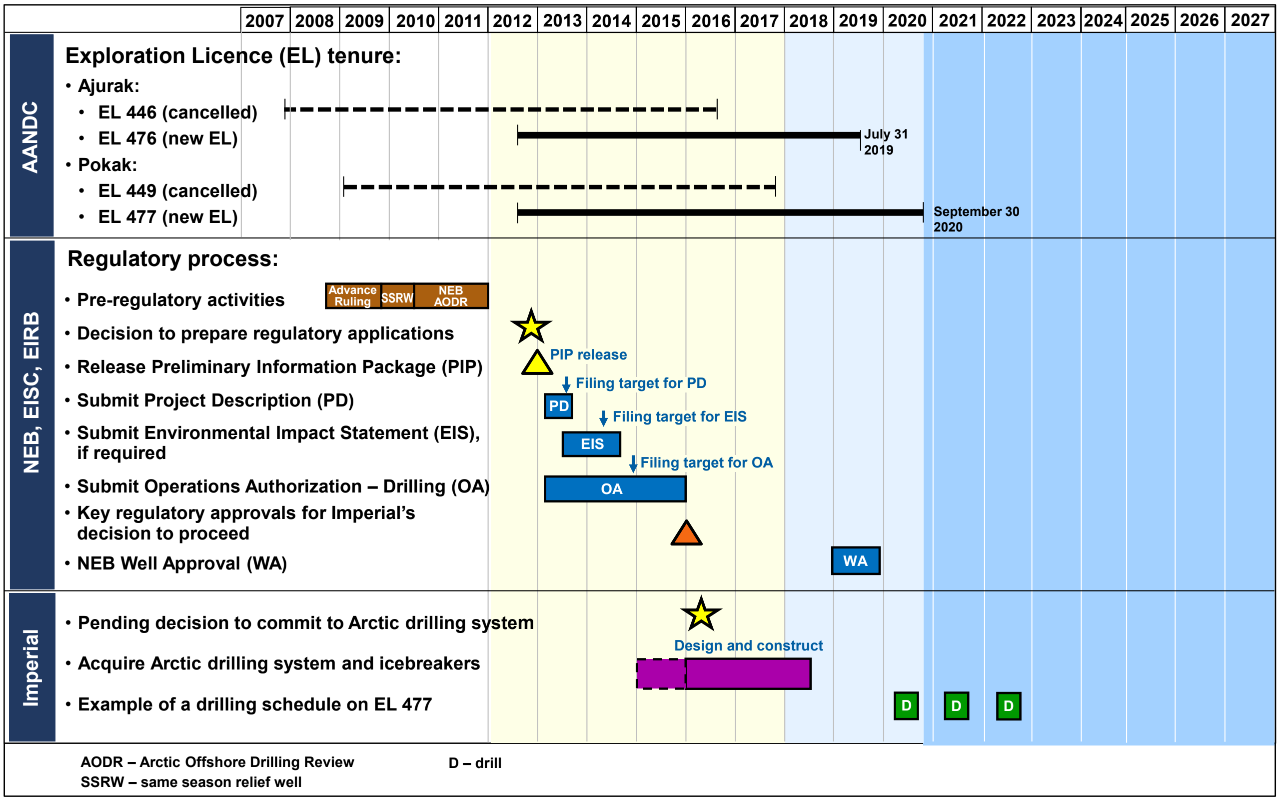


Figure 6-5: Example of a Potential Drilling Program Schedule

6.2.3 PHASES OF ACTIVITY

The scope and duration of the drilling activities would vary in any given year depending on:

- ice conditions in the Beaufort Sea at the start and end of the season
- day-to-day ice incursions at the drill site
- the annual drilling progress to well depths that are appropriate for well suspension

6.2.3.1 Years 2013 to 2015

The focus between 2013 and 2015 will be on:

- conducting community consultation and engagement with Inuvialuit, regulators and the public
- completing an environmental screening and assessment and a public review, if required
- developing an early design and performing relevant technical studies
- performing additional field studies, including seeking opportunities for collaboration with other oil and gas explorers in the Arctic
- preparing and submitting a benefits plan to the AANDC
- preparing and submitting a drilling OA application to the NEB

6.2.3.2 Year 2016

The lead time required to spud a well or wells in 2020 requires that a decision to drill be made in 2016. Factors that would affect this decision include:

- the joint venture's confidence that a well or wells can be drilled in a safe and environmentally responsible manner
- the level of support by Inuvialuit for an exploration program
- acceptable conditions from the NEB regarding the program's drilling OA
- resolution of the SSRW equivalency requirement
- availability of an Arctic drilling system within the required time frame
- availability of proven technology and resources to meet the expected operating conditions
- the necessary financial commitment from the joint venture

6.2.3.3 Pre-Spud Activities in 2016 to 2019

If a decision is made to drill one or more wells in EL 476 or EL 477, many activities would need to be completed before spudding a well in 2020, including:

- finalizing well locations
- applying for and receiving a WA from the NEB
- establishing contracts for the drilling unit, icebreakers and support vessels
- developing infrastructure, such as a shore-based facility, aviation and communications, as required
- ordering drilling supplies and equipment

6.2.3.3 Pre-Spud Activities in 2016 to 2019 (cont'd)

- providing information on potential employment and business opportunities, including opportunities for Inuvialuit communities
- training the program workforce
- testing equipment and conducting drills, including appropriate emergency response drills
- operating in accordance with program plans and commitments, such as:
  - a WMP
  - a Wildlife Protection Plan
  - an IMP
  - regulatory requirements
  - company commitments
- potentially pre-installing a mooring system on the seafloor to secure the drilling unit in subsequent seasons
- potentially mobilizing equipment, fuel and supplies into the Beaufort Sea

6.2.3.4 Post-Drilling Activities (2022+)

If no further drilling is planned after the exploration well or wells have been drilled, the shore-based facility would be returned to its pre-program condition. All remaining supplies, equipment and fuel would be shipped out of the ISR, unless other arrangements are made.

If it was decided that further geological prospects warranted new exploration, the process would begin again to:

- conduct a possible seismic program
- obtain the necessary regulatory approvals
- begin drilling a new exploration well

6.3.1 MANAGEMENT AND EXPERIENCE

The drilling program design would draw on Imperial's and ExxonMobil's experience from 90 years of working safely and responsibly during drilling and production activities in the Arctic and global experience in operating in harsh offshore environments.

Other wells drilled worldwide have experienced the conditions that a Beaufort Sea drilling program might encounter, including:

- ice conditions
- oceanographic conditions (e.g., wave heights and currents)
- weather
- temperature
- water depth
- surficial geology
- reservoir pressure

The drilling program will be designed and implemented using all relevant Imperial and ExxonMobil standards and in compliance with regulatory requirements.

To reduce the risk of incidents and mitigate potential effects on the environment, certain aspects of the planning process will undergo a detailed risk assessment. The program will be prepared using Imperial's OIMS and EMDC drilling's OIMS for drilling-related activities, which both use a systematic approach to managing risks and preventing incidents.

The OIMS provides the framework to ensure that:

- standards are met, designs and procedures are properly assessed and risks managed
- the quality of equipment is verified and maintained
- competent personnel perform the work
- significant changes are properly managed
- emergency response plans are in place for specific work areas

The expected bottomhole conditions of the licence area are well within the temperature and pressure ranges of wells previously designed by the joint venture

6.3.1 MANAGEMENT AND EXPERIENCE (cont'd)

members. Proven equipment and procedures were used on these wells to safely execute the drilling operations (see Figure 6-6).

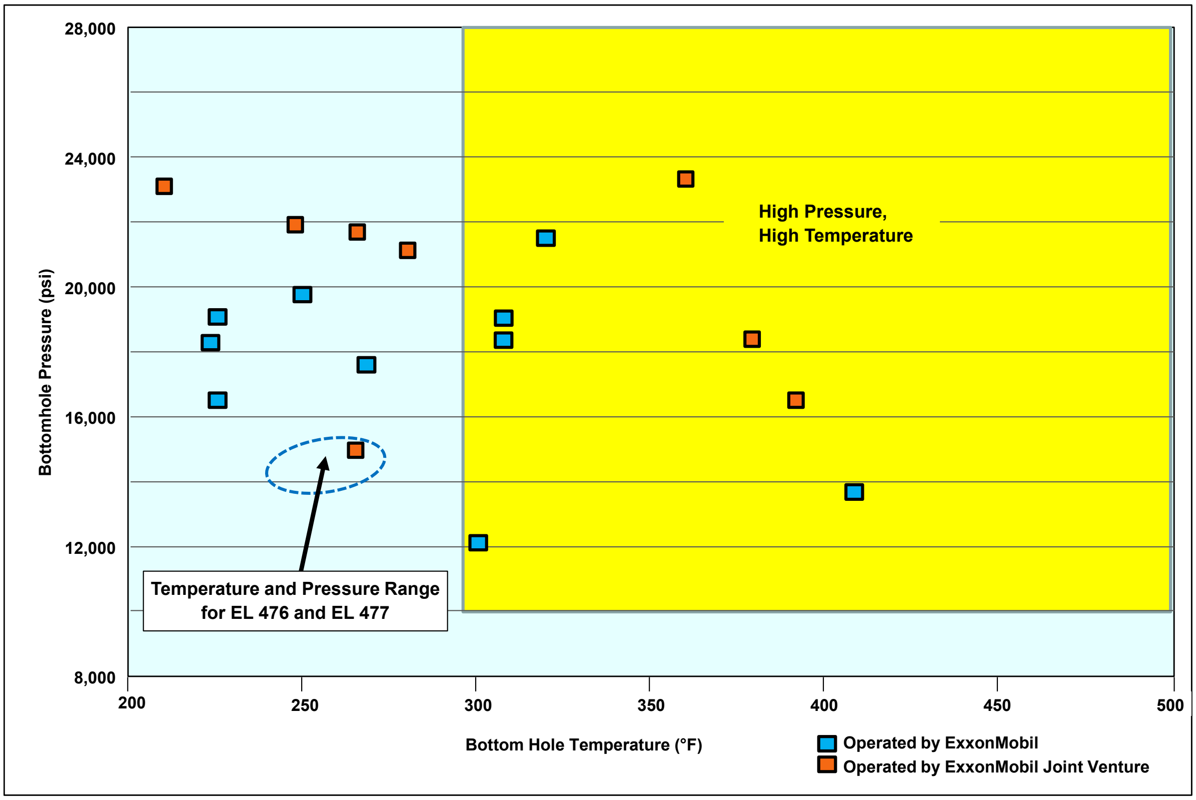


Figure 6-6: Comparison of Previously Drilled Wells with a Beaufort Sea Well

6.3.2 WELL AND EQUIPMENT DESIGN

ExxonMobil standards will be used to guide the well design and to select critical equipment. A well planning process that is used globally will incorporate well design considerations, including:

- tubulars (e.g., drill strings, casing strings and production tubing strings)
- cementing
- blowout prevention equipment
- critical rig equipment
- other critical equipment and services

Proprietary technology and tools will be used to reduce risk and enhance well designs in areas such as:

- casing and tubing design
- pressure prediction
- flow modelling

To ensure that implementation of any proposed well meets Imperial's and ExxonMobil's standards, the well design and equipment will be subjected to:

- extensive analysis and modelling
- multiple reviews
- design verifications
- a rigorous assessment of the execution plan

The assessment process involves carefully identifying and understanding the risks and determining how to prevent an incident from occurring. This process typically involves multiple layers of engineering review and control, with final approvals from senior management.

6.3.3 WELLHEAD EQUIPMENT

The wellhead equipment will be designed to be compatible with the casing design. The wellhead system would be a big-bore design capable of setting multiple casing strings and liners.

6.3.4 CASING DESIGN

The casing and liner strings will be designed to contain the maximum expected pressure in each formation. The selected casing will ensure that any fluids entering into the wellbore can be contained.

6.3.5 DRILLING FLUIDS

A drilling fluid program will be developed for each section of each well drilled. The drilling fluid weight would be sufficient to maintain hydrostatic overbalance, keeping formation fluids under control and preventing any unexpected flow of formation fluids into the wellbore.

Typically, water-based drilling fluids are used for the first and shallow-depth sections of the well. These sections are drilled without the drilling riser in place and the drilling fluid and drill cuttings are discharged to the seafloor. A typical well of this design could generate between 1,300 to 1,500 m^3 of water-based cuttings.

Subsequent and deeper sections of the well would likely be drilled using nonaqueous drilling fluids (NADF). The NADF formulations in use today have fewer environmental effects than traditional oil-based fluids.

Equipment on the drilling unit would be used to handle and treat the drill cuttings for discharge into the sea. Treated cuttings will be tested, and if they meet regulatory criteria, the treated cuttings will be discharged to the seafloor according to approval conditions.

6.3.6 CEMENTING

A detailed cementing program will be developed for each casing and liner string for each well that is planned to be drilled. The cement weight and strength would be sufficient to:

- maintain hydrostatic overbalance
- keep formation fluids under control
- avoid any unexpected intrusion of oil, gas or water into the wellbore

Each casing string would be independently cemented to ensure hydraulic isolation between the individual casing strings and the formations.

6.3.7 LOGGING WHILE DRILLING OPERATIONS

Logging while drilling tools would likely be used while drilling a typical well in the Beaufort Sea. The logging while drilling tools measure formation properties in real time. Additional tools might be used to measure formation pressure to ensure that the hydrostatic pressure in the wellbore is always sufficient to:

- maintain hydrostatic overbalance
- keep formation fluids under control
- avoid any unexpected intrusion of oil, gas or water into the wellbore

6.3.8 WELL CONTROL

Imperial's primary approach to well control is prevention.

Procedures will be developed to prevent a single point of failure leading to a catastrophic event. These procedures will ensure that:

- wells are designed for the range of risk expected
- equipment is inspected and maintained
- operators are trained
- tests and drills are conducted to verify personnel competency
- adequate barriers and redundancy are in place and tested to safely execute the work

Overbalanced fluids will be used to provide the primary barrier against well flow. Specialized pressure hunt teams and tools will be used on the drilling rig to:

- analyze well data for signs of abnormal pressure
- make the necessary adjustments to mud weight to ensure overbalance
- select casing setting depths to ensure that wellbore integrity can be maintained

The well will be monitored at all times to detect signs of well flow. If well flow is detected, personnel will have been trained and certified to quickly activate the secondary barrier (i.e., the blowout preventer) to stop the well flow and properly manage the well control event to restore the primary barrier (i.e., overbalanced fluid).

6.3.9 BLOWOUT PREVENTER DESIGN

The blowout preventer (BOP) and ancillary well control equipment used on a Beaufort Sea exploration well will comply with industry and ExxonMobil standards. These standards will ensure that the equipment is fit for purpose and operational.

For a given well, the required working pressure of the BOP system will exceed the maximum expected surface pressure of the wellbore fluids, assuming the presence of gas in the wellbore. The temperature rating of the BOP rubber components will be greater than the maximum expected wellbore temperature in the BOP. Only elastomeric materials from the original equipment manufacturer (OEM) will be used in BOP equipment, and they will meet the specifications for the intended service environment.

Only OEM or OEM-licensed parts will be used on all blowout prevention equipment, including:

- BOPs
- valves
- choke manifolds
- risers
- diverter systems
- ring gaskets
- control systems

Subsea blowout prevention equipment is designed and equipped to provide redundant control systems and components to secure the well. The BOP stack would be designed with multiple barriers to well flow, including:

- double valves for each outlet
- multiple ram preventers
- two annular preventers

The control systems will include:

- actuation panels at various locations on the drilling unit
- redundant systems to transmit control signals from the drilling unit to the subsea equipment
- redundant subsea control pods to provide hydraulic power fluid to actuate BOP components
- remotely operated vehicle intervention capability as a backup to the primary BOP control system

6.3.9 BLOWOUT PREVENTER DESIGN (cont'd)

- a deadman and auto shear system (used only on dynamically positioned drilling units)

A typical subsea BOP for offshore drilling is shown in Figure 6-7.

Imperial will follow defined policies and practices, and will apply rigorous management plans to any proposed Beaufort Sea exploration wells to ensure safe operations in the unique Arctic environment.

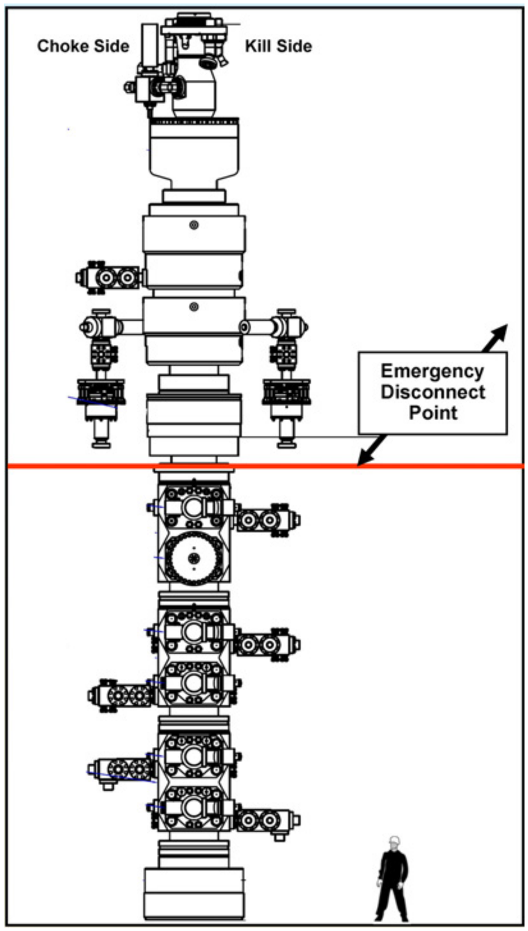


Figure 6-7: Example of a Typical Subsea BOP for Offshore Drilling

6.3.10 FORMATION EVALUATION

6.3.10.1 Well Logging and Sampling

During drilling and after completion of an exploration well, well logging would be conducted to measure the formation properties, including the porosity and permeability of the rock. Fluid and rock sampling might be conducted during logging to determine the reservoir fluid properties if oil or gas is encountered.

6.3.10.2 Vertical Seismic Profile

After drilling completion, a vertical seismic profile (VSP) could be conducted using geophones inside the wellbore to obtain real depth information for comparison to the original seismic data. This would result in a series of detailed seismic images.

6.3.10.3 Well Testing

If appropriate, well testing could be carried out on any zone of interest. Under carefully controlled conditions for the well test, reservoir fluids would be produced from the well and allowed to flow to the surface for a period of time. Depending on the requirements and goals of the test, the duration of the test might range from several hours to several days. The produced oil or gas could be flared at the surface from the drilling rig, if required by the regulator.

6.3.11 WELL ABANDONMENT

Once drilling of a well is completed and all testing has been finished, the well would be plugged and permanently abandoned in accordance with NEB regulations and Imperial’s procedures.

6.4.1 CONTINGENCY PLANS

Contingency planning describes how Imperial would respond to a non-routine event that could compromise safety or the environment. Contingency plans are formulated to provide the necessary plans for immediate and long-term response to incidents. For a Beaufort Sea drilling program, contingency plans will be developed for emergency response and oil spill response.

The optimal response to restore well control is well specific. Surface intervention would be the primary means of regaining well control and the fastest method to put in place. Other effective same-well intervention methods include:

- activating the subsea BOP stack, which is typically the first option for regaining well control
- implementing pump and kill methods (techniques such as dynamic, bullhead or conventional circulating kills performed in the original wellbore have been proven to be effective)
- mechanical intervention (mechanical, hydraulic, and inflatable packers or stingers have proven to be effective same-well intervention techniques to stop or reduce flow from a well)
- securing the well with a capping stack

6.4.2 SOURCE CONTROL

The wellhead and intermediate casing strings will be designed to contain hydrocarbons to surface. In the unlikely event that the intermediate casing integrity is compromised and pressure from deeper horizons is exerted on the surface casing, the surface casing will be designed to divert the flow below the surface casing shoe and prevent hydrocarbon discharge at the seafloor.

Source control plans using the incident command structure will be in place to address the unlikely scenario where a loss of well control results in hydrocarbon discharge to the environment.

The optimal response to controlling the source will be specific to each well.

6.4.3 SURFACE INTERVENTION

If a well control event occurs and control is not immediately regained by conventional mechanical means or natural occurrences, surface intervention could include:

- re-establishing the primary barrier by:
    - circulating or bullheading fluids
    - performing a dynamic kill to restore a sufficient column of mud to overcome formation pressure
- installing or repairing the secondary barrier blowout prevention equipment by:
    - capping the well
    - restoring the integrity of the existing blowout prevention equipment

The nature and severity of the well control event will dictate the surface intervention response. In the event of a small flow of oil, the control methods could be as simple as sealing a leak or repairing an equipment component. If a substantial flow of oil and gas occurred, appropriate surface intervention methods would be used, ranging from re-establishing kill weight mud in the hole, restoring the blowout prevention equipment integrity or well capping, depending on the nature of the well control event.

6.4.4 RELIEF WELL

As required by the NEB, Imperial will prepare a Relief Well Plan as part of its drilling OA application, but the plan will not be for an SSRW.

If a relief well is required, it would take longer than drilling the original well because:

- the relief well would have a longer wellbore – it would need to be drilled from a location other than the original wellbore
- the relief well would be a directional well
- the additional surveys and directional accuracy required to drill a relief well result in slower drilling progress

A relief well might be started in the same season, but it could not be finished in the same season.

6.5.1 MAJOR COMPONENTS

The major equipment components of an offshore drilling operation will include:

- a drilling unit and related equipment
- marine support vessels

6.5.2 DRILLING UNIT

There are many types of drilling systems used around the world today, including:

- jack-up rigs
- moored semi-submersible drilling units
- drillships

For the water depths and conditions likely to be experienced in the Beaufort Sea, a floating drilling unit is the system of choice. The early drilling units used in the Beaufort Sea, such as the Canmar Explorer III, have been much improved over the past decades with newer designs and built-in technologies. The drilling units have a hole, or moon pool, which extends through the ship and hull allowing the drill string to extend into the water below.

A key requirement of any drilling system is its ability to maintain its position (referred to as stationkeeping) at the well site location. The two most common stationkeeping methods used today are:

- moored drilling systems that use anchors attached to the seafloor
- DP using a computer-controlled system to automatically maintain the drilling unit's position and heading by using its own propellers and thrusters

Dynamic positioning allows for operations in deep water where mooring is not feasible because of water depth.

Whatever drilling unit is selected for use in the Beaufort Sea, the most important factor is that it be fit for purpose and use proven technologies appropriate for the most severe conditions that could be experienced.

6.5.2.1 Drilling Unit Specifications

Water depths over EL 476 and EL 477 range from 60 to 1,500 m, with prospects for a potential exploration well, or wells, in water depths of 80 to 850 m.

6.5.2.1 Drilling Unit Specifications (cont'd)

A drilling unit will be selected that can operate safely in the range of ice conditions that could be experienced in the Beaufort Sea. The design of the drilling unit would use proven technologies and the specifications would likely include:

- greater structural integrity to withstand ice conditions, including thicker bulkheads and additional internal beams
- equipment for drilling operations capable of operating in subfreezing temperatures

For the water depths in the program's ELs, the Arctic drilling unit might be configured with mooring and DP assist capability, which would allow the drilling unit to maintain a constant position with mooring, but be able to move off location under its own power using thrusters.

6.5.2.2 Fixed Heading Moored DP Arctic Drilling Unit

A fixed heading moored DP Arctic drilling unit might have 8 to 12 mooring lines leading from the drilling unit to anchoring systems on the seafloor.

A fixed heading moored DP Arctic drilling unit would be able to:

- maintain station heading by using thrusters and anchors
- withstand large ice loads using the mooring system

If ice conditions make it necessary for the fixed heading moored DP Arctic drilling unit to leave the drill site, the drilling unit would be able to:

- safely suspend the well
- disconnect from the moorings
- move off the drill site under its own power

6.5.2.3 Turret-Moored DP Arctic Drilling Unit

A typical turret-moored DP Arctic drilling unit has 8 to 12 mooring lines leading from a turret on the drilling unit to anchors or pre-set buoys on the seafloor (see Figure 6-8).

A turret-moored DP Arctic drilling unit would be able to:

- maintain station heading by using thrusters and anchors
- respond to changes in the direction of environmental loads, including ice loads, using its capability of rotating 360º around the turret

If ice conditions make it necessary for the turret-moored DP Arctic drilling unit to leave the drill site, the drilling unit would be able to:

- safely suspend the well

- disconnect from the moorings
- move off the drill site under its own power

A turret-moored system has lower environmental loading than a fixed heading moored system.

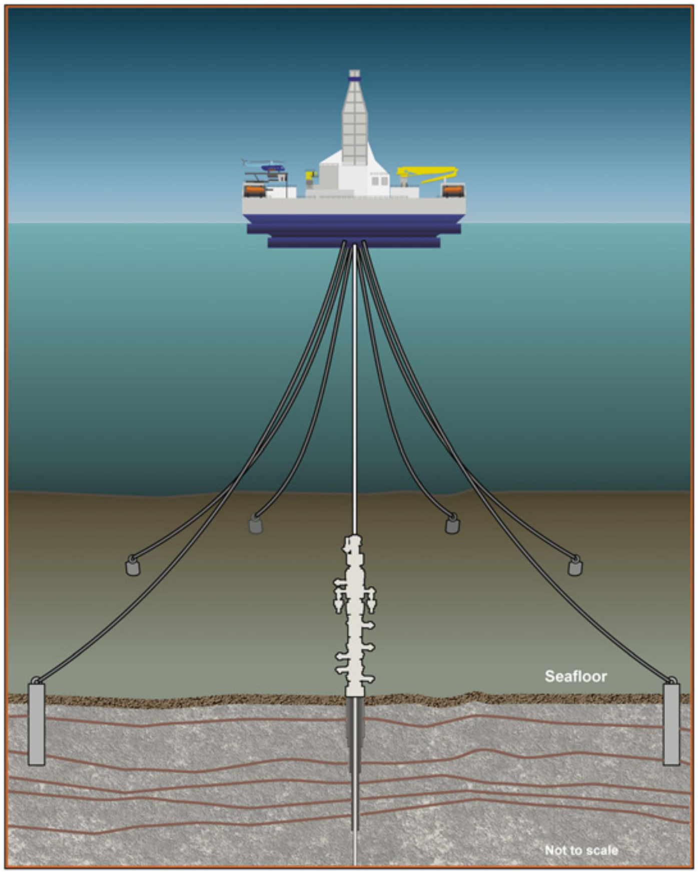


Figure 6-8: Turret-Moored DP Arctic Drilling Unit

6.5.3 MARINE SUPPORT VESSELS

Multiple vessels will be required to support the drilling program. These vessels can generally be categorized by their level of ice strengthening and their mission and could include:

- icebreaking support vessels
- ice-strengthened supply vessels
- ice-strengthened fuel tankers
- an ice-strengthened wareship

All of these vessels will be powered by diesel engines burning low sulphur diesel. No nuclear-powered vessels will be used. Each vessel might also have one or more boilers that will also burn low sulphur diesel to generate heat for the

6.5.3 MARINE SUPPORT VESSELS (cont'd)

vessel's living compartments and other spaces. Each vessel would have multiple roles.

6.5.3.1 Icebreaking Support Vessels

Most drilling unit options in the Arctic would require icebreaking support. Several icebreaking support vessels will be used. Each vessel will be capable of performing one or more of the following functions:

- breaking ice to clear a path for a drilling unit into and out of the Beaufort Sea at the beginning and end of each drilling season (see Figure 6-9 for an example of a medium-powered icebreaker)
- breaking ice a considerable distance from the drilling unit (ice management)
- breaking ice to clear a path into and out of the Beaufort Sea for fuel tankers or a wareship, if these vessels are used
- breaking ice and providing ice management for fuel tankers or a wareship while they are in the licence areas, if these vessels are used
- carrying fuel, drilling materials and other supplies for the drilling unit
- carrying, installing and retrieving the pre-set anchors used to moor the drilling unit at the drilling site, if required
- deploying and retrieving a remotely operated vehicle to support well work operations
- carrying and refuelling helicopters for personnel transfer and ice reconnaissance
- supporting source control operations in the unlikely event of loss of well control
- supporting oil spill response operations, including applying dispersants and skimming oil from the water surface
- providing emergency response for the drilling unit, including firefighting and evacuating the drilling unit's crew

Icebreaking support vessels will be of various sizes, but will likely be too big to enter Tuktoyaktuk Harbour. These vessels would normally remain in or near the EL areas, except when escorting the drilling unit, fuel tankers or wareship (if used) into and out of the Beaufort Sea. These vessels will be designed:

- for breaking and ramming ice
- in accordance with Canadian regulations and international standards, including the IACS Unified Requirements for Polar Ships

Figure 6-9: Example of a Medium-Powered Icebreaker – the Fesco *Krasin*

All of these vessels will have two or more propellers and one or more bow thrusters for propulsion and maneuvering.

Each vessel will have about 20 to 30 crew members and will be fully equipped with all necessary facilities to enable them to operate independently for an extended duration, including cooking and cleaning facilities, fresh water generators, waste collection and waste treatment equipment.

6.5.3.2 Ice-Strengthened Supply Vessels

Depending on the final strategies for logistics, waste management, oil spill response and well control, several ice-strengthened supply vessels might be used to perform one or more of the following functions:

- carry fuel, drilling materials and other supplies from Tuktoyaktuk to the drilling unit and icebreaking support vessels
- carry waste products from the drilling unit and icebreaking support vessels to Tuktoyaktuk for shipment out of the ISR
- carry drilling unit and icebreaking support vessel crew members to and from Tuktoyaktuk
- support source control operations in the unlikely event of loss of well control
- support oil spill response operations, including deploying containment booms

These vessels would be designed to enter and operate out of Tuktoyaktuk Harbour and would be smaller in size than the icebreaking support vessels described previously (see 6.5.3.1). Ice-strengthened supply vessels would be:

- capable of operating independently throughout the drilling season in the ice conditions expected between Tuktoyaktuk and the licence areas
- designed in accordance with Canadian regulations and international standards, including the IACS Unified Requirements for Polar Ships

Each of these ice-strengthened supply vessels would:

6.5.3.2 Ice-Strengthened Supply Vessels (cont'd)

- have two or more propellers and one or more bow thrusters for propulsion and maneuvering
- have about 10 to 15 crew members
- be able to operate independently for weeks at a time because they would be fully equipped with all necessary facilities, including:
  - cooking and cleaning facilities
  - fresh water generators
  - waste collection
  - waste treatment equipment

Figure 6-10 shows examples of ice-strengthened supply vessels.

Figure 6-10: Examples of Ice-Strengthened Supply Vessels – the Fesco *Sakhalin* and the MSV *Fennica*

6.5.3.3 Ice-Strengthened Fuel Tankers

Depending on the exploration drilling program's final logistics strategy, ice-strengthened fuel tankers (see Figure 6-11) might be used over the course of each drilling season to supply some or all of the diesel fuel and other supplies required by:

- the drilling unit
- icebreaking support vessels
- ice-strengthened supply vessels

The number and size of fuel tankers could vary from:

- a single large tanker
- several smaller tankers
- a combination of a large tanker and several small tankers

A single large tanker could be used to carry fuel for the drilling unit and all support vessels for the entire drilling season, including the vessel transit in and out of the Beaufort Sea. After arriving at the beginning of the drilling season, the fuel tanker would remain in an ice-free section of the licence area and move only as necessary to avoid ice. The icebreaking support vessels and ice-strengthened supply vessels (if used) would offload fuel from the single large tanker for their own needs and also to transfer fuel to the drilling unit. This tanker would have a capacity to carry between 40,000 and 75,000 tons of fuel.

Figure 6-11: Example of an Ice-Strengthened Fuel Tanker – the Stena *Poseidon*

Several smaller tankers could be used and would make multiple excursions between the licence area and a port outside of the Beaufort Sea. In this scenario, the fuel tankers would be scheduled so that one tanker would arrive in the licence area every two to four weeks, offload its cargo to the icebreaking support vessels and ice-strengthened supply vessels (if used) and then depart. Each tanker would have the capacity to carry between 10,000 and 15,000 tons of fuel.

A combination of a single large fuel tanker and several smaller fuel tankers could be used to supply fuel for the program.

Fuel tankers would be too large to enter Tuktoyaktuk Harbour and would remain in or near the licence areas, except when transiting into and out of the Beaufort Sea.

The fuel tankers used would likely:

- have double hulls
- be designed in accordance with Canadian regulations and international standards including the IACS Unified Requirements for Polar Ships
- be capable of independent operations in the ice conditions expected between the port of departure and the licence area throughout the drilling season, except at the beginning and ends of the season when it is expected that escort by one of more of the icebreaking support vessels would be required

6.5.3.3 Ice-Strengthened Fuel Tankers (cont'd)

- be specially configured for ship-to-ship transfer of fuel to smaller vessels, such as the icebreaking support vessels and ice-strengthened supply vessels
- have about 15 to 20 crew members and would be fully equipped with all necessary facilities to enable them to operate independently for weeks at a time, including:
  - cooking and cleaning facilities
  - fresh water generators
  - waste collection
  - waste treatment equipment
  - oil spill response capabilities

6.5.3.4 Ice-Strengthened Wareship

Depending on the final strategies for logistics, waste management, oil spill response, and well control, an ice-strengthened wareship might be used to perform one or more of the following functions:

- carry fuel, drilling materials and other supplies for the drilling unit and support vessels
- receive waste products from the drilling unit and support vessels for storage and shipment out of the licence areas
- support helicopter operations
- provide a location to conduct or support maintenance work needed for the drilling unit and support vessels
- support for source control operations in the unlikely event of loss of well control
- support for oil spill response operations, including carrying containment booms and dispersant

The wareship, if used, would be too large to enter Tuktoyaktuk Harbour and would normally remain in or near the licence area, except when transiting into and out of the Beaufort Sea at the beginning and end of each season. After arriving at the beginning of the season, the wareship would remain in an ice-free section of the licence area and move only as necessary to avoid ice. The icebreaking support vessels and ice-strengthened supply vessels (if used) would offload fuel and other supplies from the wareship both for their own needs and to transfer fuel to the drilling unit.

6.6.1 SUPPORT FACILITIES

Deepwater drilling operations typically require a deep-draft port for operations support. Because there is no deep-draft port in the Beaufort Sea, an offshore wareship might be used.

Various land-based facilities and services might be needed to support offshore drilling operations, including:

- a shore-based facility, which might include:
  - accommodations
  - staging sites and storage areas
  - a dock area
- transportation services (i.e., air and land) for moving supplies and personnel
- emergency equipment storage
- a potable water supply
- waste management services

6.6.2 SHORE-BASED FACILITY

The offshore drilling program could require the support of a shore-based facility, most likely located in Tuktoyaktuk, which is about 125 km from the potential drilling location in EL 476 or EL 477. The shore-based facility would be leased from one or more of the existing commercial locations.

A satellite image showing Tuktoyaktuk Harbour and the general route that could be taken by shallow-draft vessels to the shore-based facility is shown in Figure 6-12.

6.6.2.1 Onshore Accommodations

Onshore accommodation could be required for:

- shore-based facility personnel, if such a facility were established for the program
- personnel transiting to and from the offshore drill site
- personnel evacuated from the offshore drill site in an emergency

The accommodation requirements will be determined at a later date.

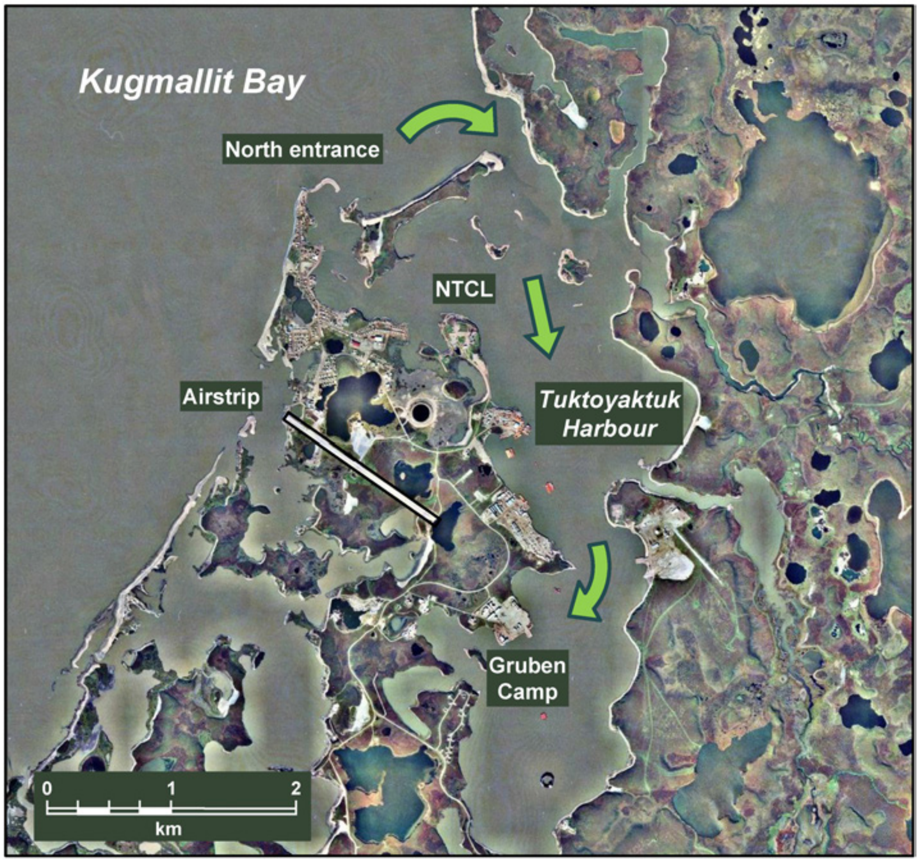


Figure 6-12: Tuktoyaktuk Infrastructure and Shipping Route to the Shore-Based Facility

6.6.2.2 Staging Sites and Storage Areas

It is not expected that a lot of equipment would be stored at the shore-based facility.

Infrastructure at the shore-based facility to support the drilling operations might include:

- a staging site and storage area for equipment and materials
- a heated warehouse
- offices and communication services

6.6.2.3 Dock Area

Some dock construction and upgrading might be required to handle the loading and unloading of supplies and personnel. To allow shallow-draft vessels to enter and exit Tuktoyaktuk Harbour, dredging might be required near the dock area and at some locations inside the harbour. The dock area would require equipment to handle small tools and lightweight containers.

6.6.3 TRANSPORTATION SERVICES

One of the major logistical considerations for an offshore drilling program is the transportation of supplies and personnel to and from the drill site during the drilling season. Once work begins at the drill site, ongoing resupply will be required.

The drilling operations at the drilling unit would require large quantities of supplies such as:

- pipe
- drilling fluids
- cement
- fuel
- equipment
- other materials

These materials would likely be stored on a wareship.

In addition, crews on the drilling unit or on support vessels would require:

- food
- medical supplies
- other consumables

In the spring, ships carrying crew members for the drilling unit or support vessels, and vessels carrying supplies, including fuel tankers, might travel to the Beaufort Sea from ports outside of the area. Options for resupply of consumables could include using a:

- single supply warebarge or wareship to transport all of the supplies expected to be needed for a single season. A warebarge or wareship could be positioned at the drill site and consumables transferred to the drilling unit as required.

- combination of a warebarge or wareship and a shore-based facility

Workers will need to be transported safely when moving between the drilling unit and the shore-based facility, either by helicopter or by supply vessel, particularly if weather conditions restrict flying.

Imperial would consider using the limited municipal infrastructure at Tuktoyaktuk only if such use is supported by the Hamlet Council. Potential issues were identified during community consultations with the hamlet's stakeholders, and in the Environmental Studies Research Funds' June 2010 report *Review of Tuktoyaktuk Harbour as a Base for Offshore Oil and Gas Exploration and Development*. These issues would be managed and resolved by Imperial with the support of the Hamlet Council. Issues identified include:

- increased traffic on the roads
- vessel traffic in the harbour
- breaking ice in the harbour

6.6.3.1 Land Transportation Services

It is expected that some vehicle transportation for personnel and supplies would be required, primarily between the shore-based facility and the airstrip. During the winter, some materials and supplies could be transported by land to Tuktoyaktuk over ice roads and stockpiled for the next drilling season.

6.6.3.2 Air Transportation Services

The existing airstrip would be used for air transportation. For workforce rotations, two or more helicopters would be chartered to make regularly scheduled transits between the drilling unit, support vessels and the Tuktoyaktuk airstrip, averaging about one flight per day to the drill site.

6.6.4 WASTE MANAGEMENT SERVICES

Waste would be removed from the drilling unit and transported by supply vessel to the shore-based facility. A qualified contractor would arrange for onshore disposal or for storage in preparation for shipping waste out of the Beaufort Sea region. Alternatively, waste from the drilling unit and support vessels could be stored on the wareship for shipment out of the licence areas.

6.7.1 TRANSIT ROUTES

The drilling unit and support vessels could mobilize from a west coast Canadian port by early June to take on crew, fuel and drilling consumables. Depending on weather and ice conditions along the route, vessel transit into the Beaufort Sea could take one to two weeks.

Depending on the location of the drilling unit and support vessels, entry into the Beaufort Sea could also be from a port on the east coast of Canada via the Northwest Passage. Figure 6-13 shows the possible east and west transit routes to the Beaufort Sea.

The decision to suspend the well, demobilize and exit would depend on actual and predicted ice conditions at the drill site, and ice and weather conditions along the egress route.

The routes chosen for transit in the Alaskan and Canadian Beaufort Sea would maximize the use of existing open-water leads.

If a decision was made to overwinter vessels in the Canadian sector of the Beaufort Sea in the fall, there would be a contingency plan to use one or more sites in the region that have been used in the past, such as McKinley Bay, Summers Harbour or Wise Bay.

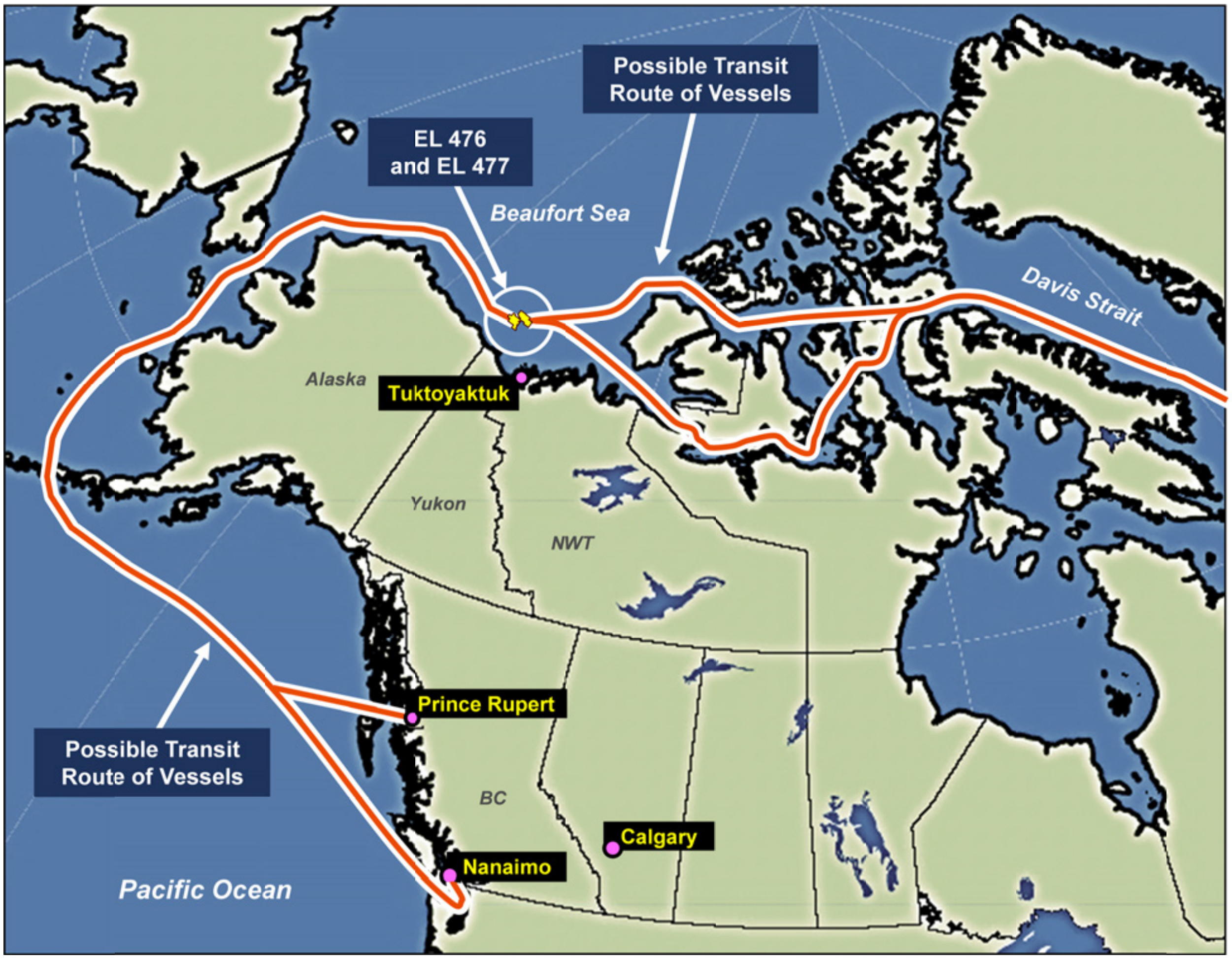


Figure 6-13: Possible Transit Routes for Vessels Entering and Leaving the Beaufort Sea

6.8.1 OPPORTUNITIES

Imperial and ExxonMobil personnel would typically occupy and/or provide oversight to the senior positions on the drilling unit, support vessels and at the shore-based facility. Most of the workforce for a Beaufort Sea drilling program would consist of individuals hired by contractors working under service agreements with Imperial and ExxonMobil.

Work would be awarded based on an assessment of whether a proposal provides the best total value, including:

- safety and environmental performance
- technical and operational capabilities
- Inuvialuit and Canadian content
- cost competitiveness
- the ability to deliver work within Imperial's schedule requirements

Imperial's intent is to provide opportunities for Inuvialuit companies by:

- notifying Inuvialuit suppliers of potential opportunities as early as possible
- preparing work packages that encourage Inuvialuit companies to bid on the work or align with other companies in joint ventures to manage larger work packages

If an Inuvialuit company secures a contract, Imperial will assist the successful bidder to:

- achieve first-class safety and environmental performance
- provide training and development opportunities
- verify that the company has all the required procedures and policies in place to do the work safely and successfully
- deliver timely and high-quality results, which would put the company in good standing for future work opportunities in the Beaufort Sea region or at the national and international level

Identifying specific jobs and contracting services at this time in the planning cycle would be premature. If the joint venture partners decide in 2016 to proceed with drilling, the job identification effort will be further defined. The first areas of employment opportunities will be for positions to provide long lead time

6.8.1 OPPORTUNITIES (cont'd)

services, if required, such as new-build vessels and upgrading the shore-based facility at Tuktoyaktuk.

Table 6-3 shows examples of the types of potential employment opportunities.

Table 6-3: Examples of Potential Employment Opportunities

Opportunities on the Drilling Unit and Support Vessels	Opportunities Onshore
Able-bodied seamen	Accommodation service providers
Cooks	Community liaison advisers
Custodial personnel	Dispatchers
Environmental technicians	Office managers and assistants
Galley hands	Crane operators
Ice-management technicians	Drivers
Marine mammal observers	Electricians
Ordinary seamen	Firefighting personnel
Roughnecks	Forklift operators
Roustabouts	Helicopter and fixed-wing aircraft staff
Ship captains	Mechanics
Waste management technicians	Oil spill response personnel
Wildlife monitors	Radio operators
	Security personnel
	Vessel traffic managers
	Warehousing personnel
	Waste management personnel
	Welders

7.1.1 PREVIOUS ACTIVITY

Since acquiring EL 446 (now EL 476) in July 2007, and subsequently becoming the operator for BP's EL 449 (now EL 477) in 2010, Imperial has undertaken a number of activities related to potential drilling plans. To communicate information about these activities, Imperial has prepared various public presentations, documents, submissions and statements, including:

- five workshops given in the ISR during 2009 and 2010, and attended by Inuvialuit and regulators:
  - Deepwater Drilling Well Control – September 2009
  - Ice Management Workshop – December 2009
  - Waste Management Workshop – January 2010
  - Wildlife Harvesting Workshop – February 2010
  - Spill Prevention Response Workshop – April 2010
- two submissions to the NEB:
  - the Relief Well Policy for Offshore Drilling in Arctic Waters – submitted March 2010
  - response to the AODR Call for Information – submitted April 2011
- opening comments at the NEB AODR roundtable forum from September 12 to 14, 2011
- responses to questions during the NEB AODR roundtable forum, as detailed in the AODR transcripts
- the Preliminary Information Package (PIP) released in December 2012
- presentations to, and consultations with, Inuvialuit organizations, Inuvialuit communities, and territorial and federal regulators from 2011 to 2013

For a detailed description of these consultations and presentations, see Section 12, Community Engagement and Consultation and Section 13, Co-Management, Inuvialuit Organizations and Government Engagement and Consultation. For further information on proposed mitigation measures, see Section 16, Proposed Mitigation Measures to Address Potential Impacts.

7.1.2 COMMITMENTS

While the design for a drilling program in EL 476 and EL 477 continues to be advanced, some previous early planning has been revised. Nonetheless, many statements made by Imperial in the past are still applicable and will likely continue to be applicable throughout the drilling program development and implementation.

Past and present statements that could be considered as commitments to Inuvialuit, northerners and regulators are provided in:

- Table 7-1 Proponent Commitments – Program Management
- Table 7-2 Proponent Commitments – Drilling and Well Control
- Table 7-3 Proponent Commitments – Support Operations
- Table 7-4 Proponent Commitments – Consultation and Regulatory
- Table 7-5 Proponent Commitments – Environmental, Prevention, Emergency and Oil Spill Response
- Table 7-6 Proponent Commitments – Benefits and Financial Capacity

These tables also include the timing for implementing each commitment.

Table 7-1: Proponent Commitments – Program Management

Summary Commitment	Implementation Timing
• Imperial will employ trained personnel, apply world-class experience and use best available proven technologies and equipment.	• Ongoing for the life of the program.
• Imperial will focus on managing risks and safe operations to prevent its operations from causing environmental impacts.	• Ongoing for the life of the program.
• Imperial will conduct a series of program risk assessments to reduce or mitigate specific risks associated with all aspects of the program to an acceptable level, taking into account environmental operating conditions that could affect the drilling program.	• A series of risk assessments will be undertaken and documentation provided to the NEB as part of the OA application submission.
• Imperial will ensure that all contractors meet Imperial's requirements for creating a stringent safety and environmental protection culture.	• Ongoing for the life of the program.
• Imperial's personnel on site will have the authority to stand down an operation if it is unsafe.	• Ongoing for the life of the program.
• Imperial will have a series of management plans to meet internal and regulatory requirements, including: • OIMS required plans, including EMDC drilling's OIMS for drilling-related activities • a Safety Plan • a Well Control Plan • an EPP	• Key components of these plans will be included in the OA submission filed with the NEB. Some aspects of the plans will need to be finalized before spudding the well.

Table 7-1: Proponent Commitments – Program Management (cont'd)

Summary Commitment	Implementation Timing
• a WMP • an IMP • an ERP, including oil spill response • a Regulatory Compliance Plan	
• Imperial will review applicable draft management plans with Inuvialuit before filing with the NEB, to the extent possible.	• Before filing the OA submission with the NEB.
• Imperial will file its management plans with the NEB, except for proprietary and commercial information that would need to remain confidential.	• Included in the OA submission filed with the NEB.

Table 7-2: Proponent Commitments – Drilling and Well Control

Summary Commitment	Implementation Timing
• Imperial will apply a rigorous well control system to all aspects of well design, drilling and completions.	• Ongoing throughout drilling operations.
• Drilling contractors will be trained and capable of carrying out their functions.	• Before the start of drilling.
• Drills and exercises will be performed regularly at the well site to ensure competency of operations personnel.	• Ongoing throughout drilling operations.
• Imperial will develop an Abandonment Plan to ensure that there are sufficient barriers in place, depending on specific well conditions.	• Included in the OA submission filed with the NEB. The Abandonment Plan will be implemented upon well completion.
• Imperial will consider the potential application of well control innovations as they advance from concept to best available proven technologies.	• Ongoing for the life of the program.
• Imperial will apply proven pore pressure prediction and formation evaluation technologies to detect abnormal pressure conditions to prevent or contain kicks.	• A description of the proposed technology will be included in the OA submission filed with the NEB. The technology will be in place for drilling operations.

Table 7-3: Proponent Commitments – Support Operations

Summary Commitment	Implementation Timing
• An IMP will be developed to ensure that all marine vessels, equipment and trained personnel are in place to monitor ice conditions continuously in the field and take necessary actions to prevent ice incursions into the safety zone around the drilling unit.	• An IMP will be included in the OA submission filed with the NEB. The plan will be reviewed with TC and implemented during drilling.
• All support vessel activities will be coordinated to preclude any possible collisions with the drilling unit or with another vessel.	• To be in place throughout drilling operations.
• The frequency of support vessels entering and leaving Tuktoyaktuk Harbour will be reduced or stopped after the harbour starts to freeze.	• To be in place throughout drilling operations.
• No fuel will be stored in barges over the winter.	• To be in place throughout drilling operations.
• Imperial will develop safety and environmental procedures for vessel traffic in Tuktoyaktuk Harbour with local authorities.	• To be in place throughout the drilling operations.

Table 7-4: Proponent Commitments – Consultation and Regulatory

Summary Commitment	Implementation Timing
Consultation	
• Imperial will consult with Inuvialuit throughout the life of the program, from initial design and planning through to completion on all issues of interest or concern.	• Ongoing for the life of the program.
Regulatory	
• Imperial will fulfill the obligations of the ELs.	• In place and will continue through the life of the ELs.
• All applicable regulations and conditions will be identified, tracked and verified through documentation, and complied with at all times.	• A Regulatory Compliance Plan will be developed and included in the OA submission with the NEB.
• Imperial will be responsible for preparing and filing all regulatory applications.	• As required, filings will be made, as required, by with each regulator.

Table 7-5: Proponent Commitments – Environmental, Prevention, Emergency and Oil Spill Response

Summary Commitment	Implementation Timing
Environmental	
• An environmental and socio-economic assessment will address short- and long-term impacts of all program activities.	• The assessment will be filed with the NEB and, if a referral is made by the EISC, to the EIRB.
• The environmental assessment will use best available information from scientific and traditional knowledge sources.	• Included in the environmental assessment process.
• As part of ice management, Imperial will monitor the area for the presence and impacts from icebreaking and vessels transits on marine mammals, such as polar bears and seals.	• This will be included in the Wildlife Protection Plan that will be reviewed with Inuvialuit.

Table 7-5: Proponent Commitments – Environmental, Prevention, Emergency and Oil Spill Response (cont'd)

Summary Commitment	Implementation Timing
Environmental (cont'd)	
• Imperial will meet the EISC *Flight Altitude Guidelines*.	• Ongoing for the life of the program.
• Imperial will avoid vessel routes in the Beluga Management Zone 1A.	• Ongoing for the life of the program.
• Imperial will hire marine mammal observers for support vessels during the beluga harvest period to help direct vessels from beluga whale harvesting areas. The marine mammal observers will also maintain close communications with the HTCs regarding vessel transits and schedules.	• Ongoing for the life of the program.
• Imperial will develop a Polar Bear Interaction and Management Plan in consultation with Inuvialuit.	• The plan will be developed and in place before spudding the well.
Prevention, Emergency and Oil Spill Response	
• Imperial will ensure that preventing incidents that might result in a spill is top priority. This will be done by applying disciplined risk assessments and management processes.	• Ongoing throughout design and implementation of the drilling program.
• In the unlikely event of a spill, Imperial will safeguard the health and safety of oil spill response personnel and the public.	• In the event of a spill.
• Imperial will develop a level of spill response that is fit for purpose, taking into account the risks, probability and consequences.	• An OSRP would be included in the OA submission filed with the NEB.
• Imperial will take immediate responsibility for responding to spills that might occur during operations and will respond as quickly and effectively as possible.	• In the event of a spill.
• Imperial will conduct the necessary studies, using local knowledge and expertise, to understand the fate, behaviour and transport of an oil spill, and identify the most vulnerable and sensitive species, habitats and areas.	• In the event of a spill.
• Imperial will apply a net environmental benefit analysis to help determine the best response options that will lead to the lowest overall impacts on the environment, wildlife harvesting and the most rapid recovery.	• In the event of a spill.
• Credible and effective oil spill response options will be available in the offshore, nearshore, Tuktoyaktuk Harbour and shorelines for open water and ice conditions.	• In the event of a spill.
• Imperial will have the capability in place to apply a combination of the best modelling, tracking and surveillance technologies for oil spill response.	• In place for the drilling program.
• Imperial will continue to enhance oil spill response capabilities through research and development.	• Ongoing for the life of the program.
• Primary oil spill response options will be dispersant use (by aerial application and subsea injection at the wellhead) and in situ burning to reduce or avoid effects on key species and shorelines.	• Testing and implementation in place before the start of drilling.

Table 7-5: Proponent Commitments – Environmental, Prevention, Emergency and Oil Spill Response (cont'd)

Summary Commitment	Implementation Timing
Prevention, Emergency and Oil Spill Response (cont'd)	
• Imperial will ensure that all oil spill response providers have appropriate safety and operations training.	• Training will be conducted before the start of drilling operations.
• All support vessels will comply with the IMO protocols, have a Shipboard Oil Pollution Emergency Plan and have the necessary equipment on board for a Tier 1 spill.	• In place when support vessels are in Canadian Arctic waters.

Table 7-6: Proponent Commitments – Benefits and Financial Capacity

Summary Commitment	Implementation Timing
Benefits	
• Imperial will have a benefits strategy specific to identifying opportunities for Inuvialuit and northern businesses and for employment.	• Ongoing for the life of the program.
• Imperial will look for ways to advance early training, education and on-the-job experiences for northerners seeking job and business opportunities.	• Ongoing for the life of the program.
Financial	
• Imperial will have the financial capacity to fund any cleanup of its activities or remediate any environmental and economic impacts from an oil spill without need for further financial guarantees.	• The IFA already stipulates the unlimited financial liability of the operator.
• Imperial will establish a wildlife compensation process that meets the requirements of the IFA. The compensation process will be efficient, effective, fair and timely for Inuvialuit organizations or individuals to file a claim for existing or future harvest loss.	• A draft process will be submitted to the Inuvialuit Game Council for review and input, and finalized before spudding the well.

8.1.1 RELEVANT DRILLING EXPERIENCE

Imperial has extensive experience and knowledge in drilling and managing activities in the Beaufort Sea, including using ice-class support vessels and icebreakers, starting in 1973 with the Immerk B-48 well located on an artificial island, through to 1989 and the Isserk I-15 well drilled from the Molikpaq platform. During this period, about 90 wells were drilled in the Beaufort Sea, a third of which were drilled by Imperial without any drilling-related incidents.

The experience gained by Imperial in the Canadian sector of the Beaufort Sea, particularly by using established technologies to drill in cold climate waters, was used by ExxonMobil to drill offshore of:

- Alaska in the late 1980s
- Sakhalin Island, Russia in the Sea of Okhotsk in the 1990s

ExxonMobil has also drilled wells in some of the world's most challenging deepwater environments, including:

- Angola
- Australia
- Brazil
- Indonesia
- Libya
- Nigeria
- the North Sea (72° latitude)
- the east coast of Canada
- the Philippines
- the United States (US) Gulf of Mexico

Further experience will be gained by ExxonMobil and its affiliates over the coming years from offshore operations in other Arctic interests under conditions similar to the Beaufort Sea.

8.1.2 TECHNOLOGY REVIEW PROCESS

When designing wells worldwide, including wells for the Canadian sector of the Beaufort Sea, Imperial and ExxonMobil well design standards will be applied. These standards have been developed based on many years of experience and the application of proven technologies. In addition to these standards, EMDC

8.1.2 TECHNOLOGY REVIEW PROCESS (cont'd)

drilling's OIMS will be used to ensure that all wells are drilled and operated consistently in a safe and environmentally responsible manner worldwide. When new technologies are developed, they go through a rigorous review process before being implemented in any drilling operation.

The drilling systems and associated support activities that would be used in the Beaufort Sea operations will be the best available at the time using proven technology. The proposed drilling system will undergo a rigorous technical design and engineering review by the NEB before any drilling program is authorized, and will be closely monitored and inspected by the NEB during operations.

9.1.1 JUSTIFICATION FOR A DRILLING PROGRAM

Seismic programs, conducted over EL 476 in 2008 and EL 477 in 2009, identified a number of traps or seals deep beneath the surface in rock formations with potential for hydrocarbon accumulation. Although predictions about the presence and properties of fluids contained within these reservoir rocks can be made based on seismic interpretation, substantial uncertainty exists concerning the fluid type, amount (saturation), composition, temperature, pressure and physical properties of the fluids and the reservoir rocks.

In the 1980s some wells were drilled and discoveries made near EL 476 and EL 477 (e.g., Kenalooak, Nektoralik, Kopanoar and Koakoak). However, reservoir rocks can undergo dramatic changes in physical properties over a short distance, making extrapolations from existing discoveries difficult. In addition, AANDC and the NEB require formation testing and proof that hydrocarbons have been identified over a defined geological field before they will issue an SDL to an EL holder.

Therefore, drilling an exploration well at a favourable location on the EL is necessary to prove that an exploration discovery exists, along with a possible commercial opportunity. Consequently, there is no alternative to drilling one or more exploration wells at specific well site locations within the EL areas to test for presence of hydrocarbons.

9.2.1 CONSIDERATIONS FOR PROGRAM OPTIONS

As described in Section 6, Summary of the Proposed Development, there are many options available on how the program could be undertaken. Decisions on the best options to take forward through the regulatory phase and into planning, design and execution will be based on a combination of:

- ensuring the safety of the workforce and public
- understanding and preparing for the specific operating conditions, such as:
  - water depth
  - ice
  - oceanography
  - weather
- ensuring well integrity
- protecting the environment
- protecting Inuvialuit harvesting and other cultural activities
- ensuring that the needs and concerns of the Hamlet of Tuktoyaktuk concerning a potential shore-based facility are addressed
- creating opportunities for local and Inuvialuit businesses and employment
- meeting the terms and conditions of the NEB OA
- meeting the requirements of other regulatory agencies
- meeting the licence conditions of EL 476 and EL 477
- meeting Imperial's and EMDC drilling's operating standards and procedures under the OIMS
- ensuring that the program is cost effective
- meeting the drilling schedule

10.1.1 BACKGROUND DATA

Imperial has a large volume of baseline information to draw on for developing the program. The joint venture partners conducted field data collection programs (FDCPs) in 2009, 2010 and 2011. The scientific collaboration between ArcticNet, Imperial and BP has increased the understanding of the physical, chemical and biological oceanography, contaminants in seawater and sediment, ice climatology and surface and near-surface geohazards in the Beaufort Sea.

In addition to the FDCPs, the BREA provides more background data.

10.1.2 PHYSIOGRAPHY AND MARINE SETTING

The Beaufort Sea is a marginal sea of the Arctic Ocean, located off the western Arctic coast of North America. It is characterized by a continental shelf that extends 150 to 200 km from the coast, in contrast to the Eurasian side of the basin where the shelf extends much further from the coast. The Beaufort Sea shelf is incised by a small number of underwater canyons and is anchored or bounded by the Amundsen Gulf on the east.

The Canadian part of the Beaufort Sea is a Large Ocean Management Area (LOMA) under federal government jurisdiction, subject to exceptions in the IFA relating to wildlife management and environmental screening and assessment. This setting is described from a physical environment, biological environment, and cultural and historical resources perspective, including coastal and shoreline, and Mackenzie River and Mackenzie Delta components.

10.1.3 PHYSICAL, CHEMICAL, GEOLOGICAL AND BIOLOGICAL OCEANOGRAPHY

The oceanography of the Canadian sector of the Beaufort Sea involves many physical, chemical, geological and biological processes that are linked within the context of different oceanographic regimes:

- the inshore area, which is heavily influenced by freshwater and sediment discharges of the Mackenzie River
- the mid- and outer-shelf area, where wind forcing of the ocean current is more dominant
- the outer shelf and continental slope region, where large-scale ocean current systems of Pan-Arctic, Atlantic and Pacific origin play an important role

10.1.3 PHYSICAL, CHEMICAL, GEOLOGICAL AND BIOLOGICAL OCEANOGRAPHY (cont'd)

The seasonality of the oceanographic regime is an important factor that is best expressed in terms of the sea-ice conditions. Ice is prevalent during the fall to spring months and then retreats in late spring to mid-autumn although heavy polar pack ice can persist throughout the summer in the offshore outer shelf and slope region.

The seasonal characteristics of sea-ice formation have a major influence on the shelf and slope water properties through the uptake of salt brine as sea ice forms in autumn and winter, and the discharge of salt brine as sea ice melts in late spring and summer.

Between 1958 and 2007, sea-ice thickness in the Beaufort Sea declined by over 1 m, or 50 % of its volume (Kwok and Rothrock 2009).

10.1.3.1 Physical and Geochemical Processes

An understanding of marine life in the Beaufort Sea requires knowledge of the linkages to physical and geochemical processes, and their large spatial variations and temporal changes, especially on synoptic, seasonal and interannual time scales (Carmack and Macdonald 2002). Primary production (i.e., new organic matter produced, such as phytoplankton) is controlled by the highly variable physical, chemical and sea-ice conditions in these waters, which differ considerably by spatial regime and with the seasons. The seasonal peaks in primary productivity levels are different from one regime to another in terms of the timing and composition (species distribution) of the phytoplankton in or on the bottom of sea ice, or in the water column.

Understanding the higher marine trophic levels begins with the primary productivity patterns in time and space, which are further modulated by biophysical and geochemical processes. For example, the abundance of zooplankton is affected by ocean properties in the upper part of the water column, including vertical stratification, mixing, and formation of frontal features where abundances are higher. Animals that feed on zooplankton are drawn to areas where the zooplankton develops. The habitat and behaviour of animals that feed on zooplankton are strongly influenced by the physical, chemical and biological processes that occur in these waters.

10.1.4 OCEAN CIRCULATION AND CURRENTS IN THE BEAUFORT SEA

Currents in the Beaufort Sea are driven by a combination of various oceanographic processes including:

- large-scale circulation features
- winds
- the Mackenzie River discharges
- tidal forcing

The program EL areas (EL 476 and EL 477) lie along the continental slope between two major underwater canyons, the Mackenzie Trough and Kugmallit Valley. Large-scale circulation features in this area include:

- the clockwise Beaufort Gyre that is driven by the high-pressure atmospheric system, which results in a westward movement of the near-surface waters
- the eastward transport of Pacific Ocean water (Pacific water) that originates in the Bering Sea, thought to occur as an episodic eastward-flowing shelf-break jet along the edge of the Beaufort Shelf at depths of 50 to 200 m (Schulze and Pickart 2012)
- a deeper (greater than 200 m) eastward movement of Atlantic Ocean water (Atlantic water)

These geophysical features, combined with the effects of regional winds and the Mackenzie River plume, create a complex of surface currents (Fissel and Melling 1990). A schematic overview of major circulation elements is shown in Figure 10-1.

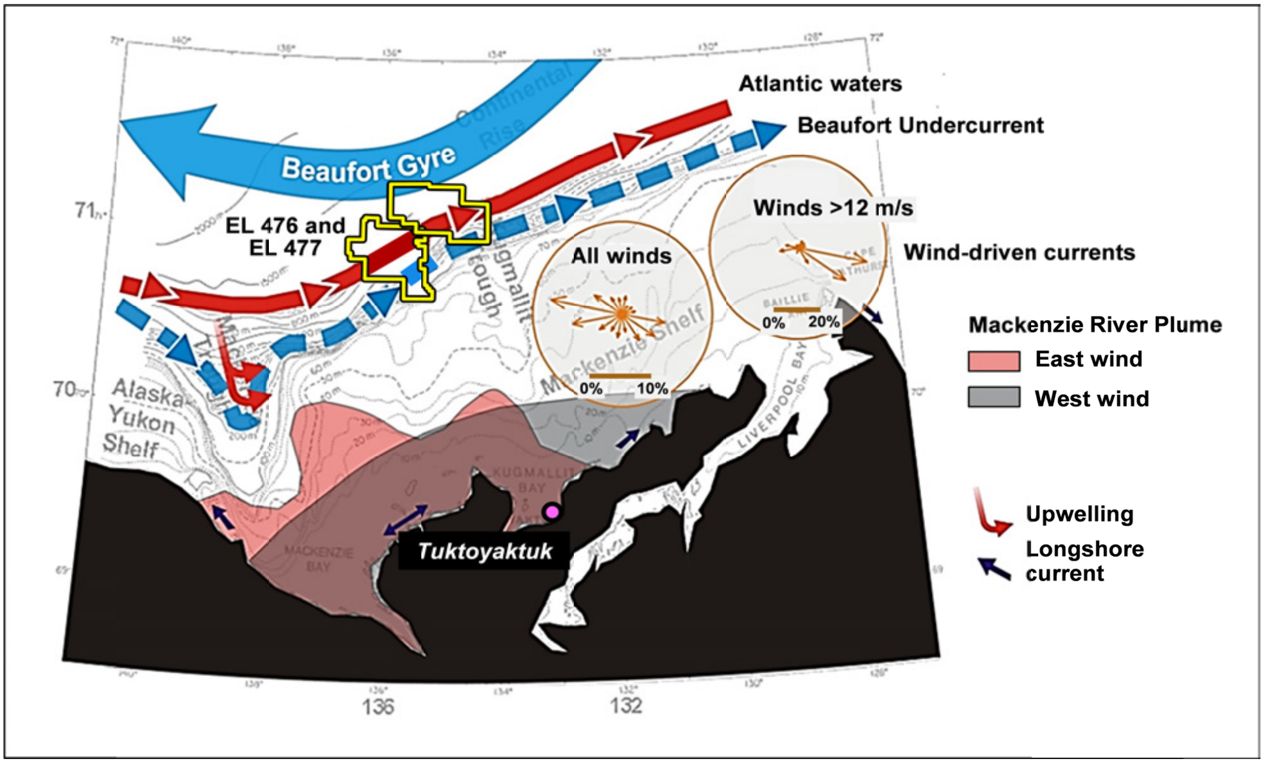


Figure 10-1: Ocean Currents in the Canadian Beaufort Sea

The currents over the shelf edge and continental slope are highly episodic with events occurring over a few days, largely in response to wind forcing as modulated by the local sea-ice cover, topographic waves and mesoscale eddies (Carmack and Kulikov 1998). Current meter measurements from the 2009 to 2011 FDCPs in the exploration licence areas identified events with current speeds as high as 99 cm/s in the upper 200 m of the water column and up to

10.1.4 OCEAN CIRCULATION AND CURRENTS IN THE BEAUFORT SEA (cont'd)

47 cm/s in the deeper (greater than 250 m) Atlantic water layer (Fissel et al. 2012c, Osborne et al. 2012). Such strong current events are associated with northeasterly winds and resulted in ocean upwelling, a process that brings more saline nutrient-rich waters to the surface along the Beaufort Shelf edge and slope (Williams et al. 2006, Williams and Cormack 2008).

Upwelling is enhanced near the Mackenzie Trough and influences the currents along the entire shelf-break area (Carmack and Kulikov 1998). Strong episodic currents over the continental slope have been observed, that include a few large current speed events from 2004 to 2006 that were characterized by large sediment fluxes in the water column, indicative of erosion and redistribution of bottom sediments in the region (Forest et al. 2008).

In the shallower waters on the Beaufort Shelf, ocean currents are predominantly wind-driven (Fissel and Melling 1990). Wind direction is primarily from the east and from the west-northwest (Cobb et al. 2008). Environment Canada data obtained at the weather station on Pelly Island indicates that wind direction is most frequently from the east and that significant wind speeds (i.e., those exceeding 12 m/s) are most common from the west-northwest. The surface currents generated by the two dominant wind directions generally follow the wind direction with a 15 to 30 degree rightward deflection. Current speeds are roughly 2 to 3% of the wind speed, with typical velocities of 0.25 to 0.4 m/s (up to a maximum velocity of 0.8 m/s).

On the inner shelf, the surface currents are influenced by the Mackenzie River plume and the effects of shoreline features, such as islands and headlands. The winds from the west result in strong alongshore currents. Winds from the east result in an offshore displacement of water from the Mackenzie River and pack ice (Carmack and Macdonald 2002). Water from the Mackenzie River was observed in the southern Canada Basin in:

- 1993 and 1994 (Guay and Falkner 1997)
- 1997 (Macdonald et al. 1999)
- 2007 (Yamamoto-Kawai et al. 2009)

However, the water observed from the Mackenzie River was constrained to the coastline, likely exiting the Arctic through the Arctic Archipelago in:

- 1974 (Macdonald et al. 2002)
- 2000 to 2006 (Yamamoto-Kawai et al. 2009)

This suggests that the fate of water from the Mackenzie River depends on interannual climate variability provided by the Arctic oscillation. Observations that are relevant to this situation were also obtained during the FDCPs in 2009, 2010 and 2011.

Tidal currents in the Canadian sector of the Beaufort Sea are weak, typically less than 5 cm/s, with small tidal heights (less than 0.5 m) (Kulikov et al. 2004). However, inertial oscillations, which have a 12-hour period (similar to semidiurnal tides), can have current speeds of up to 40 cm/s, thereby obscuring tidal currents and having important implications for ice floes. Considering the large magnitude and circular nature of inertial oscillations, anticipating when they occur is important to the ice management required to support drilling operations.

10.1.5 WATER MASSES AND OCEAN STRUCTURES

Water properties in the program area are shown in Figure 10-2. They consist of:

- relatively cold, fresh Arctic Ocean surface water in the upper 250 m
- warmer, salty Atlantic water from about 250 to 900 m
- cold, salty water from about 900 m to the bottom

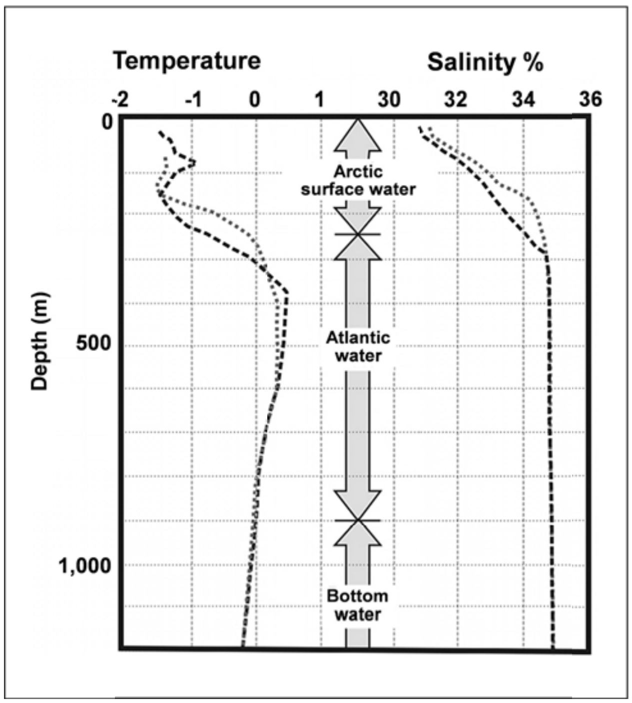


Figure 10-2: Water Properties of Arctic Surface Water and Atlantic Water in the Program Area

10.1.5.1 Water Composition in the Program Area

Arctic surface water is composed of water from the Mackenzie River, melted sea ice, winter polar mixed layer water or surface mixed layer water, and upper halocline water that can include Pacific water (Lansard et al. 2012). The inputs of fresh water from melted sea ice and river runoff results in surface water that is fresher in summer than winter.

The properties of Pacific water vary depending on whether it is modified in the Chukchi Sea in summer or winter (Coachman and Barnes 1961). Pacific summer water is warm with temperatures up to 1°C, fresh (salinity 31 to 33%), with a

10.1.5.1 Water Composition in the Program Area (cont'd)

temperature maximum in the depth range of 30 to 90 m. Pacific winter water is colder with temperatures from -1.6 to -1.5°C, salty (salinity 33.1%), with a temperature minimum in the depth range of 90 to 200 m (Steele et al. 2004). Because of the episodic nature of the Beaufort Shelf-break jet (Schulze and Pickart, 2012), the transport of Pacific summer water and Pacific winter water into the southern Beaufort Sea varies according to regional oceanographic and ice conditions and surface wind patterns.

Atlantic water and Pacific water are likely transported as a boundary current along the continental slope (Aksenov et al. 2011). Consequently, except for upwelling events, Atlantic water is not transported on the continental shelf.

The large discharges of fresh water from the Mackenzie River onto the shelf areas and beyond, and the wind-dependent advection of these river waters lead to frontal features with distance scales of tens of metres to tens of kilometres over the shelf and outer slope regions (Thomson et al. 1986, Carmack and Macdonald 2002). The frontal features from the Mackenzie River are important because they can act as a mechanism capable of concentrating plankton (and other passive water properties) that can result in an abundance of food sources for marine life (Thomson et al. 1986).

10.1.6 WAVES AND STORM SURGES

Between 1985 and 2005, the maximum statistical calculations of probable past significant wave heights (in 60 m water depth) in the EL areas was 5.66 m in October, compared to 0.53 m in July, increasing to 1.4 m in October (Swail et al. 2007). Maximum and mean wave heights vary considerably with water depth and distance offshore. The maximum significant wave height in the deepest area of the EL areas was 7.58 m in October, with average significant wave height values of 0.71 m in July, increasing to 1.63 m in October.

Direct measurements of wave heights taken in the EL areas during the FDCPs yielded wave height measurements of up to 4.9 m. Changes in ocean wave properties might have been occurring over the past decade as a consequence of reduced ice concentrations and increased wind fetches, resulting in a longer duration of ocean wave activity in recent years (Fissel et al. 2012a). In recent years, there is also evidence of moderate to large wave events starting in early June and extending into November, which is longer than the previous wave season observed in the 1980s (Fissel et al. 2012a).

Storm surges occur most commonly in late summer and fall. Typical water level changes associated with positive storm surges have durations of one to two days and do not normally exceed 0.5 m (Henry and Heaps 1976). The largest recorded storm surge was measured in September 1970 with peak surge values of 2.4 m at Tuktoyaktuk and values of 1.1 to 1.9 m along the Yukon coastline (Murty et al. 1995). A similar event occurred in 1999 (Kokelj et al. 2012). At a model grid location near EL 476, the largest surge level each year was calculated at 0.2 m.

From this finding an expected 10-year maximum value of 0.4 m and an expected 100-year maximum of 0.6 m can be extrapolated.

10.1.7 ACOUSTIC CONDITIONS

The acoustic environment in the Beaufort Sea is characterized by acoustic propagation conditions and the ambient noise regime. Acoustic propagation is governed by the water mass properties, the topography and the acoustic properties of the bottom and surface. Ambient acoustic conditions have been studied by the joint venture partners and ArcticNet, in association with Cornell University, during the 2009 and 2010 FDCPs. Marine autonomous recording units were deployed and recovered from Canadian Coast Guard Ship (CCGS) *Amundsen* to record ambient sound levels and marine mammal vocalizations in the program area.

The water mass structure in the exploration licence areas reflects colder, lower salinity Arctic surface water overlying warmer, more saline Atlantic water (see Figure 10-2 shown previously). When ice cover is present, the sound speed minimum is at the surface. Summer heating or river discharge can result in warmer temperatures near the surface, which will displace the sound speed minimum below the surface to a depth of up to 50 m. For typical sound speed profiles in the local study area (LSA), see Figure 10-3.

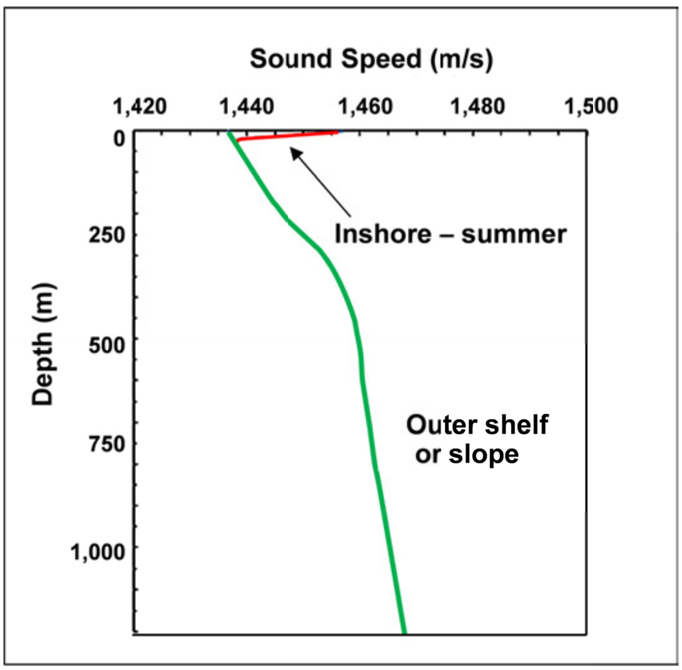


Figure 10-3: Typical Sound Speed Profiles in the LSA

In the deep water of the outer shelf and slope, the sound speed minimum forms a surface sound channel where sound can travel long distances with relatively low losses. The rate of loss depends on the roughness and scattering properties of the surface. This includes the underside or bottom of the ice cover and the air-water

10.1.7 ACOUSTIC CONDITIONS (cont'd)

interface (Milne 1967, Thode et al. 2010). In the nearshore and shallow shelf waters, sound propagation will be more variable in summer, influenced by the Mackenzie River plume with its warmer, fresher water, which is both spatially and temporally variable. In the shallow shelf waters, sound propagation involves multiple surface and bottom reflections, and losses with distance are more dependent on the acoustic properties of the seafloor. Various sources of climatological sound speed data and geoacoustic properties of the seafloor in EL 477 were documented as a component of a 3-D seismic survey carried out in the program area in 2009 for BP by JASCO.

Under ice-free conditions, the ambient noise in the Beaufort Sea is attributed to wind over the ocean surface, precipitation, biological sources and, to the extent that they are present, shipping and industrial sources. When ice cover is present, the character and level of ambient noise differs significantly compared with ice-free conditions. Under a mobile pack ice, ambient noise can be several decibels (dB) higher, while under landfast ice, noise levels might be very low (Milne 1967). Recent measurements conducted during the FDCPs with marine autonomous recording unit equipment provided data on summer and fall low-frequency ambient noise on the shelf and over the slope in the EL areas, including instances of seismic survey activity (Cornell University 2011a).

10.2.1 ICE ZONES

As shown in Figure 10-4, sea ice in the Canadian sector of the Beaufort Sea can be divided into distinct categories or regimes, the:

- landfast ice zone
- active shear zone
- transition zone
- offshore polar pack zone

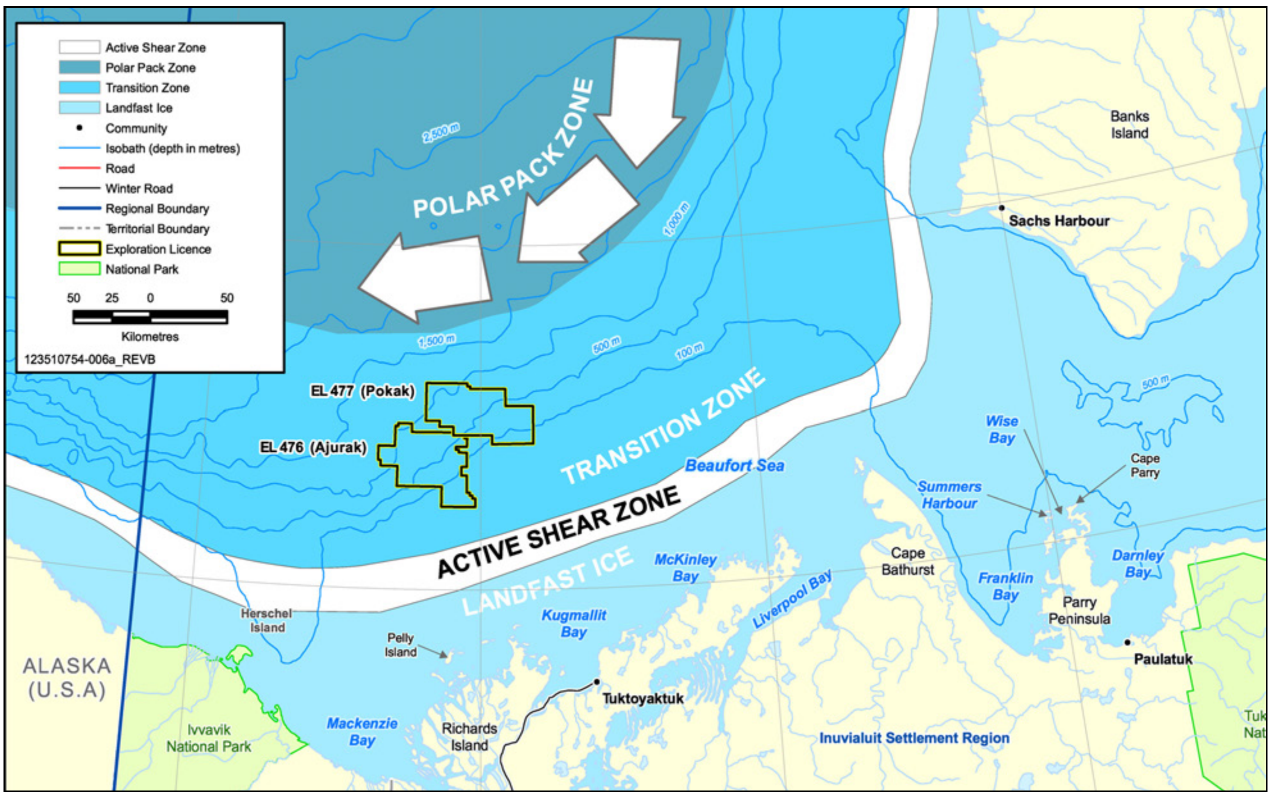


Figure 10-4: Schematic Representation of Zones of Ice Dynamics in the Beaufort Sea

The seasonal first-year landfast (largely immobile) ice cover forms in the shallow water portions of the continental shelf in the fall, and disperses and melts in the following summer.

A transition zone lies landward of the polar pack ice that might be present in the EL areas at some times of the year, as well as over the outer and mid-shelf.

10.2.1 ICE ZONES (cont'd)

Typically, this transition zone is associated with high concentrations of first-year ice and a gradual degradation of the anticyclonic (clockwise) average flow. Degradation appears most strongly in the form of higher variability and lower average ice drift in the most southern areas, where a dynamic shear zone is often separately designated to denote regions of intense ice deformation near the flow discontinuity defining the offshore edge of the landfast ice zone.

The offshore, mobile polar pack ice of the Arctic Ocean describes a large anticyclonic pattern of ice movement related to the Beaufort Gyre.

10.2.1.1 Ice Zone Dynamics

The EL areas are largely situated in the transition zone for sea ice, between the landfast ice on the inner shelf and the Arctic Ocean polar pack ice further offshore. In the transition zone, local navigation and operating conditions are highly sensitive to fluctuations in the character of the offshore ice pack and its seasonal interactions with landfast ice.

According to ice chart information obtained from the Canadian Ice Service for the years 1981 to 2010, ice formation in the EL areas has typically occurred in the middle of October, with ice formation developing seaward from the coastline about two weeks earlier. Ice breakup does not usually occur until late August, although ice can clear as much as four weeks earlier in locations along the shoreline. However, Canadian Ice Service observations from 2000 to 2009 reveal a trend toward sea ice forming later (i.e., the end of October to early November) and clearing earlier (i.e., July). This shift in timing is supported by data on ice conditions obtained with ice profiling (upward-looking) sonars installed on current meter moorings during the 2009, 2010 and 2011 FDCPs (Fissel et al. 2012c) and during a BREA-funded program in 2012.

For nearshore areas, ice formation begins in late September or early October when the outer edge of the offshore ice pack can be as much as several hundred kilometres north of the coastline. In the fall and early winter, ice development is characterized by outward extension and thickening of the nearshore ice cover, punctuated by localized ice deformations generating increasingly deep first-year ice keels. This first-year ice development can be associated with intrusions of thick second-year and older ice (Kovacs and Mellor 1974). Simultaneously, new growth also appears in the offshore ice pack, primarily in areas of open water and thin ice. Rapid deformation of this new and young ice into large first-year ice keels is generally followed by its incorporation into the mixtures of new first year, second year and multi-year-ice, which are typical of the offshore Beaufort Sea ice cover.

10.2.2 LANDFAST ICE

The landfast ice zone forms in the late fall and grows in place until late spring. The thickness and seasonal duration of landfast ice within the Canadian Arctic depends strongly on air temperature and snow cover (Brown and Cote 1992). The outer boundary of the landfast ice is marked by a rubble ice field (stamukhi) formed by grounded ice ridge fragments in winter. Their presence increases significantly with offshore distance at roughly the 10 to 20 m bathymetric contour. Through contacts between their keels and the seafloor, these features inhibit local ice movement, playing a key role in establishing the seaward boundary of the effectively immobile landfast ice. In deeper waters, grounding events tend to occur during periods of negligible or slow gyre-related drift, giving rise to the temporary outward extensions of the seasonal landfast ice boundary.

10.2.3 ACTIVE SHEAR AND TRANSITION ZONES

Shoreward incursions of mobile first-year ice present in the shear and transition zones result in episodic large ice deformation. The shear zone represents the shoreward edge of the transition zone. The episodic ice deformation, driven by strong winds usually from the northwest, results in high ice stresses as the drifting ice of the polar pack ice zone encounters the landfast ice and the shallower waters adjoining it. Individual ice floes impinge upon each other or push against weaker ice, producing areas of ice that are ridged, rafted or rubbled further. In some cases, this ice becomes grounded and pushed upward, embedding itself in the outer part of the landfast ice zone. This highly deformed ice, often referred to as stamukha, might take the form of an elongated hummock or series of hummocks. When the scale of the hummocked sea ice becomes massive, the resulting features are referred to as floebergs, which can extend over distances of many kilometres parallel to the coastline with sail heights of 5 to 25 m. The remnants of such grounded sea-ice features can persist as significant ice hazards during the summer navigation period.

10.2.4 MULTI-YEAR ICE

While first-year ice is predominant in the Arctic Ocean, some of the sea ice is older, having survived at least one summer. In recent years, this older ice has been limited to the polar pack zone. Old sea ice is classified into two categories:

- second-year ice
- multi-year ice

Multi-year ice is predominant throughout the year in the deeper waters of the Canada Basin and is less frequent on the outer portions of the Mackenzie Shelf in late summer.

As sea ice ages from year to year its physical, chemical and other properties change (Wadhams 2000). The salinity is reduced as brine channels are evacuated and frozen over, increasing ice hardness. This change accounts for the more hazardous nature of encounters with multi-year ice as compared to first-year ice. The topography of multi-year ice also changes, becoming smoother on the top and bottom as a result of partial melting in the summer. For shipping operations, including those associated with stationkeeping during drilling unit operations,

10.2.4 MULTI-YEAR ICE (cont'd)

occasional incursions of multi-year ice under the influence of onshore winds are predicted, especially in a less favourable ice year.

The properties and behaviour of multi-year ice in the Beaufort Sea, especially in areas north and northeast (or upstream) of the EL areas, have been studied with ship-based and airborne methods during the 2009, 2010 and 2011 FDCPs. This work and projects carried out by other groups has led to (and provided justification for) major BREA programs on multi-year ice. These BREA programs, which are ongoing, and supported by other agencies or groups, are summarized by Barber et al. (2013), Haas et al. (2013) and Johnston (2013).

10.2.5 EXTREME ICE FEATURES

Hazardous sea-ice features in the Canadian sector of the Beaufort Sea include large individual ice keels and segments of highly concentrated large hummocky (rubbled) ice. Individual large ice keels can be up to 20 m thick or more, while large hummocky ice features, including floebergs, have greater horizontal scales of 100 m to several hundred metres with lesser ice thicknesses ranging from a few to several metres (Fissel et al. 2012b). Upward-looking sonar data sets obtained in the EL areas during the FDCPs involved full-year measurements at multiple locations (Fissel et al. 2012c) and yielded several observations of ice keels exceeding 15 m in draft (thickness below sea surface).

Ice island fragments are infrequent in the offshore waters of the Canadian sector of the Beaufort Sea. They have their origins in parent ice islands which are large detached sections of glacial ice shelves formed from tidewater glaciers and ice sheets. They usually appear first off northern Greenland and the northernmost Arctic Islands (Ellesmere and the Axel Heiberg islands) and drift south-westward through offshore portions of the Canadian Arctic Archipelago and into the Canadian sector of the Beaufort Sea. This large continuous shelf ice began to break up at much increased rates early in the last decade with complete loss of the Markham and Ayles ice shelves and significant mass loss of the Ward Hunt, Milne, Petersen and Serson ice shelves (e.g., Copland et al. 2007). The features were very thick (greater than 40 m) and extend in area from hundreds of metres to kilometres in radius (D.G. Barber, personal communication). The larger ice islands are often marked with air-droppable satellite beacons to facilitate tracking these hazards. Ice islands are typically present further north than the EL areas. For example, during the 2011 FDCP, three ice island fragments were observed and tagged with position-tracking beacons off the northwest coast of Banks Island. These extreme ice features were not observed in the LSA during the 2009 and 2011 FDCP ice studies, nor were they present in this area during the BREA program work conducted in 2012 (Barber et al. 2013).

10.3.1 BACKGROUND

In general, the low average air temperatures over the Beaufort Sea and along the western Arctic coast (associated with the high northern latitudes and the high degree of seasonality) are linked to the formation of sea ice and permafrost conditions. The large-scale atmospheric circulation over the Western Arctic Ocean is the most important factor in determining oceanographic and sea ice movement patterns.

10.3.2 TEMPERATURE, PRECIPITATION AND FOG

Despite the low incidence angle of sunlight, the meteorology of the Beaufort Sea is driven by the cyclical amount of daylight (Overland 2009). Observations at the Tuktoyaktuk ‘A’ meteorological station show that the mean air temperature exhibits a large seasonal cycle between -27°C in the winter and 10°C in the summer (EC 2013). By October, mean temperatures are generally well below freezing at -7°C and remain at subfreezing values until June. Further to the northeast at Sachs Harbour, the air temperature is typically a few degrees colder with the minimum reaching -29°C.

Cold Arctic air holds little moisture resulting in low overall precipitation rates with much of the precipitation occurring in the form of snow (NSIDC 2013). At the Tuktoyaktuk ‘A’ station the mean annual total rain is 8 cm with most of this occurring from June to September (EC 2013). Snowfall occurs year-round with 97% of it occurring between September and May.

Fog occurs in late spring and onwards through the summer, in association with warmer air masses (influenced by coastal areas and large areas of open water) that are advected over the sea or with low air temperatures. During the spring and fall shoulder seasons when open water persists longer in the presence of cold air temperatures, fog can occur more frequently.

10.3.3 WIND CLIMATOLOGY AND STORMS

Atmospheric patterns in the Arctic have significantly changed since 2007 and are now characterized by high seasonal, interannual, and regional variability (Liu et al. 2012, Serreze and Barry 2011).

Since 1996, the Beaufort Sea high-pressure system has become stronger, enhancing the predominant easterly winds in the Beaufort Sea with larger increases at more offshore locations (Moore and Pickart 2012, Schulze and

10.3.3 WIND CLIMATOLOGY AND STORMS (cont'd)

Pickard 2012). These changes in high pressure are shown in Figure 10-5. Inshore surface winds have exhibited only small or negative trends over the last 50 years (Fissel et al. 2009 and 2013, Hakkinen et al. 2008, Martinez et al. 2011).

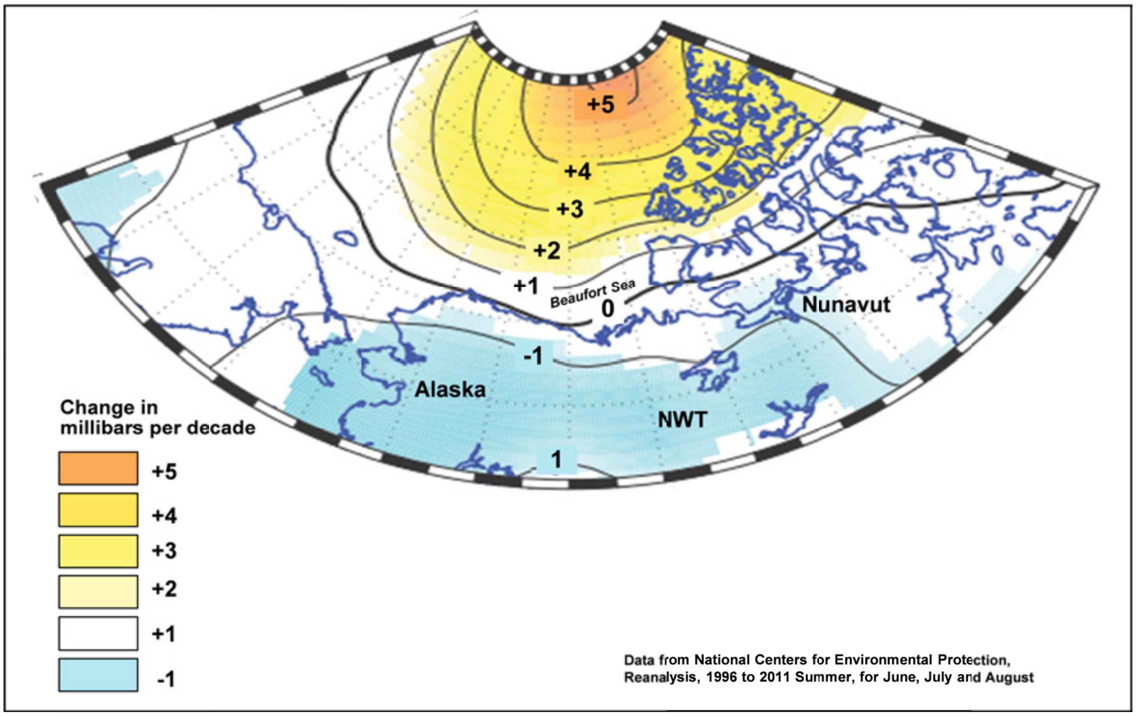


Figure 10-5: Atmospheric Pressure Trends in Sea-Level Pressure in the Program Area, 1996 to 2011

Cyclonic low-pressure systems are important in the Arctic, especially during the summer and fall. Typical Canadian summer storm tracks are shown in Figure 10-6. Several distinct systems have been identified (Asplin et al. 2009, Zhang et al. 2013). More cyclones tend to follow the sea ice–ocean interface, causing ice edge retreats as these storms move further offshore (Hakkinen et al. 2008, Moore and Pickart 2012, Overland et al. 2012). There has been an increase in the depth of offshore low-pressure systems but not an increase in the frequency of cyclones (Lukovich and Barber 2006, Lukovich et al. 2009, Barber 2012 personal communication).

Polar lows, which are an uncommon occurrence in the Beaufort Sea, are low-level and small-scale features that form near the ice edge or in coastal regions where cold air flows from ice or land surfaces over open water. As the cold air warms and rises, the pressure falls and a cyclonic circulation is created, often generating strong winds. The duration of polar lows over a particular location can be less than other low-pressure systems, often one day or less.

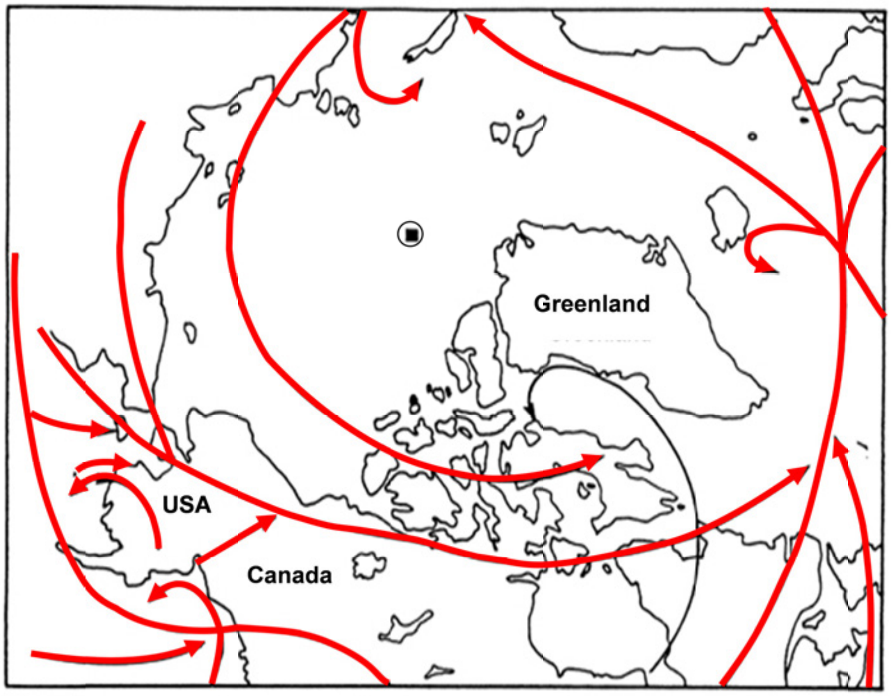


Figure 10-6: Typical Canadian Summer Storm Tracks

10.3.4 ICING FROM FREEZING PRECIPITATION OR SEA SPRAY

The accretion of ice on marine vessels and superstructures occurs when water droplets produced by freezing rain, drizzle, wet snow, super-cooled fog or sea spray in the atmosphere are present in below-freezing air temperatures (Overland 1990).

Generally, freezing spray has the greatest potential for marine icing incidents during the fall. During this period the air temperatures are significantly below 0°C and open water is still prevalent in Baffin Bay, Davis Strait and the northern portions of the Labrador Sea. Although it occurs less frequently, incidents of freezing spray in the western Arctic and Beaufort Sea have been reported, with extreme cases of ice accumulation exceeding 15 cm (Canadian Coast Guard 2013). As shown in Figure 10-7, the potential for freezing spray increases with the degree of subfreezing air temperatures and the wind speed (Overland et al. 1986, Overland 1990).

10.3.5 AIR QUALITY

Ambient air quality over the Beaufort Sea (in offshore and nearshore environments) is influenced by local, regional and non-regional air emissions, which are subject to various physical processes, such as:

- atmospheric transport and dispersion

10.3.5 AIR QUALITY (cont'd)

- wet and dry removal
- surface exchange between the atmosphere and terrestrial or marine environment
- chemical transformation processes

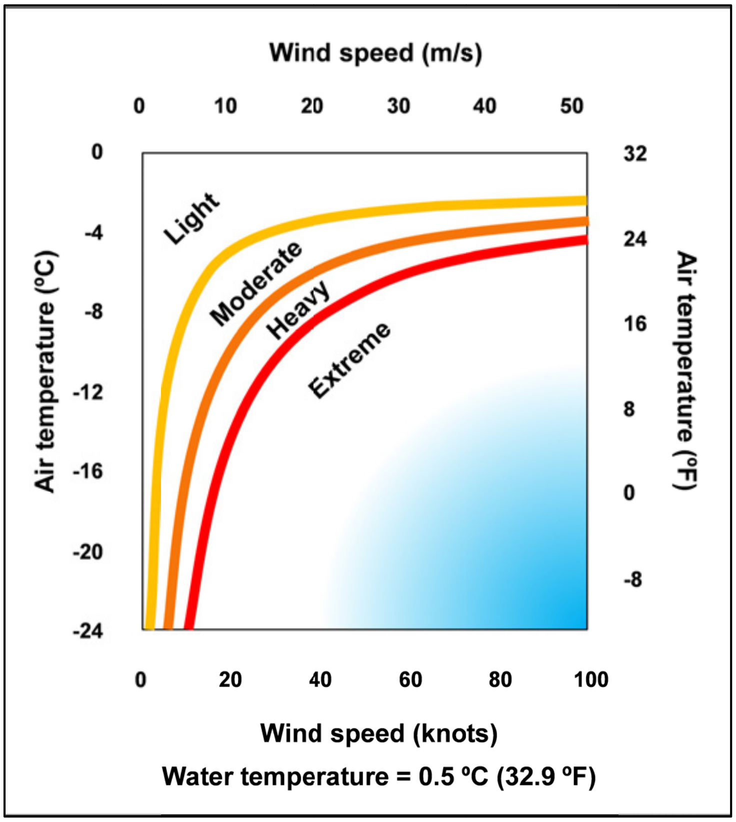


Figure 10-7: Freezing Spray Air Temperatures and Wind Speeds for Typical Water Temperatures During the Fall in the Canadian Beaufort Sea

Most contaminants found within the Arctic result from the long-range transport of pollutants from the industrialized areas of Europe, North America and Asia (AMAP 1998). Atmospheric contaminants include:

- black carbon, i.e., soot
- persistent organic pollutants, e.g., organochlorine pesticides and industrial chemicals
- combustion products, e.g., polycyclic aromatic hydrocarbons (PAHs)
- heavy metals

Emissions from sources beyond the Arctic also result in low but widespread levels of sulphur and nitrogen compounds within Arctic regions (AMAP 1998).

This sulphur, in the form of sulphate, augmented by humidity effects and ice crystals, can result in the formation of Arctic haze (Shaw 1995), which can reduce visibility to a few kilometres or less. Arctic haze is most common during the winter because of inversions that are typical of the cold and stable conditions during Arctic winters (AMAP 2006). However, fall and winter surface inversions are weakening under warming air temperatures, which has the potential to increase the amount of surface air temperature increases resulting from climate change (Bintanja et al. 2011).

In Tuktoyaktuk, local emission sources include:

- home heating and cooking
- power generation
- fuel storage
- transportation

Ambient air quality information is not available for Tuktoyaktuk. However, the GNWT collects ambient air quality data in Inuvik. The Inuvik monitoring station has been operating since 2003 and measures particulates (GNWT 2011a):

- less than 10 microns (PM_{10}), such as:
  - sulphur dioxide (SO_2)
  - ozone (O_3)
  - nitrogen dioxide (NO_2)
  - hydrogen sulphide (H_2S)
- less than 2.5 microns ($PM_{2.5}$)

10.4.1 SEDIMENT TYPES AND PROCESSES

Sediments in the Beaufort Sea are generally thick and span the full range of grain sizes from clays to sands and gravels. Sedimentation has been strongly influenced by:

- glacial processes
- the deposition of suspended material from the Mackenzie River plume and resuspension, transportation and redeposition at some locations along the shelf break
- sea-level change over geological timescales

10.4.1.1 Sediment Dispersal

In the upper part of the sediment column there is evidence from multi-beam and sub-bottom profiling surveys that recent sedimentation has buried glacial landforms, shorelines and outwash deposits when the sea level was about 120 m lower than present during the last ice age (Törnqvist et al. 2006).

The Mackenzie River plume, consisting of fresh water, dissolved material and suspended sediment, flows across and along the shelf to the northeast, under the influence of the Coriolis and the regional wind field during ice-free periods. Some of the plume, as it mixes with seawater on the middle and outer shelf during summer and fall, particularly during prolonged periods of easterly or northeasterly wind, can be transported to the west or southwest when these waters become part of the surface circulation driven by the Beaufort Gyre. In some cases, eddies generated by meanders in the plume can transport suspended material even further offshore.

Typical estimated sedimentation rates determined from age dating on recovered cores range from 0.1 mm/yr to 1.3 mm/yr within the EL areas (Fugro 2011, Bringue and Rochon 2008). Rates of 0 to 2 mm/yr are typical for the Beaufort Shelf, with some evidence that the sedimentation rate has slowed in recent times (Richerol et al. 2008, Scott et al. 2008). In the EL areas, work conducted as part of the FDCPs identified that on the outer shelf and slope, sediments are typically silt and clay, which can also include ice-rafted debris in the form of pebbles, sand and clay balls (Fugro 2011).

10.4.1.2 Geotechnical Properties

Geotechnical properties of samples obtained in the upper sediments in the EL areas have a high plasticity index of 35 to 50 and water content of 65 to 110% consistent with a normally to lightly over-consolidated marine clay. The measured undrained shear strength and compressibility are within the expected range for such sediments (Fugro 2011).

10.4.1.3 Ice Scour

Ice scouring is a particular feature of sediments in ice-covered waters that are identified as almost linear grooves on the seafloor. Observed ice keels appear to be limited to about 60 m, but relict scours are apparent in deeper waters on the slope and outer shelf. During the 2010 FDCP, a paleo-scour zone was identified within the upper slope area of EL 477, in which grooves on the seafloor are interpreted to be the expression of a buried ice keel-scoured surface, generally between 5 and 40 m below the seafloor. There is evidence that disturbance related to ice scouring completely remoulds near-surface sediments (depending on water depth, sediment type and ice regime) to depths of 2 to 4 m.

Bottom-fast ice in coastal areas, such as along the Tuktoyaktuk Peninsula, can rework sediment as well. Ice-bonded sediment can include marine soils that are attached or frozen into or onto the ice bottom. This bottom-fast sediment is mobilized during melting or ablation and breakup when the ice detaches from the bottom and either continues to melt in place, or drifts to another location under the influence of wind and surface currents.

10.4.1.4 Sediment Studies

To study contaminants within sediment, samples were collected during the 2009 FDCP in EL 476 for analysis of:

- metals
- parent and alkylated PAHs
- alkanes

During the 2010 FDCP in EL 477, samples were obtained for analysis of:

- metals
- parent and alkylated PAHs
- alkanes
- polychlorinated biphenyls
- acid base neutral extractable organic compounds
- petroleum hydrocarbons (benzene, toluene, ethylbenzene and xylene F1 and F2 to F4)

Large volume seawater sampling for analysis of parent and alkylated PAHs and alkanes in solution and on particulate was also carried out each year. The sediment results indicated that:

- concentrations of metals, PAHs and polychlorinated biphenyls were relatively low compared to available sediment quality guidelines
- alkane and PAH concentrations were within the range of concentrations previously reported for uncontaminated Beaufort Sea surficial sediments (Yunker et al. 1996, AMAP 1998 and 2007, Devon 2004)
- the predominant source of the PAHs in the sediment samples collected appeared to be petrogenic, which is consistent with AMAP (1998) and Yunker et al. (1993) recognizing that the Mackenzie River delivers petroleum hydrocarbons to the southern Beaufort Sea after flowing through a drainage basin rich in petroleum hydrocarbon deposits

During the 2009 FDCP, surficial sediment samples were collected from coastal stations in the Beaufort Sea area and in Tuktoyaktuk Harbour and its approaches, for analysis of metals and hydrocarbons (PAHs and alkanes). Concentrations of metals and PAHs in these nearshore areas were relatively low compared to the *Canadian Interim Sediment Quality Guidelines*. However, they were higher than the results obtained in the EL areas in 2009 and 2010.

10.5.1 DESCRIPTION

The bathymetry of the Beaufort Sea is dominated by an extensive shallow shelf, which gradually slopes north to a depth of 200 m before rapidly dropping off to several thousand metres.

Bottom morphology and associated sub-bottom features have been identified using a combination of multi-beam and sub-bottom profiling systems on the CCGS *Amundsen* during the 2009, 2010 and 2011 FDCPs. The sub-bottom features result from several different processes, such as those related to:

- glaciation
- river or stream discharges to the ocean during periods of lower sea level during the last ice age
- scouring or gouging by pressure ridges and other extreme features
- other localized and clustered features, both active and inactive, related to natural seafloor venting processes of gas and fluids that originate from shallow and potentially deeper sources

These sub-bottom features and processes have also been extensively studied by the Geological Survey of Canada, and they continue to be investigated for their potential as geohazards as a component of the multi-year BREA program that is supported by other government programs.

10.5.2 BATHYMETRIC MAPPING

Bathymetric mapping in the Beaufort Sea at the regional scale is acceptable for navigation and planning purposes, and continues to improve. A deep-draft shipping channel has been charted through the Beaufort Sea at mid-shelf depth by the Canadian Hydrographic Service, largely to avoid a dense distribution of underwater pingo-like features that pose a hazard to shipping. In the EL areas, accurate, high-resolution data on water depths was obtained during the 2009, 2010 and 2011 FDCPs, and during 3-D seismic surveys conducted by Imperial in 2008 and BP in 2009.

10.6.1 CURRENTS AND CIRCULATION

The currents in the inshore and coastal areas are dominated by wind forcing, but are also affected by the Mackenzie River plume, tides and ice extent (Thomson et al. 1986, Carmack and Macdonald 2002). Current measurements obtained during the 2009 FDCP, included one-day to two-day studies of four harbours (Tuktoyaktuk Harbour, Summers Harbour, Wise Bay and McKinley Bay) (Fissel et al. 2012c). The measurements from these studies indicated strong horizontal gradients in the currents (i.e., 40 cm/s to less than 10 cm/s over just a few hundred metres) in relation to large horizontal salinity, temperature and turbidity gradients associated with density fronts related to Mackenzie River plume waters (Fissel et al. 2012c).

Extensive historical ocean current data sets for inshore areas are also available, mostly from the late 1970s to late 1980s.

10.6.2 WATER PROPERTIES

Water in the inshore portion of the Mackenzie Shelf is a combination of fresh water from the Mackenzie River along with incursions of Arctic Ocean waters (Thomson et al. 1986). The water properties vary over short distances and over a few days according to the dominant river discharge and wind forcing. These dynamic conditions lead to the formation of large frontal features in the nearshore waters, especially between the Mackenzie River plume and the shelf Arctic waters. The fresh waters mix with marine waters and a relatively fresh mixed layer forms along the coastal areas and maintains a strong thermohaline (or temperature-salinity) gradient in the southern Beaufort Sea. These conditions are largely responsible for the basin's surface-water stratification. This can be important in the aggregation of plankton and zooplankton for feeding by fish and marine mammals (e.g., Thomson et al. 1986, Carmack and Macdonald 2002). These processes, and other aspects of coastal oceanography in this area, are well described in a synthesis by Macdonald and Yu (2006).

The Mackenzie River is the largest river system that influences the Beaufort Sea. It annually transports about 130 million tonnes of sediment and 18 million km^3 of fresh water into the Beaufort Sea. The Mackenzie River does not form a single coherent plume. Consequently, several distinct temperature, salinity and turbidity fronts might be present on the Mackenzie Shelf as a diffuse plume at any given time (Carmack et al. 1989). Oceanographic surveys show the plumes that form as surface layers of turbid freshwater discharge extending seaward over the saline

10.6.2 WATER PROPERTIES (cont'd)

Beaufort Sea water (Carmack and Macdonald 2002). However, the size, shape and direction of the plumes are strongly influenced by winds.

Easterly winds create upwelling, causing plume waters to extend into offshore areas up to several hundred kilometres. However, westerly winds typically force plume waters against the coast and enhance the flow of this water along the Tuktoyaktuk Peninsula (Carmack and Macdonald 2002).

10.6.2.1 Spatial Variability

The extent and location of the Mackenzie River density fronts is variable and dependent on runoff, currents, winds and wave conditions. Belkin et al. (2003) note that: "under favourable ice/wind conditions, the Mackenzie River plume can spread across the Canadian shelf and extend well into the open ocean, as far as 400 km away from its source, being clearly visible in satellite imagery" (also noted in Borstad 1985, Thomson et al. 1986, Macdonald et al. 1999). The plume extent was investigated in the 1980s (Fissel et al. 1987) and again during the 2009 FDCP. Ship-based measurements of near-surface temperature, salinity and turbidity were obtained (Fissel et al. 2012c). The surface expression of the density fronts can be observed across the shelf, occurring in water depths of 20 to 80 m.

The intense Mackenzie River plume waters are characterized by salinities of less than 10 to 14% practical salinity unit and temperatures greater than 6 to 10°C. The diffuse plume waters have temperature and salinity values at intermediate ranges (Fissel et al. 1987). The diffuse plume can extend further offshore (up to 200 km in some cases) and along the shore as far as Cape Bathurst and across the Alaskan border (Thomson et al. 1986). In some years the Mackenzie freshwater discharge influence can be observed westward to the Alaskan Shelf.

Under-ice plumes have been traced west to Herschel Island and east to the tip of the Tuktoyaktuk Peninsula. During the winter, the plume spreads slowly under landfast ice and tends to move eastward along the Tuktoyaktuk Peninsula, extending seaward to the rough ice (stamukhi) zone (rubbled ice field), at about 20 m water depth (Carmack and Macdonald 2002).

10.6.2.2 Seasonal Variability

Seasonal variations in discharge from the Mackenzie River, ice formation, breakup and winds are reflected in the seasonal character of the river density fronts. The Mackenzie River flows year-round, with peak discharges from mid-May to June and with strong outflow during late May through September (Carmack et al. 1989, Carmack and Macdonald 2002). During the ice-free months, the density front reaches its maximum seaward extent. The reduced outflow during late fall and winter, along with formation of landfast and offshore ice, results in a narrower plume and density fronts nearer the shore.

Generally, fresh water input is lower in late winter (about 4,000 m^3/s) and accumulates behind an ice dam near the mouth of the Mackenzie River

(Macdonald et al. 1989). This damming results in the eventual formation of a large mass of fresh or brackish water, known locally as Lake Mackenzie. Lake Mackenzie floats above underlying marine water further out into the estuary. This mass of fresh water covers an area of about 12,000 km^2 and has a volume of about 70 km^3.

10.6.3 WAVES

During the 2009 FDCP, directional wave measurements were obtained in water depths of 15 m along the proposed marine resupply corridor between the EL areas and Tuktoyaktuk Harbour (Fissel et al. 2012c). The EC model wind-wave study (Swail et al. 2007) also provided wave results, although these results might not be fully representative of present conditions.

10.6.4 STORM SURGES

Changes in water levels associated with wind-driven storm surges in combination with the small tides of the region are important in terms of possible flooding of the low-lying coastal lands, especially in the coastal Mackenzie Delta area. Storm surges occur most commonly in late summer and fall, when strong and sustained winds are experienced in the area and the areas of open water are the highest.

Typical water level changes that are caused by positive storm surges (resulting from onshore winds) do not normally exceed 0.5 m, with a typical duration of one to two days (Henry and Heaps 1976). A storm surge that occurred in 1999 is regarded from a traditional knowledge and western science point of view as the largest surge that has affected water levels in the western part of the Mackenzie Delta. This surge had long-term impacts on flooded areas, including vegetation, and was observed more than 20 km up-river by residents of Aklavik (Kokelj et al. 2012).

The effects of storm surges are compounded by rising sea level and coastal subsidence, which is occurring in some areas of the western Arctic, such as Tuktoyaktuk and Sachs Harbor. Projections of a continuing rise in sea level and subsidence for some areas of the western Arctic increases the potential risks to infrastructure, such as the shore-based facility and docks.

10.6.5 SEDIMENT DYNAMICS NEARSHORE

In collaboration with other government agencies and industry, the Geological Survey of Canada collected information on sediment dynamics and coastal erosion from previous studies involving aerial reconnaissance and ground-based surveys in the 1980s, 1990s and 2000s. Some data relevant to this situation was collected during the 2009 FDCP and continues to be obtained and interpreted during a multi-year BREA program and other programs.

The present day Mackenzie River Delta started forming during the retreat of glaciers after the last glacial maximum, about 12,000 to 13,000 years ago (Cobb

10.6.5 SEDIMENT DYNAMICS NEARSHORE (cont'd)

et al. 2008). The Mackenzie River Delta includes wetlands, river channels, lakes, barrier islands, deltaic islands and Richards Island, encompassing more than 13,000 km^2 (Hirst et al. 1987). Continuous deposition of sediment over the last 65 million years has built up to a thickness of about 15 km under the southern part of the Mackenzie River Delta. Unlike much of the area to the west, this region was greatly affected by processes during and after the last glaciation (Cobb et al. 2008) and includes characteristic glacial topography and landforms (e.g., eskers, drumlins, moraines and terraces).

In addition to the significant regional role of the Mackenzie River and its delta, other rivers along the coast, including the Firth, Babbage, Blow, Anderson and Horton are locally important (Cobb et al. 2008). Many of these rivers have associated deltas, especially those that discharge through unconsolidated material along the coastal plain to the west and east (Hill et al. 1991, Welch 1993). The sediment that is being deposited on the Canadian Beaufort Shelf consists mostly of clay or silt, with relatively little gravel. Most gravel deposits probably originate from ice rafting or drowned beaches from which the finer sediments have been previously eroded (Carmack and Macdonald 2002). Shelf sediments are also resuspended and transported during storms, especially in late autumn (Carmack and Macdonald 2002).

Landslides, which occur when icy sediments thaw, are common occurrences in the Mackenzie Delta and along the Tuktoyaktuk Peninsula (Dyke et al. 1997). Fine-grained sediments, such as silts and clays, cover much of the Tuktoyaktuk Peninsula and are prone to slope failure because of the characteristically high ice content. Severe meteorological events, such as heavy precipitation or an abnormally warm summer, might induce permafrost thaws and subsequent landslides (Aylsworth and Duk-Rodkin 1997).

Delta channels are also prone to extensive erosion as a result of high flow velocities and thermal niching (Dome et al. 1982). As a result of this erosion-related process, substantive quantities of suspended sediments are introduced to the southeastern Beaufort Sea.

The effects of coastal erosion are most pronounced along the Yukon North Slope, the western coastline of Banks Island and along the coast near Tuktoyaktuk Peninsula, although other areas of the Tuktoyaktuk Peninsula are likely also subject to increased erosion. The coastline of the southern Beaufort Sea exhibits retreat rates greater than 1 m/yr, although this rate might reach a maximum of 18 m/yr (observed at Shallow Bay in the Mackenzie Delta). These high rates of shoreline erosion can result in unstable and dynamic shoreline habitats. Cliffs located along the Beaufort Sea coast that are formed of unconsolidated frozen material typically erode at rates of 1 to 3 m/yr (Solomon and Forbes 1994).

Coastal erosion is an important local source of sediments, but the relative contribution of coastal erosion to sediment loading in the Beaufort Sea is minor compared to sediments originating from the Mackenzie River (Carmack and Macdonald 2002). However, coastal erosion will probably increase as a result of elevated temperatures resulting from climate change. Warmer temperatures can destabilize frozen sediments and ice that are found in coastal cliffs (Solomon and Forbes 1994).

10.7.1 PHYTOPLANKTON

In the Arctic, the occurrence of phytoplankton blooms is closely associated with the timing and movement of melting sea ice. In the spring, phytoplankton production on the Arctic shelves is often dominated by diatoms. During summer, nutrient limitation often induces a system shift to support the growth of smaller-celled flagellates over larger diatom species, although diatoms might remain abundant if sufficient nutrients are available. Other phytoplankton groups (Hsiao 1976) in the Beaufort Sea include:

- dinoflagellates
- chrysophytes
- blue-green algae (cyanobacteria)

From 2005 to 2007, measurements of phytoplankton production, biomass, and composition in the Beaufort Sea indicated that the eastern Beaufort Sea, including the Mackenzie Shelf, was characterized by low total chlorophyll *a* biomass (mean ± SD = 16.0 ± 5.5 mg m^{-2}) and production (73 ± 37 mg C m^{-2} d^{-1}) in the euphotic zone (Ardyna et al. 2011). The limiting factors influencing primary production in the Beaufort Sea are:

- temperature
- salinity
- nutrient availability
- the amount of light or solar radiation available for photosynthesis, known as photosynthetically active radiation

These factors vary considerably between estuarine areas, polynya zones and marine areas underlying consolidated sea ice.

10.7.1.1 Estuarine Waters

The estuarine region of the Beaufort Sea is characterized by nutrient-poor surface waters and low primary production resulting from strong vertical stratification created by fresh water input from the Mackenzie River and melting sea ice (Carmack and Macdonald 2002). Within the Mackenzie system, phytoplankton concentrations remain relatively level across the river-to-estuary transition, with a marked chlorophyll maximum observed offshore at a depth of about 25 m (Emmerton et al. 2008). Concentrations of nitrate and phosphate in freshwater discharge are lower than in marine waters, while silica and dissolved oxygen concentrations are higher (Holmes et al. 2012). Variations in dissolved nitrate

10.7.1.1 Estuarine Waters (cont'd)

and phosphate concentrations suggest that phosphorus limits total primary production at lower salinities (from between 0 to 10%) and nitrogen limits total primary production further offshore in the Beaufort system (McClelland et al. 2012).

10.7.1.2 Polynya Zones

Primary production in polynya zones is generally weak and dominated by flagellates (Hsiao 1976), except in areas with pronounced upwelling. As the ice breaks up to form a polynya, upwelling creates local nutrient enrichment at the surface, which supports greater primary production than in most nearshore areas (Carmack et al. 2004). Several biological hotspots occur in the Beaufort Sea, including the central Amundsen Gulf and the Cape Bathurst polynya (Williams and Carmack 2008). These areas support the highest abundance and biomass of phytoplankton in the Beaufort Sea (Ardyna et al. 2011).

10.7.1.3 Consolidated Sea Ice

For up to nine months of the year, short daylight hours and thick ice and snow cover strongly limit light availability in the water column. Primary production under the ice is limited to summer (May to August) and is restricted by light availability and by water column stratification (Boetius et al. 2013). During summer, the mixed layer depth is limited to 10 to 30 m (Bourgain and Gascard 2011, Rabe et al. 2011), which constrains the nutrient supply for algal growth (Tremblay and Gagnon 2009). Average estimates for primary production in the ice-covered central Arctic are low, on the order of 1 to 25 g C m^{-2} $year^{-1}$ (Wassmann et al. 2010). However, recent surveys completed in the Arctic suggest that warming trends might actually contribute to enhancing primary production under the ice (Arrigo et al. 2012).

Seasonal sea ice and snow cover were assumed to strongly limit incoming solar radiation (Arrigo et al. 2012) and subsequently impede any significant growth of phytoplankton in the sub-ice environment. Recent reports of extensive blooms beneath fully consolidated pack ice have been associated with increased trans-ice light transmission resulting from a thinning ice cover and proliferation of melt ponds in recent years (Mundy et al. 2009, Nicolaus et al. 2010, Arrigo et al. 2012). Zhange et al. (2010) reported that about 50% of the ice-covered ocean in the Arctic has surface nitrate concentrations greater than 10 µmol l^{-1} in early spring, which are conditions that are highly suitable for sub-ice primary production.

During the spring freshet, low nutrient river discharge displaces richer winter water under the ice. Carmack et al. (2004) demonstrated that landfast ice in the Mackenzie River region delays the onset of phytoplankton production in the water column by about one month over the inner shelf compared to the outer shelf. While this delay is largely a function of light availability, the offshore nutrient regime supports a higher incidence of primary production as well.

The contribution of ice algae to total primary production levels is not well understood, ranging from 0 to 80% in different studies (Hegsdeth 1998, Wassmann et al. 2006). Sea-ice algae are estimated to contribute between 4 and 26% of total primary production in seasonally ice-covered waters (Legendre et al. 1992) and more than 50% in regions covered by ice year-round (Gosselin et al. 1997).

10.7.2 ZOOPLANKTON

Biomass composition within the Beaufort Sea is dominated by three species of copepod (Darnis et al. 2008):

- *Metridia longa*
- *Calanus glacialis/marshallae*
- *Calanus hyperboreus*

Five other species are also abundant (Robert et al. 2009 and 2010) as also identified during the FDCPs:

- *Oithona similis*
- *Microcalanus pygmaeus*
- *Pseudocalanus spp.*
- *Cyclopina spp.*
- *Oncaea borealis*

The abundance and biomass of zooplankton varies seasonally with peaks that are generally observed in August. Total abundance, biomass and species richness increases offshore towards the slope (Robert et al. 2010). Biomass is highest in areas of increased salinity and outside the influence of the Mackenzie River outflow (Bradstreet et al. 1987).

Larval fish, or ichthyoplankton, were also captured at most plankton sampling stations. Larval fish abundance was dominated by Arctic cod (*Boreogadus saida*) and was more abundant at inshore locations than at sampling stations further offshore (Robert et al. 2009 and 2010), which was also the finding during the FDCPs.

10.8.1 SIGNIFICANCE OF BENTHIC INVERTEBRATES

For the purpose of this PD, benthos refers to benthic invertebrates living either on the seafloor (epifauna) or within the seafloor (infauna). In the Canadian Arctic, marine benthos is an important food source for many species of fish, marine birds and mammals (Frost and Lowry 1984). Benthic invertebrates affect the physical environment by redistributing sediment, breaking down pelagic waste and recycling nutrients back into the water column (Conlan et al. 2008). Benthic community composition is largely determined by near-bottom salinity, water temperature levels (Cusson et al. 2007) and other biophysical factors, such as:

- ice scour
- oxygen availability
- sediment particle size
- organic carbon availability from riverine and coastal erosion

Benthos diversity and abundance is also influenced by the degree of pelagic-benthic coupling, which describes the level of organic matter exchange between the pelagic and benthic environments (Renaud et al. 2007).

Data on benthic communities within the Canadian sector of the Beaufort Sea are sparse and originate from either early hydrocarbon exploration investigations (Wacasey 1975, Wacasey et al. 1977, Atkinson and Wacasey 1989) or relatively recent studies (Cusson 2007, Conlan et al. 2008, DFO 2008, Robert et al. 2009 and 2010), including surveys conducted in the program area FDCPs. Results from investigations demonstrate that diversity and abundance varies widely across the continental shelf, with crustaceans, gastropods, polychaetes and echinoderms being the most representative groups.

Benthos in Tuktoyaktuk Harbour is characterized by low abundance and diversity and is mostly dominated by polychaetes and amphipods (Hopky et al. 1994). Conversely, upwelling areas near Cape Bathurst support an increased level of benthos diversity with significantly higher densities observed (up to 17,127 individuals/m^2) than surrounding shelf and inshore areas (about 0 to 3,000 individuals/m^2) (Cusson et al. 2007, Conlan et al. 2008, DFO 2008).

10.8.1.1 Biogeographic Zones

The distribution of marine benthos can be divided into four key biogeographic zones (Wacasey 1975) based on differences in water depth, temperature, salinity and benthic community metrics (diversity and biomass):

10.8.1.1 Biogeographic Zones (cont'd)

- the estuarine
- the transitional
- the marine
- the continental slope

Reported occurrences of larger invertebrates in one or more of the biogeographic zones include giant Pacific octopus (*Enteroctopus dofleini apollyon*), North Atlantic octopus (*Bathypolypus acticus*), snow crab (*Chionoecetes opilio*), toad crab (*Hyas coarctatus alutaceus*) and several squid species (Arctic Laboratories and LGL 1987, Atkinson and Wacassey 1989, Siferd 2001). However, data on these species is scarce given that they routinely escape standard epibenthic sampling devices. Therefore, true distribution and densities of the larger invertebrates are unknown.

10.8.1.1.1 Estuarine Zone

The estuarine zone, which includes all coastal areas influenced by the Mackenzie River, including Tuktoyaktuk Harbour (Hopky et al. 1994), is characterized by water depths less than 15 m with salinity levels of less than 20 ‰ (parts per thousand). At these shallow depths, benthos is strongly influenced by the outflow of fresh water, which creates pockets of low salinity water within inshore areas (up to 0.1 ‰ near the mouth) (Wacasey 1975). Benthic communities in the estuarine zone are characterized by low diversity and low biomass, potentially because of a low species tolerance to fluctuating salinity levels (Wong 2000). Common species present in this zone include polychaetes (*Ampharete vega*), amphipods (*Boeckosimus affinis, Onisimus glacialis* and *Pontoporeia affinis*), cumaceans (*Diastylis sulcata*), mysids (*Mysis femorata* and *M. relicta*), isopods (*Mesidotea entomom*) and bivalves (*Macoma balthica, Cyrtodaria kurriana* and *Yoldiella intermedia*) (Percy et al. 1985, DFO 2008). Echinoderms are generally absent from this zone.

10.8.1.1.2 Transitional Zone

The transitional zone is characterized by water depths between 15 and 30 m with salinity levels fluctuating between 20 and 30 ‰ (Wacasey 1975). The benthic environment at these depths is affected by a high rate of ice scouring, which periodically disturbs local assemblages of benthic invertebrates (Percy et al. 1985). As a result, biomass is typically low in this zone (DFO 2008), although diversity is typically higher than the estuarine zone as it serves as a transitional area for many mobile invertebrates between the estuarine and marine zones. High species richness is also reported in this zone at about 15 m depth (DFO 2008). The bivalve *Portlandia arctica* is particularly abundant in areas where ice scouring rates are high (Conlan et al. 2008). Other common species in this zone include echinoderms, polychaetes (*Artacama proboscidea* and *Trochochaeta carica*) and isopods (*Mesidotea sibirica*) (Percy et al. 1985, DFO 2008).

10.8.1.1.3 Marine Zone

The marine zone is characterized by water depths ranging from 30 to 200 m where salinity fluctuations are minor, 30 to 33 ‰ (Wacasey 1975). The lack of fresh water influence and ice scouring events in this zone, as well as the wide range in water depth, results in higher productivity levels (biomass and diversity) in this zone than the estuarine and transitional zones. Common species include polychaetes (*Maldane sarsi, Aricidea suecica, Paraonis gracilis, Onuphis conchylega* and *Pectinaria hyperborea*), amphipods (*Haploops laevis*), isopods (*Mesidotea sabini*) and bivalves (*Astarte borealis, A. montagui, Macoma calcarea,* and *Macoma spp.*) (Percy 1985, DFO 2008). Other macrofauna observed within this zone include sea stars, octopus and squid.

10.8.1.1.4 Continental Slope Zone

The continental slope zone is characterized by water depths from 200 to 900 m where salinity levels range from 34 to 35 ‰ (Wacasey 1975). This zone supports a homogeneous physical environment marked by lower food availability because of weaker pelagic-benthic coupling than in shallower environments (Morata et al. 2008). Benthic productivity in this zone is variable. Epifaunal biomass is generally lower than in the marine zone while infaunal biomass is typically higher than in the marine zone (Robert et al. 2010). Both epifaunal and infaunal diversity are similar to that observed in the marine and transitional zones, and higher than that in the estuarine zone (DFO 2008). Many of the species occurring on the slope also inhabit the marine zone. However, several species are unique to this area, including the polychaetes *Onuphis quadricuspis* and *Laonice cirrata*, amphipods *Haploops tubicola* and *Hippomedon abyssi*, and the isopod *Gnathia stygia* (DFO 2008).

10.8.2 TRADITIONAL HARVEST

The community conservation plans indicate that edible crustaceans might be harvested along the coastline and the Mackenzie Delta shoreline between Aklavik and Tuktoyaktuk (Aklavik 2008, Inuvik 2008, Sachs Harbour 2008, Paulatuk 2008, Ulukhaktok 2008, Tuktoyaktuk 2008) but do not identify specific species or gathering locations. During interviews completed as part of the 2010 joint venture traditional knowledge study, Tuktoyaktuk participants indicated that crab is harvested (along with other fish species) and that harvesting locations include Tuktoyaktuk Harbour and along the shoreline (Golder 2011a).

10.9.1 PRINCIPAL HABITATS

The Canadian sector of the Beaufort Sea provides a diverse range of fish habitats for marine, freshwater and anadromous species (i.e., fish that travel from the sea up freshwater watercourses to spawn). Three principal habitats exist in the Beaufort Sea region, including:

- freshwater drainages
- nearshore coastal waters
- offshore marine waters

Freshwater streams and rivers, including the Mackenzie River, empty into the Beaufort Sea and are used by both freshwater and anadromous fish. The brackish, mixed waters along the nearshore coastal zone provide important habitat for both anadromous and marine fish. In the deeper offshore waters, varied assemblages of marine fish species can be found.

10.9.1.1 Presence, Distribution, Abundance and Habitat Use

Fish species presence, distribution, abundance and habitat use in the Canadian sector of the Beaufort Sea have been identified as important areas for ongoing research for environmental and social impact assessments (Kavik-Axys 2008, ArcticNet 2011, BREA 2012). According to varied lists compiled by Coad and Reist (2004), Cobb et al. (2008), the Working Group on General Status of NWT Species (2011) and Majewski et al. (2013), about 85 marine and anadromous fish species, consisting of 20 families are thought to occur in the Beaufort Sea LOMA. For a list of the common and scientific names of fish species present in the Beaufort Sea LOMA, see:

- Table 10-1, for anadromous and freshwater fish
- Table 10-2, for marine fish

Table 10-1: Scientific and Common Names of Anadromous and Freshwater Fish Species Present in the Beaufort Sea Large Ocean Management Area

Common Name	Scientific Name	COSEWIC Status	SARA Status
Lamprey	***Petromyzontidae***		
Arctic lamprey*	*Lethenteron camtschaticum**	—	—
Sucker	***Catostomidae***		
Longnose sucker	*Catostomus catostomus*	—	—
Pike	***Esocidae***		
Northern pike	*Esox Lucius*	—	—
Smelt	***Osmeridae***		
Pond smelt	*Hypomesus olidus*	—	—
Rainbow smelt	*Osmerus mordax mordax*	—	
Salmon and Whitefish	***Salmonidae***		
Arctic char	*Salvelinus alpinus*	—	—
Arctic cisco	*Coregonus autumnalis*	—	—
Arctic grayling	*Thymallus arcticus*	—	—
Bering cisco	*Coregonus laurettae*	Special concern (Yukon)	No status – no schedule
Broad whitefish	*Coregonus nasus*	—	—
Chinook salmon	*Oncorhynchus tshawytscha*	—	—
Chum salmon	*Oncorhynchus keta*	—	—
Cisco	*Coregonus artedi*	—	—
Coho salmon	*Oncorhynchus kisutch*	—	—
Dolly Varden	*Salvelinus malma malma*	Special concern	No status – no schedule
Inconnu	*Stenodus leucichthys*	—	—
Lake trout	*Salvelinus namaycush (brackish/freshwater)*	—	—
Lake whitefish	*Coregonus clupeaformis*	—	—
Least cisco	*Coregonus sardinella*	—	—
Pink salmon	*Oncorhynchus gorbuscha*	—	—
Round whitefish	*Prosopium cylindraceum*	—	—
Sockeye salmon	*Oncorhynchus nerka*	—	—
Cod/burbot	***Gadidae***		
Burbot	*Lota lota*	—	—
Stickleback	***Gasterosteidae***		
Nine-spined stickleback*	*Pungitius pungitius**	—	—
Three-spined stickleback	*Gasterosteus aculeatus*	—	—
Sculpin	***Cottidae***		
Slimy sculpin	*Cottus cognatus*	—	—
Spoonhead sculpin	*Cottus ricei*	—	—

Note:
Family names are in bold.
COSEWIC = Committee on the Status of Endangered Wildlife in Canada
SARA = *Species at Risk Act*
* = Larval fish
– = not listed

Table 10-2: Scientific and Common Names of Marine Fish Species Present in the Beaufort Sea Large Ocean Management Area

Common Name	Scientific Name	COSEWIC Status	SARA Status
Skate	***Rajidae***		
Arctic skate	*Amblyraja hyperborea*	—	—
Skates (unspecified)	*Bathyraja sp.*	—	—
Herring	***Clupeidae***		
Pacific herring*	*Clupea pallasii pallasii**	—	—
Smelt	***Osmeridae***		
Arctic cod*	*Boreogadus saida**	—	—
Capelin	*Mallotus villosus*	—	—
Cod	*Gadidae*		
Greenland cod	*Gadus ogac*	—	—
Saffron cod*	*Eleginus gracilis**	—	—
Sculpin	***Cottidae***		
Arctic hookear sculpin	*Artediellus uncinatus*	—	—
Arctic sculpin	*Myoxocephalus scorpioides*	—	—
Arctic staghorn sculpin*	*Gymnocanthus tricuspis**	—	—
Bigeye sculpin*	*Triglops nybelini**	—	—
Fourhorn sculpin*	*Myoxocephalus quadricornis**	Not at risk (salt water form)	No information in SARA list
Hamecon*	*Artediellus scaber**	—	—
Ribbed sculpin*	*Triglops pingelii**	—	—
Sculpin*	*Icelus sp.**	—	—
Shorthorn sculpin	*Myoxocephalus scorpius*	—	—
Spatulate sculpin	*Icelus spatula*	—	—
Twohorn sculpin	*Icelus bicornis*	—	—
Poacher	***Agonidae***		
Arctic alligatorfish*	*Ulcina olrikii**	—	—
Atlantic poacher*	*Leptagonus decagonus**	—	—
Lumpsucker	***Cyclopteridae***		
Atlantic spiny lumpsucker	*Eumicrotremus spinosus*	—	—
Leatherfin lumpsucker	*Eumicrotremus derjugini*	—	—
Snailfish	***Liparidae***		
Gelatinous snailfish*	*Liparis fabricii**	—	—
Greenland seasnail*	*Liparis tunicatus**	—	—
Sea tadpole	*Careproctus reinhardti*	—	—
Variegated snailfish	*Liparis gibbus*	—	—
Eelpout	***Zoarcidae***		
Archer eelpout	*Lycodes sagittarius*	—	—
Aurora pout	*Gymnelus retrodorsalis*	—	—
Canadian eelpout	*Lycodes polaris*	—	—
Eelpout*	*Lycodes sp.**	—	—
Glacial eelpout	*Lycodes frigidus*	—	—
Knipowitsch’s pout	*Gymnelus knipowitschi*	—	—
Longear eelpout	*Lycodes seminudus*	—	—
Saddled eelpout	*Lycodes mucosus*	—	—

Table 10-2: Scientific and Common Names of Marine Fish Species Present in the Beaufort Sea Large Ocean Management Area (cont'd)

Common Name	Scientific Name	COSEWIC Status	SARA Status
Eelpout (cont'd)	***Zoarcidae***		
Shulupaoluk	*Lycodes jugoricus*	—	—
Threespot eelpout	*Lycodes rossi*	—	—
Twolip pout	*Gymnelus viridis*	—	—
White sea eelpout	*Lycodes marisalbi*	—	—
Prickleback/Blenny	***Stichaeidae***		
Arctic shanny*	*Sticaeus punctatus punctatus**	—	—
Daubed shanny*	*Leptoclinus maculates**	—	—
Fourline snakeblenny	*Eumesogrammus praecisus*	—	—
Blackline prickleback Pighead prickleback	*Acantholumpenus mackayi*	Data deficient	Special concern – Schedule 3
Slender eelblenny*	*Lumpenus fabricii**	—	—
Stout eelblenny*	*Anisarchus medius**	—	—
Wolffish	***Anarhichadidae***		
Northern wolffish	*Anarhichas denticulatus*	Threatened	Threatened – Schedule 1
Sand lance	***Ammodytidae***		
Northern sand lance	*Ammodytes dubius*	—	—
Pacific sand lance	*Ammodytes hexapterus*	—	—
Sand lance*	*Ammodytes sp.**	—	—
Right-eyed flounder	***Pleuronectidae***		
Arctic flounder	*Pleuronectes glacialis*	—	—
Bering flounder	*Hippoglossoides robustus*	—	—
Greenland halibut	*Reinhardtius hippoglossoides*	—	—
Starry flounder*	*Platichthys stellatus**	—	—

Note:
Family names are in bold.
COSEWIC = Committee on the Status of Endangered Wildlife in Canada
SARA = *Species at Risk Act*
* = Larval fish
– = not listed

10.9.2 ANADROMOUS SPECIES

Brackish water habitats are found along the Yukon coast and Kugmallit Bay coast during summer (Carmack and Macdonald 2002, Cobb et al. 2008). These locations:

- support an important migration route for juvenile and adult anadromous fish species between the coastal lagoons and estuaries
- provide important nursery and feeding areas

This nearshore area has been characterized as an anadromous fish highway (Carmack and Macdonald 2002 - adapted from Gallaway et al. 1983, Loseto et al. 2010). Runs of anadromous fish species also extend east and west of the Mackenzie Delta during ice breakup and early spring, with fish returning to their natal rivers in the fall to overwinter in fresh water (LGL 1982, Cobb et al. 2008). Freshwater and anadromous fish species also use the northern portion of the Mackenzie Delta for feeding, spawning and rearing (LGL 1982).

The Mackenzie River and other Yukon North Slope Rivers discharge large volumes of fresh water into coastal areas of the southern Beaufort Sea, providing an influx of fresh water that creates low salinity habitats suitable for freshwater species, such as Arctic grayling, northern pike and round whitefish (LGL 1982). Arctic cisco, fourhorn sculpin and least cisco are among the most abundant fish species found along the nearshore area, with Dolly Varden and rainbow smelt also present in the area (Karasiuk et al. 1993, Cobb et al. 2008).

Seasonal changes in salinities influence fish assemblage along the coast. The open-water season is dominated by Dolly Varden, least cisco, broad whitefish, inconnu and other anadromous fish. During ice-cover periods, marine fish species dominate the area, including fourhorn sculpin, saffron cod and other marine species (Karasiuk et al. 1993, Cobb et al. 2008). Anadromous and freshwater fish species in the nearshore waters feed on the abundant small invertebrates and fishes living on or near the bottom substrates (Craig and Haldorson 1981).

Anadromous adult and large juvenile Dolly Varden migrate during the summer months to the coastal areas of the Beaufort Sea to feed (Cobb et al. 2008). Three and four-year-old Dolly Varden migrate and smolt in the estuaries of their natal streams, remaining at these locations during the summer, feeding and growing and following migration patterns along the coast (Sandstrom 1995). Local residents have reported that changes in the water and ocean currents along the Yukon North Slope coastline have resulted in Dolly Varden being found further offshore than in the past (Cobb et al. 2008).

10.9.2.1 Traditional Harvest

The following species are important to local Inuvialuit and Gwich'in harvesters, and are considered to be an important part of the food chain. They might also be considered as VECs:

- Arctic char
- Arctic cisco
- Bering cisco
- broad whitefish
- Dolly Varden
- inconnu
- lake whitefish
- least cisco
- rainbow smelt
- round whitefish

The Dolly Varden is of importance to both the local Inuvialuit and Gwich'in harvesters. Dolly Varden stocks have been declining throughout the Canadian Arctic and are an important management concern for the local communities

10.9.2.1 Traditional Harvest (cont'd)

and DFO. Integrated fisheries management plans and community-based plans are in place to help manage these stocks.

Subsistence fishing occurs all year along the Yukon North Slope coastal areas (especially in locations such as Shingle Point and Herschel Island) and Tuktoyaktuk. Commonly fished species include Dolly Varden, Arctic char, whitefish and Pacific herring (Aklavik 2008, Inuvik 2008, Sachs Harbour 2008, Paulatuk 2008, Ulukhaktok 2008, Tuktoyaktuk 2008). The joint venture traditional knowledge study conducted in 2010 also identified that traditional harvesting also takes place in Tuktoyaktuk Harbour and further north, overlapping the proposed marine resupply corridor to the EL areas.

10.9.3 MARINE SPECIES

There are about 50 species of marine fish in the Beaufort Sea, primarily shelf focused, with relatively few pelagic marine fish species and high benthic marine fish diversity (Majewski et al. 2013). Marine fish species presence in the deeper colder offshore area is known (see Table 10-1, shown previously). However, species distribution, abundance and habitat are not as clearly understood (Majewski et al. 2013). Skates, herring, smelt, sculpins, poachers, lumpfish, flounders, wolffish, sand lance, prickleback/blenny, lumpsucker snailfish and eelpout are found throughout the LOMA.

Cod (*Gadidae spp.*), snailfish (*Liparidae spp.*) and sculpin (*Cottidae spp.*) are among the most frequently reported marine fish collected from the western Beaufort Sea and Canadian High Arctic (Cobb et al. 2008). Similar to anadromous species, marine fish species also use nearshore coastal habitat for feeding during the summer (Bond 1982, Lawrence et al. 1984, Anderson Resources Ltd. 2001). Many marine fish species, such as Arctic cod and snailfish, are dependent on the influx of cold saltwater into the brackish coastal waters nearshore. Other marine species of fish can be found with relative consistency in coastal habitats including fourhorn sculpin and Arctic flounder (Bond 1982, Lawrence et al. 1984).

Pelagic marine fish, especially Arctic cod, are an important food source for marine mammals and birds in the Beaufort Sea ecosystem (Dome et al. 1982, Craig et al. 1982, Cobb et al. 2008). It is generally accepted that additional research is required to fully understand seasonal migrations, populations and distributions of Arctic cod and other marine fish species in the Canadian Arctic. Arctic cod are the most abundant pelagic fish species over the shelf and slope of the Canadian sector of the Beaufort Sea (Geoffroy et al. 2011). Recent studies (Geoffroy et al. 2011 and 2013) have reported aggregations of adult Arctic cod over the slope during fall and winter. During the ice-free season, Arctic cod (+1 year age class) are also distributed over the slope. There are clear segregations between young-of-the-year Arctic cod (less than 100 m depth) and age 1+ Arctic cod (greater than 200 m depth) (Geoffroy et al. 2011 and 2013). Age 1+ Arctic cod are present over the entire continental slope (1,400 to 9,200 m depths) as well as possibly even further offshore (Geoffroy et al. 2011 and 2013).

A higher biomass of Arctic cod was observed at bottom depths of 350 and 1000 m. Within the EL areas, young-of-the-year and adult Arctic cod were shown to have overlapping distributions (Geoffroy et al. 2011 and 2013).

Anadromous fish species make up the most of the local subsistence fisheries as compared to marine species (Bond 1982, Geoffroy et al. 2012). Marine fish species considered as VECs for the program for biological and ecological reasons include:

- Arctic cod
- Arctic flounder (abundant in nearshore coastal waters)
- blackline prickleback (noted as a marine benthic fish of uncertain status with potential vulnerability to disturbance)
- fourhorn sculpin
- northern wolffish (Schedule 1 SARA listing as threatened)
- Pacific herring
- starry flounder (abundant in nearshore coastal waters)

Marine fish species are harvested less in subsistence fisheries than the anadromous fish species (Bond 1982, Geoffroy et al. 2012).

10.9.4 HEARING ABILITY

All fish species can hear with varying degrees of sensitivity within the frequency range of sound produced by seismic sources and other industrial sound sources (Popper and Fay 1973, Fay 1988, Popper and Fay 1993, Fay and Popper 2000). Fish use sound for communication, to detect predators and prey and to learn about their environment (Popper and Fay 1999, Zelick et al. 1999, Fay and Popper 2000, Popper et al. 2003). The hearing range for most fish is believed to be in the frequency range of 100 to 1,000 Hz (Fay 1988). Behavioural responses and the susceptibility of fish to auditory trauma can vary. This is attributed to wide differences in hearing capability and morphologies among fish species (Popper and Fay 1993).

Fish can be divided into two broad categories (Popper et al. 2003, Ladich and Popper 2004):

- hearing generalists
- hearing specialists

10.9.4.1 Hearing Generalist Fish Species

Hearing generalists are fish species without any auditory system specializations. They have relatively poor auditory sensitivity characterized by a narrow bandwidth of hearing. Typically they can detect sounds from below 50 Hz up

10.9.4.1 Hearing Generalist Fish Species (cont'd)

to 1 or 1.5 kHz. Hearing generalist fish species include most bottom-dwelling species (Popper et al. 2003). Most fish species that fall into this category generally do not hear frequencies much above 1 kHz, with peak sensitivities around 300 to 500 Hz (Ladich and Popper 2004).

10.9.4.2 Hearing Specialist Fish Species

Hearing specialists have morphological adaptations that allow them to detect sound pressure with greater sensitivity (i.e., lowering their hearing threshold) and in a wider bandwidth than hearing generalist species. This makes hearing specialist species more sensitive to high-amplitude sound introduced into the marine environment (Popper and Fay 1993). Polar cod and Arctic cod are both hearing specialist species and are likely to be present in the program area. Cod fish can detect both sound acceleration and sound pressure over a substantial frequency range (e.g., 20 to 150 kHz). Sound pressure thresholds in cod fish are in the frequency range of 60 to 300 Hz and lie in the range of 80 to 90 dB re 1 µPa.

10.10.1 OVERVIEW

The Mackenzie River Delta and Beaufort Sea marine ecosystem provide important resources to resident and migrant marine birds throughout the year. Salter et al. (1980) documented 122 bird species using the Arctic Coastal Plain, including those that use the following habitats:

- offshore
- inshore
- intertidal
- salt marsh

These species can be categorized as:

- passerines (including corvids and ptarmigan, 40 species)
- raptors (including owls, 13 species)
- seabirds (29 species)
- shorebirds (24 species)
- waterfowl (16 species)

For the purposes of this PD, seabirds are considered those that feed in salt water and waterfowl are confined to those that feed primarily or exclusively in fresh water (e.g., most ducks and geese).

10.10.2 YEAR-ROUND SPECIES

Of these 122 species, only four are considered year-round residents (Salter et al. 1980):

- common raven (*Corvus corax*)
- gyrfalcon (*Falco rusticolus*)
- snowy owl (*Nyctea scandiaca*)
- willow ptarmigan (*Lagopus lagopus*)

10.10.3 MIGRATORY SPECIES

Most bird species use these locations during the summer for staging, moulting, nesting and brooding purposes (see Figure 10-8) before migrating to their traditional southerly wintering grounds, many of which are outside the ISR (e.g., Arctic terns).

For an overview of key migratory bird habitats in the southern Beaufort Sea region, see Figure 10-9. Figure 10-10 shows the offshore migratory bird sensitivity mapping for the region, as adapted from AECOM.

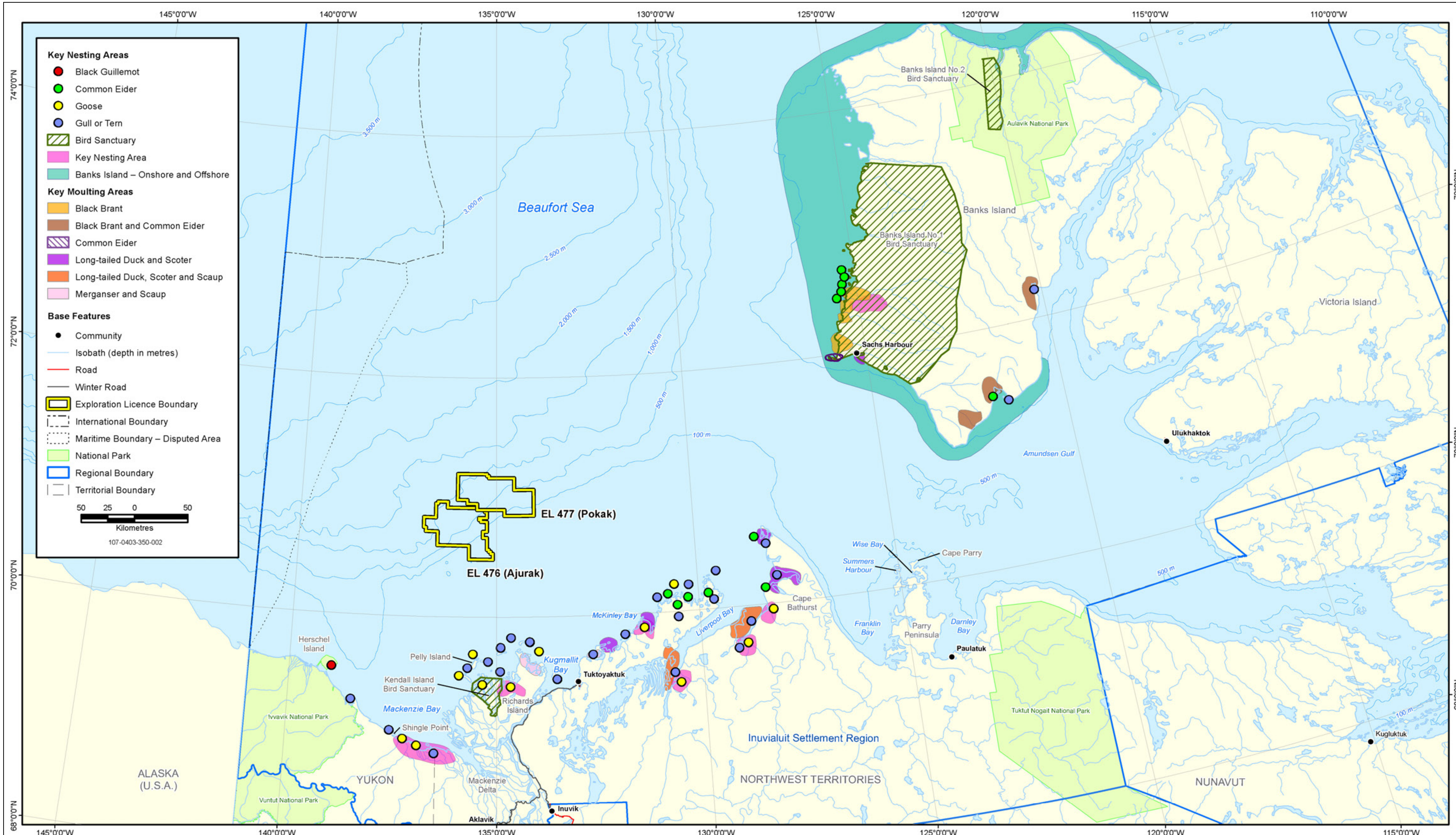


Figure 10-8: Overview of Key Nesting and Moulting Areas for Marine Avifauna in the Southern Beaufort Sea Region

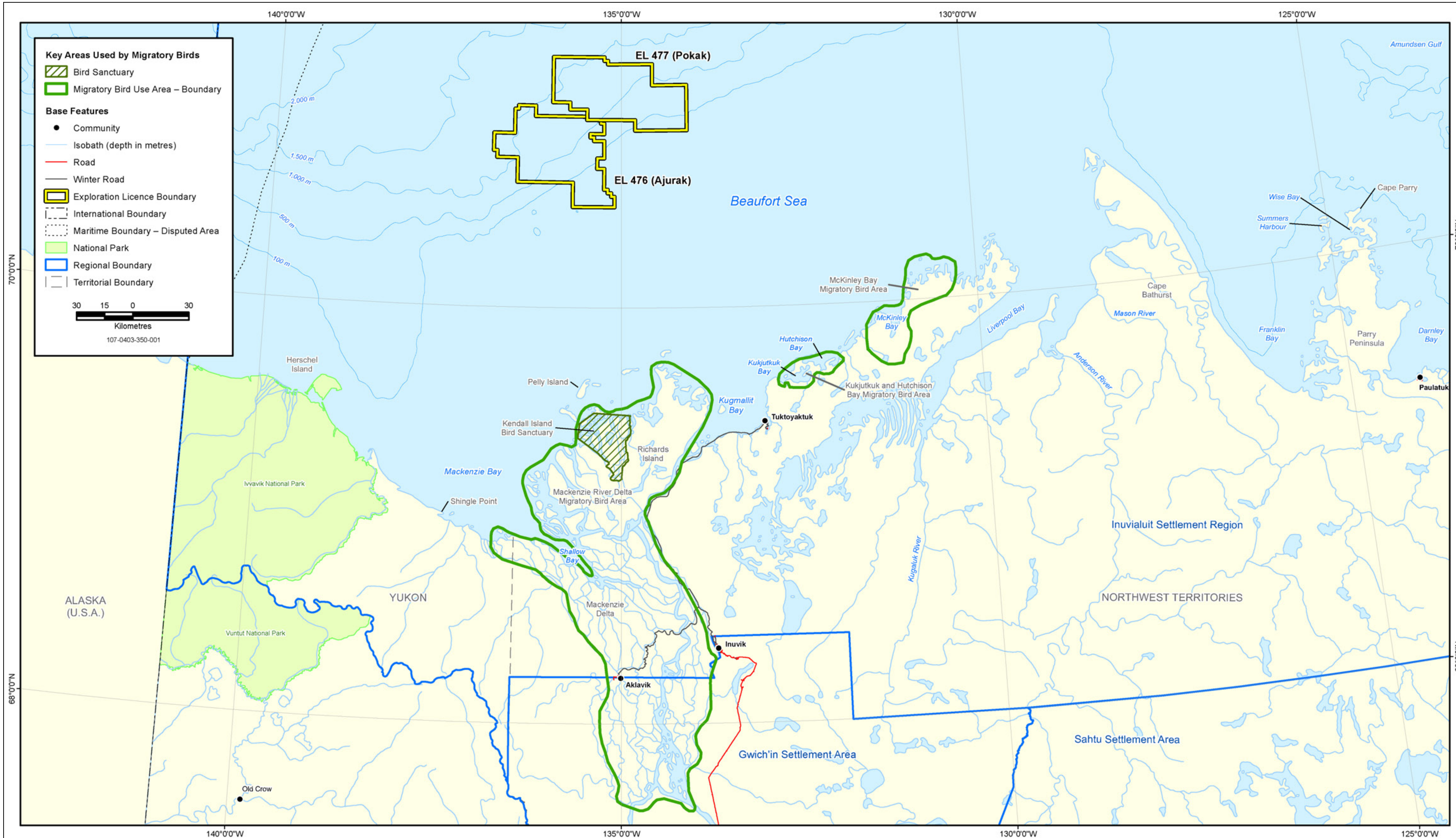


Figure 10-9: Overview of Key Areas Used by Migratory Birds in the Southern Beaufort Sea Region

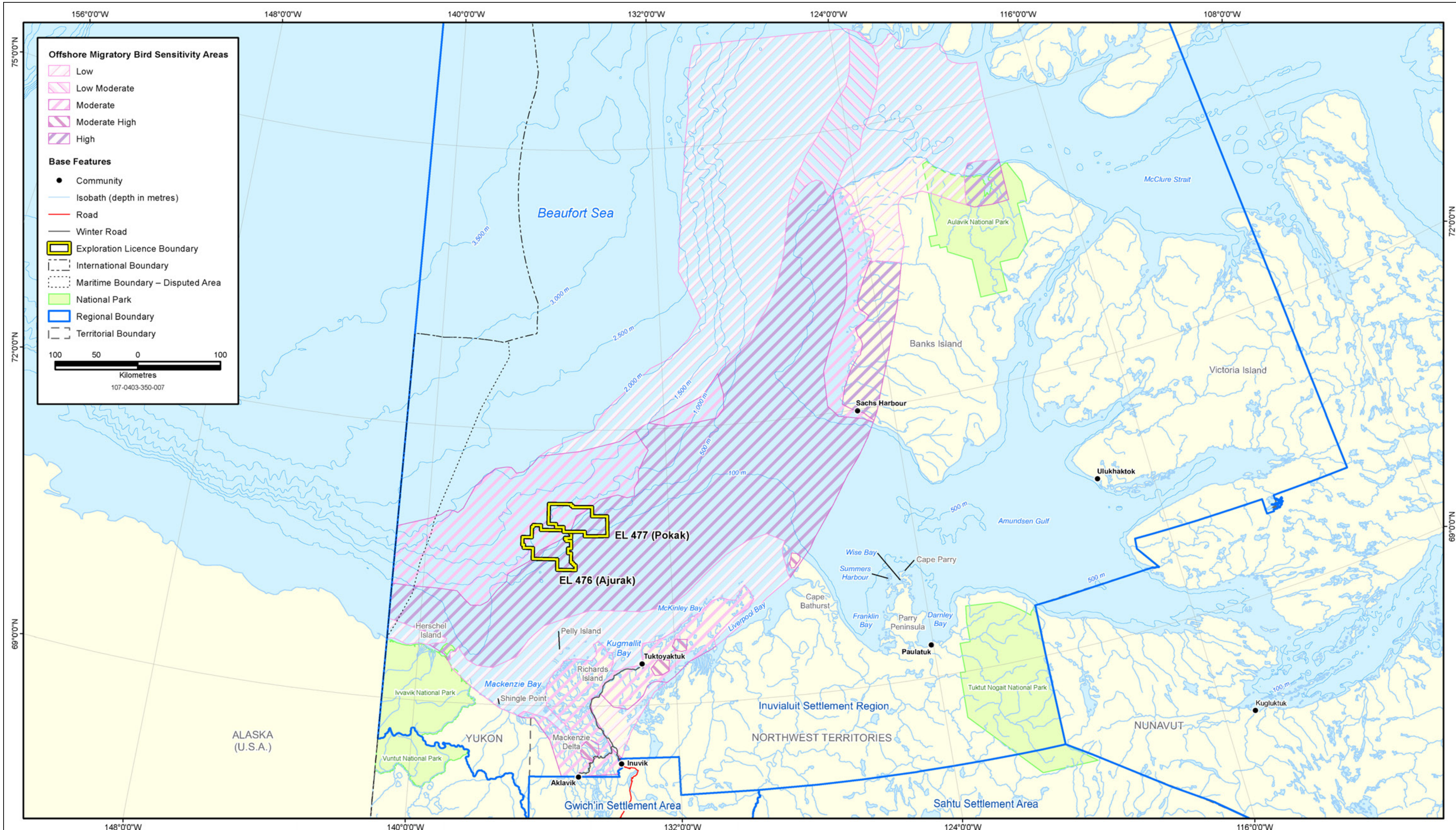


Figure 10-10: Offshore Migratory Bird Sensitivity Areas for the Beaufort Sea Region

10.10.4 MARINE AVIFAUNA SPECIES, DISTRIBUTION AND STATUS

Table 10-3 is a comprehensive list of marine avifauna species present in the Beaufort Sea and Mackenzie Delta ecosystem. This table provides detailed information for:

- seabirds
- waterfowl
- shorebirds
- raptors

Table 10-3: Marine Avifauna Species Present in the Southern Beaufort Sea and Mackenzie Delta Ecosystem

Common Name	Species	Seasonal Occurrence	Distribution	Other Relevant Information	COSEWIC Status	SARA Status
Seabirds						
Arctic loon	*Gavia arctica*	Summer	Coastal	Migratory species	Not assessed	No status
Arctic tern	*Sterna paradisaea*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Black guillemot	*Cepphus grylle*	Year-round	Coastal/offshore		Not assessed	No status
Black-legged kittiwake	*Rissa tridactyla*	Summer	Coastal/offshore		Not assessed	No status
Black scoter	*Melanitta americana*	Summer	Coastal	Migratory species	Not assessed	No status
Bonaparte's gull	*Chroicocephalus philadelphia*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Brant	*Branta bernicla*	April to October	Coastal	Migratory species	Not assessed	No status
Common eider	*Somateria mollissima*	Year-round	Coastal/offshore		Not assessed	No status
Common loon	*Gavia immer*	Summer	Coastal	Migratory species	Not at risk	No status
Glaucous gull	*Larus hyperboreus*	Summer	Coastal/offshore		Not assessed	No status
Harlequin duck	*Histrionicus histrionicus*	Summer	Coastal	Migratory species	Special concern	Special concern Schedule 1
Herring gull	*Larus argentatus*	April to November	Coastal/offshore	Migratory species	Not assessed	No status
Iceland gull	*Larus glaucoides*	Year-round	Coastal/offshore		Not assessed	No status
Ivory gull	*Pagophila eburnea*	Year-round	Coastal/offshore		Endangered	Endangered Schedule 1
King eider	*Somateria spectabilis*	Year-round	Coastal		Not assessed	No status
Little gull	*Larus minutus*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Long-tailed duck	*Clangula hyemalis*	May to October	Coastal		Not assessed	No status
Long-tailed jaeger	*Stercorarius longicaudus*	Summer	Coastal/offshore	Migratory species. Breeds along the coast.	Not assessed	No status
Mew gull	*Larus canus*	Year-round	Coastal/offshore		Not assessed	No status

Table 10-3: Marine Avifauna Species Present in the Southern Beaufort Sea and Mackenzie Delta Ecosystem (cont'd)

Common Name	Species	Seasonal Occurrence	Distribution	Other Relevant Information	COSEWIC Status	SARA Status
Seabirds (cont'd)						
Murre	*Uria sp.*	Summer	Coastal/offshore		Not assessed	No status
Northern fulmar	*Fulmarus glacialis*	Summer and fall	Coastal/offshore		Not assessed	No status
Pacific loon	*Gavia pacifica*	Summer	Coastal	Migratory species. Arctic-breeding species. Common and numerous along the mainland and island coasts.	Not assessed	No status
Parasitic jaeger	*Stercorarius parasiticus*	Summer	Coastal/offshore	Migratory species. Breeds along the coast and nearshore islands.	Not assessed	No status
Pomarine jaeger	*Stercorarius pomarinus*	Summer	Coastal/offshore	Migratory species. Breeds along the coast.	Not assessed	No status
Red-breasted merganser	*Mergus serrator*	Summer	Coastal	Migratory species. Males and non-breeding birds frequent coastal marine waters.	Not assessed	No status
Red-throated loon	*Gavia stellata*	Summer	Coastal	Migratory species. Arctic-breeding species. Common and numerous along the mainland and island coasts.	Not assessed	No status
Sabine's gull	*Xema sabini*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Surf scoter	*Melanitta perspicillata*	Summer	Coastal	Migratory species	Not assessed	No status
Thayer's gull	*Larus thayeri*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
White-winged scoter	*Melanitta deglandi*	Summer	Coastal	Migratory species	Not assessed	No status
Yellow-billed loon	*Gavia adamsii*	Summer	Coastal/offshore	Migratory species	Not at risk	No status
Waterfowl						
American wigeon	*Anas americana*	Summer	Coastal	Migratory species	Not assessed	No status
Barrow's goldeneye	*Bucephala islandica*	Summer	Coastal/offshore	Migratory species	Special concern	Special concern Schedule 1
Canada goose	*Branta canadensis*	Summer and fall	Coastal	Breeds in large numbers along the coasts and on nearshore islands.	Not assessed	No status
Canvasback	*Aythya valisineria*	Summer	Coastal	Migratory species	Not assessed	No status
Common goldeneye	*Bucephala clangula*	Summer	Coastal	Migratory species	Not assessed	No status
Greater scaup	*Aythya marila*	Summer	Coastal	Migratory species	Not assessed	No status

Table 10-3: Marine Avifauna Species Present in the Southern Beaufort Sea and Mackenzie Delta Ecosystem (cont'd)

Common Name	Species	Seasonal Occurrence	Distribution	Other Relevant Information	COSEWIC Status	SARA Status
Waterfowl (cont'd)						
Greater white-fronted goose	*Anser albifrons*	Summer	Coastal	Migratory species	Not assessed	No status
Green-winged teal	*Anas crecca*	Summer	Coastal	Migratory species	Not assessed	No status
Horned grebe	*Podiceps auritus*	Summer	Coastal	Migratory species. Breeds on freshwater lakes and ponds across western boreal forest.	Special concern (2009) – western population	No status
Lesser scaup	*Aythya affinis*	Summer	Coastal	Migratory species	Not assessed	No status
Mallard	*Anas platyrhynchos*	Summer	Coastal	Migratory species	Not assessed	No status
Northern pintail	*Anas acuta*	Summer	Coastal	Migratory species	Not assessed	No status
Northern shoveler	*Anas clypeata*	Summer	Coastal	Migratory species	Not assessed	No status
Red-necked grebe	*Podiceps grisegena*	Summer	Coastal	Migratory species. Breeds on freshwater lakes and ponds across western boreal forest.	Not at risk	No status
Snow goose	*Chen caerulescens*	May to September	Coastal	Migratory species. Breeding colonies occur along the coasts.	Not assessed	No status
Whistling swan	*Olor colombianus*	Summer	Coastal	Migratory species	Not assessed	No status
Shorebirds						
American golden plover	*Pluvialis dominica*	Summer	Coastal	Migratory species	Not assessed	No status
Baird's sandpiper	*Calidris bairdii*	Summer	Coastal	Migratory species	Not assessed	No status
Black-bellied plover	*Pluvialis squatarola*	Summer	Coastal	Migratory species	Not assessed	No status
Buff-breasted sandpiper	*Tryngites subruficollis*	Summer	Coastal/offshore	Migratory species	Special concern (2012)	No status – no schedule
Common snipe	*Capella gallinago*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Dunlin	*Calidris alpina*	Summer	Coastal	Migratory species	Not assessed	No status
Hudsonian godwit	*Limosa haemastica*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Killdeer	*Charadrius vociferus*	Summer	Coastal	Migratory species	Not assessed	No status
Least sandpiper	*Calidris minutilla*	Summer	Coastal	Migratory species	Not assessed	No status
Lesser yellowlegs	*Tringa flavipes*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Long-billed dowitcher	*Limnodromus scolopaceus*	Summer	Coastal/offshore	Migratory species	Not assessed	No status

Table 10-3: Marine Avifauna Species Present in the Southern Beaufort Sea and Mackenzie Delta Ecosystem (cont'd)

Common Name	Species	Seasonal Occurrence	Distribution	Other Relevant Information	COSEWIC Status	SARA Status
Shorebirds (cont'd)						
Northern phalarope	*Lobipes lobatus*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Pectoral sandpiper	*Calidris melanotos*	Summer	Coastal	Migratory species	Not assessed	No status
Red knot	*Calidris canutus*	Summer	Coastal	Migratory species	Endangered *(rufa spp.)* Special concern *(islandica spp.)*	No status
Red phalarope	*Phalaropus fulicarius*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Ruddy turnstone	*Arenaria interpres*	Summer	Coastal	Migratory species	Not assessed	No status
Sanderling	*Calidris alba*	Spring and summer	Coastal	Migratory species	Not assessed	No status
Sandhill crane	*Grus Canadensis*	Summer	Coastal	Migratory species	Not assessed	No status
Semi-palmated plover	*Charadrius semipalmatus*	Summer	Coastal	Migratory species	Not assessed	No status
Semi-palmated sandpiper	*Calidris pusilla*	Summer	Coastal	Migratory species	Not assessed	No status
Spotted sandpiper	*Actitis macularius*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Stilt sandpiper	*Calidris himantopus*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
Whimbrel	*Numenius phaeopus*	Summer	Coastal/offshore	Migratory species	Not assessed	No status
White-rumped sandpiper	*Calidris fuscicollis*	Summer	Coastal	Migratory species	Not assessed	No status
Raptors						
Peregrine falcon	*Falco peregrinus tundrius*	Summer	Coastal	Breeds and hunts along the coasts.	Special concern	No status
Snowy owl	*Bubo scandiacus*	Summer	Coastal	Breeds and forages along the coasts.	Not at risk	No status

Note: List adapted from Salter et al. 1980. Year of COSEWIC status assessment indicated in brackets.
COSEWIC = Committee on the Status of Endangered Wildlife in Canada
SARA = *Species at Risk Act*

10.10.5 SEABIRDS

In the spring, leads of open water in the southeastern Beaufort Sea are used by large numbers of seabirds. The most commonly observed species being (Frame 1973, Dickson and Gilchrist 2002):

- black-legged kittiwake

- common eider
- glaucous gull
- king eider
- long-tailed duck
- Pacific loon
- parasitic jaeger
- pomarine jaeger
- red-throated loon
- Sabine’s gull
- surf scoter
- white-winged scoter
- yellow-billed loon

Spring migration occurs in May, peaking through late May to mid-June (Richardson and Johnson 1981, Dickson and Gilchrist 2002). Seabirds are likely to be present in the program area during May, June and intermittently through the remainder of the open-water season.

Common eider tend to concentrate in shallow water (less than 20 m deep) along the Tuktoyaktuk Peninsula, Cape Bathurst, and Dolphin and Union Strait, while king eider often stage in deeper waters (up to 50 m deep) off of Banks Island (Dickson and Gilchrist 2002). Long-tailed ducks feed within the water column, on bottom substrate, and on the undersurface of sea ice. They are not limited by water depth and are generally found in largest numbers in deeper water (Alexander et al. 1997). Gulls, kittiwakes, jaegers and terns can be found up to 750 km from the shore among the pack ice (Harwood et al. 2005) although their abundance is generally correlated inversely with distance from land (Frame 1973). Overall, sea duck abundance is highest off of Cape Bathurst, with lower numbers reported off the Mackenzie Delta (Dickson and Gilchrist 2002). The distribution of birds at sea is often associated with subsurface features, such as canyons, ridges and shelf breaks (Harwood et al. 2005).

By mid-June, most of the sea ducks that staged in the Beaufort Sea have dispersed to nest inland or to the east in the Central Arctic (Dickson and Gilchrist 2002). During the summer, the males, immatures and non-breeding females of several species (e.g., surf scoter, white-winged scoter, long-tailed duck, scaup, and red-breasted merganser) migrate to the southern Beaufort Sea (Johnson and Richardson 1982, Dickson and Gilchrist 2002). Sheltered coastal waters behind barrier beaches and spits, particularly around Herschel Island, are used throughout July and early August (Johnson and Richardson 1982). The Mackenzie Delta is not used by moulting sea ducks, presumably because of the turbid water impedes foraging during a time when they are unable to fly and seek out better food resources (Dickson and Gilchrist 2002).

In the fall, following summer brood rearing, moulting and feeding in the highly productive polar waters, birds begin their migratory movements out of the area, including seabirds, such as the long-tailed duck, scoters, eiders, Brant, glaucous gulls, red-breasted merganser, scaup, Pacific loons and red-throated loons (Dickson and Gilchrist 2002).

10.10.5 SEABIRDS (cont'd)

Between 2008 and 2011, about 350 hours of vessel-based marine avifaunal surveys were conducted in the program area, identifying a total of 31 bird species, including the SARA-listed ivory gull (Schedule 1, endangered). The most commonly observed birds during the surveys were glaucous gulls, black-legged kittiwakes, eider, loons, gulls (unidentified species) and waterfowl (unidentified species).

Populations of some seabird species, including common eider, king eider, long-tailed duck, surf scoter and white-winged scoter have all declined by about 50% between the 1970s and 1996 (Suydam et al. 2000, Dickson and Gilchrist 2002). Because the status of most of the marine bird species in the Beaufort Sea region is not routinely monitored, population trends for most species are uncertain (Dickson and Gilchrist 2002).

10.10.6 WATERFOWL

Waterfowl species primarily use freshwater lakes, ponds and rivers for feeding, nesting and rearing. Therefore, they are less likely to be directly affected by marine development. Some species (e.g., scaup and goldeneye) might use nearshore marine waters, but are considered predominately a freshwater species. In contrast to sea ducks and Brant, several waterfowl species that primarily inhabit fresh water in the Beaufort Sea region are not known to be in decline (Dickson and Gilchrist 2002).

10.10.7 SHOREBIRDS

Shorebirds use shallow coastal water and intertidal areas for feeding, and coastal areas above high tide for nesting.

10.10.8 ECOLOGICALLY AND BIOLOGICALLY SIGNIFICANT AREAS

The Beaufort Sea coastline is a major corridor for birds migrating easterly from the Bering and Chukchi Sea, and westward from the Central Arctic, during May and June (Barry 1976, Salter et al. 1980) (see Figure 10-9, shown previously). In particular, the area between Herschel Island and Tuktoyaktuk is used as a stopover by shorebirds (Gudmondsson et al. 2002). The barrier beaches and spits in this area provide critical protected waters for moulting seabirds (Johnson and Richardson 1982) and are also a major staging area for phalaropes, i.e., small wading birds (Dickson and Gilchrist 2002). Open-water leads and polynyas are important to migrating birds during spring because they provide access to potential foraging areas.

Alexander et al. (1988) compiled a series of maps that included both temporal and spatial resolution and identified bird use of coastal areas of the Beaufort Sea. The maps identify areas along the Tuktoyaktuk Peninsula considered important habitat locations because large numbers of birds congregate at these sites:

- six areas in early June to mid-July
- 11 areas in mid-July to mid-August
- 11 areas in mid-August to late September

The maps also identified various locations of important bird use within the Mackenzie Delta and along the coast toward the Yukon boundary. Similarly, Latour et al. (2008) identified important migratory bird terrestrial habitat sites, which include the areas of:

- the Lower Anderson River and Mason River
- the Kugaluk River
- McKinley Bay – Phillips Island
- Kukjutkuk Bay and Hutchison Bay

There are two small breeding bird colonies in the southeast Beaufort Sea, one of about 800 thick-billed murres (*Uria lomvia*) at Cape Parry and a second of about 100 black guillemots on Herschel Island (Dickson and Gilchrist 2002) (see Figure 10-9, shown previously).

Areas of higher sensitivity for marine avifauna during the open-water season are illustrated in Figure 10-10, shown previously. These areas are representative of key life stage areas, feeding areas, as well as movement and migratory corridors necessary for year-over-year survival (AECOM 2010).

10.10.9 TRADITIONAL HARVEST

The 2010 joint venture traditional knowledge study identified that ducks, ptarmigan and, especially, geese are hunted in the spring and summer months (May until late September) between Aklavik and Tuktoyaktuk. Hunting seasons vary by community, with most activity occurring during August and September (Aklavik 2008, Inuvik 2008, Sachs Harbour 2008, Paulatuk 2008, Ulukhaktok 2008, Tuktoyaktuk 2008, Golder 2011). In Ulukhaktok and Paulatuk, hunting season begins considerably earlier in May (Paulatuk, 2008, Ulukhaktok, 2008). While birds can be hunted along the entire coast, the Mackenzie Delta, Mackenzie Bay and Shallow Bay are particularly popular hunting grounds for all communities. Birds also provide communities with a source of eggs. Typically, eggs are gathered in the spring and early summer (Aklavik 2008, Inuvik 2008, Sachs Harbour 2008, Paulatuk 2008, Ulukhaktok 2008, Tuktoyaktuk 2008).

10.11.1 OVERVIEW

There are six species of marine mammals that have the potential to be present within the program area for variable periods of time and at different times throughout the year (see Table 10-4). This includes:

- three species of cetaceans:
  - two types of toothed whales
  - one type of baleen whale
- two species of pinnipeds (seals)
- polar bears

Table 10-4: Overview of Marine Mammal Species Potentially Occurring within the Program Area

Common Name	Species	Seasonal Occurrence	Habitat	COSEWIC Status	SARA Status
Ringed seal	*Phoca hispida*	Year-round	Landfast ice and pack ice	Not at risk	No status – no schedule
Bearded seal	*Erignathus barbatus*	Year-round	Pack ice	Data deficient	No status – no schedule
Polar bear	*Ursus maritimus*	Year-round	Spring: landfast ice Summer: pack ice Winter: landfast ice and coastal areas for denning	Special concern	Special concern Schedule 1
Beluga whale, eastern Beaufort Sea population	*Delphinapterus leucas*	Winter (November to May)	Spring: ice edges and leads Summer: shallow coastal areas Fall: deep water (foraging) Winter: offshore pack ice (Hudson Strait)	Not at risk	No status – no schedule
Bowhead whale	*Balaena mysticetus*	Winter (February to June)	Spring: along ice edge Summer: open water and pack ice Winter: heavy pack ice	Special concern	No status – no schedule
Killer whale	*Orcinus orca*	June to August	Coastal and offshore	Endangered	No status – no schedule
Note: COSEWIC = Committee on the Status of Endangered Wildlife in Canada SARA = *Species at Risk Act*					

The largest stock of beluga whales (*Delphinapterus leucas*) in the world, and a large population of bowhead whales (*Balaena mysticetus*) are known to regularly inhabit the EL areas during the late spring, summer and early fall season. Ringed

10.11.1 OVERVIEW (cont'd)

seals (*Phoca hispida*) are year-round residents to the Beaufort Sea region. Polar bears can also be found in the program area, entering the pack ice in early November after their denning season. Other marine mammals are seasonal visitors, limited by the presence of landfast ice throughout the winter and spring. There is a geographical distribution bias for several species. For example, beluga whales are strongly associated with the southwest Beaufort Sea region in association with the Mackenzie River estuary. For a summary of marine mammal species harvested throughout the year by Inuvialuit communities in the ISR, see Table 10-5.

Table 10-5: Marine Mammal Species Harvested Throughout the Year by Inuvialuit Communities in the ISR

Target Species	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Ringed seal	–	x	x	x	x	x	x	x	x	x	x	x
Bearded seal	–	x	x	x	x	x	x	x	x	x	x	x
Beluga whale	–	–	–	–	–	x	x	x	x	–	–	–
Bowhead whale	Generally are no longer harvested in the ISR. Residents of Tuktoyaktuk, Ulukhaktok, and Sachs Harbour noted during the 2010 joint venture traditional knowledge study that bowhead whales are harvested in Alaska and in the Canadian eastern Arctic.											
Polar bear	x	x	x	x	x	–	–	–	–	–	–	x
X = harvesting information specific to Tuktoyaktuk Source: REF (Aklavik 2008, Ulukhaktok 2008, Sachs Harbour 2008, Paulatuk 2008, Inuvik 2008, Tuktoyaktuk 2008)												

10.11.2 BELUGA WHALE

10.11.2.1 Population Trend and Conservation Status

The eastern Beaufort Sea population of beluga whales (*Delphinapterus leucas*) is listed as not at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (COSEWIC 2004) and is not listed under the *Species at Risk Act* (SARA) and the US *Endangered Species Act*. This population is considered a non-strategic stock by the National Oceanic and Atmospheric Administration (Allen and Angliss 2011a). Duval (1993) reported an estimate of 21,000 beluga whales for the Beaufort Sea stock, similar to that reported by Burns and Seaman (1985). An aerial survey conducted in July 1992 estimated 19,629 beluga whales in the eastern Beaufort Sea (Harwood et al. 1996). A correction factor has been recommended for the Beaufort Sea beluga whale stock, resulting in a population estimate of 39,258 animals (Duval 1993). Annual monitoring studies conducted in the Beaufort Sea region do not indicate any significant changes in abundance (COSEWIC 2004).

10.11.2.2 Seasonal Distribution and Movement

Beluga whales winter in the Bering Sea and migrate into the Beaufort Sea in the spring of each year, passing Point Barrow, Alaska, in late March to early April (Norton and Harwood 1986, LGL and Greenridge 1996). They typically enter the Canadian sector of the Beaufort Sea in May to June (Fraker 1979), depending on ice and meteorological conditions. Beluga whale migration follows leads across the Beaufort Sea from about Point Barrow to Banks Island, with some migrating animals observed as far as 77°N (Fraker 1979, Norton and Harwood 1986). Later in the early summer, migrating individuals move along a more southerly route as the ice breaks up further south (Fraker 1979). Beluga whales migrate south at Banks Island and proceed to the Amundsen Gulf, where they spend four to six weeks before moving on to the Mackenzie River estuary in late June (Fraker 1979, Norton and Harwood 1986). For seasonal movements and concentrations of beluga whales, see Figure 10-11.

Beluga whales are common in the Mackenzie River estuary throughout the summer season, including waters near Tuktoyaktuk and the EL areas (Moore et al. 2002, Harwood and Smith 2002). They then move southwestward along the landfast ice edge off the Tuktoyaktuk Peninsula into Kugmallit Bay, East and West Mackenzie Bays, Shallow Bay and the Kendall Island area where they congregate for much of July (Harwood and Smith 2002) for feeding and calving (AECOM 2010). These areas are presumed to be of importance to beluga whales because they return to these areas each summer despite significant hunting pressures (North/South Consultants Inc. 2003). Figure 10-12 also shows the Beaufort Sea beluga whale management zones.

In late July, beluga whales begin moving further offshore or into Amundsen Gulf (Harwood et al. 1996). In September they migrate back to wintering areas in the Bering Sea. During fall, the migratory route is farther offshore (greater than 60 km) (LGL and Greenridge 1996), although there is evidence that they might also travel close to shore along the continental shelf and slope (Richard et al. 2001).

There can be considerable variation within the general migratory patterns. Most beluga whales can be found offshore rather than in the Mackenzie River estuary (Norton and Harwood 1986, Harwood et al. 1996, LGL and Greenridge 1996). Radiotelemetry studies have shown that beluga whales use the Mackenzie River estuary only intermittently (Richard et al. 2001).

Aerial surveys conducted in 1996 reported that beluga whale distribution during July was concentrated in four offshore areas (Harwood et al. 1996):

- 10 to 30 km northwest of west Mackenzie Bay
- within 5 to 10 km of the Tuktoyaktuk Peninsula, Baillie Island, and the mouth of the Horton River
- 50 to 80 km off Cape Bathurst in the area where the Bathurst polynya often recurs in winter
- in the central Amundsen Gulf

Although these areas do not overlap with boundaries of the EL areas, other proposed activities (e.g., vessel movements between the drill site and Tuktoyaktuk Harbour) will likely overlap with one or more of these areas during the proposed program.

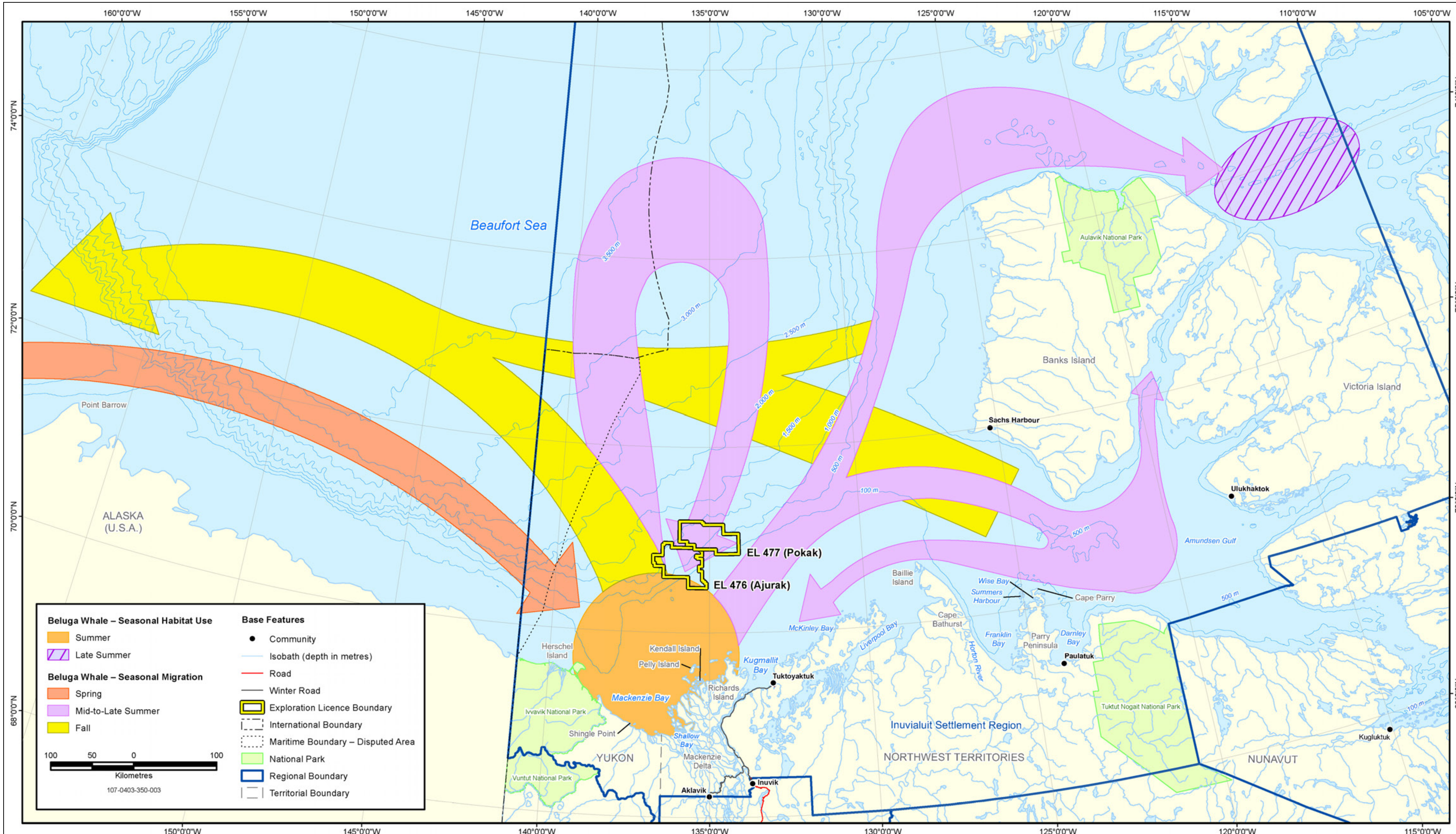


Figure 10-11: Beluga Whale Seasonal Movements and Concentration Areas in the Beaufort Sea

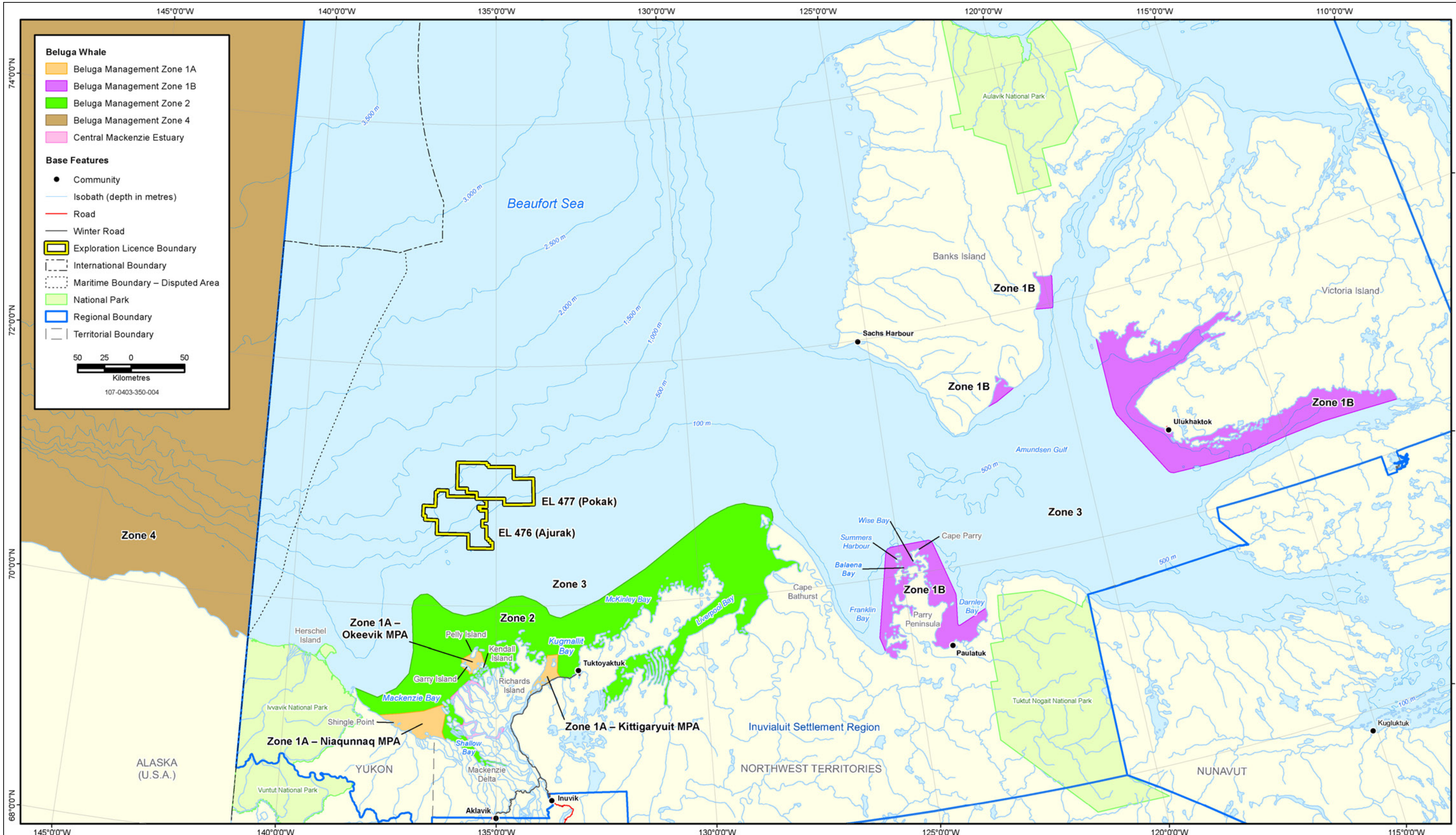


Figure 10-12: Beluga Whale Management Zones in the Beaufort Sea

10.11.2.2 Seasonal Distribution and Movement (cont'd)

Between 2008 and 2011, several vessel-based and aerial-based marine mammal surveys were conducted in the program area during the open-water season as part of the FDCPs. During the surveys, beluga whale sightings were recorded in the program area, including occurrences of mother and calf. Beluga whale sightings were most common in July and August, and sightings predominantly occurred in shallow, coastal waters and, to a lesser extent, in northern and ice environs.

During the summer and fall of 2010, Imperial worked with Cornell University to conduct passive acoustic monitoring in the program area. Twelve marine autonomous recording units were deployed in EL 477 for the purpose of quantifying beluga whale presence in the program area during the open-water season. Beluga whales were detected at one or more recording sites on 21 of 40 recording days (54%) and were less common at the shallower sites (Cornell University 2011b). This is consistent with known patterns of beluga whale migration (AECOM 2012) and habitat selection by depth (Moore et al. 2000).

Despite interannual variability in the extent and distribution of sea ice, beluga whales selected certain features (i.e., water depths of 200 to 500 m and heavy ice concentrations), frequenting regions of relatively significant seafloor slope with the potential for oceanographic upwellings (Asselin et al. 2011).

In 2001, the Fisheries Joint Management Committee (FJMC) issued an update of the Beaufort Sea Beluga Management Plan for the beluga whale population in the Canadian sector of the Beaufort Sea. Under this plan, there are various management zones and areas in the Beaufort Sea which are protected and should be avoided (see Figure 10-12, shown previously). The traditional summer locations for the eastern Beaufort Sea beluga whale population (i.e., Kugmallit Bay, east and west Mackenzie Bays, Shallow Bay and the Kendall Island area) are recognized as special designated lands under the Aklavik, Inuvik and Tuktoyaktuk community conservation plans (CCPs) as 711E, 714E and 716E – Beluga Management Zone 1A (WMAC 2000a, b, c). Category E consists of land and water where cultural or renewable resources are of extreme significance and sensitivity. The CCPs recommend the highest degree of protection for these types of lands, prohibiting development in these areas (WMAC 2000a b c, AECOM 2010).

Areas of higher sensitivity for beluga whales during the open-water season from May 1 to October 31 are shown in Figure 10-13, as extracted from AECOM 2010. These areas are representative of key life stage and feeding areas, and movement and migratory corridors necessary for year-over-year survival.

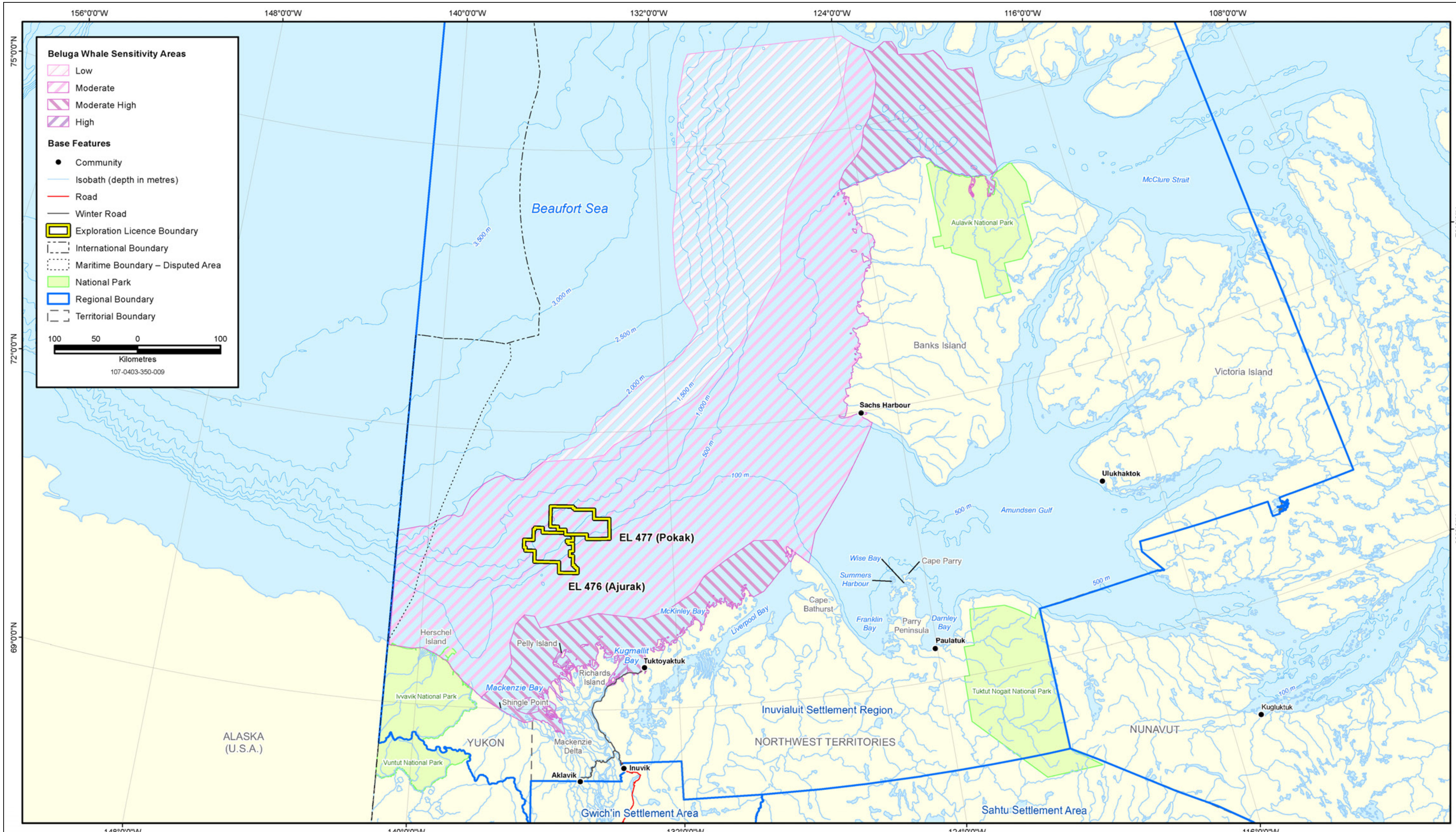


Figure 10-13: Beluga Whale Sensitivity Areas During the Summer Season

10.11.2.3 Subsistence Harvest

The 2010 joint venture traditional knowledge study identified beluga whales as an important subsistence species for local communities, providing muktuk (the outer skin and blubber) which is used as food and as a form of currency that is traded for other commodities, such as Arctic char and caribou. Communities harvest beluga whales during the summer, from June to late September, in the Beluga Management Zone 1A. The 2010 traditional knowledge study also identified the Mackenzie River Delta, Kugmallit Bay, the waters around Kendall Island and Garry Island and Balaena Bay as particularly popular subsistence harvesting locations.

10.11.2.4 Hearing Ability and Vocal Behaviour

Toothed whales, which include beluga whales, have been shown to echolocate, with beluga whales being considered the most vocal (Ketten 1992a, Karlsen et al. 2002). Echolocation is used for detection of prey and for navigation. Vocalizations are also used for social contact among pod members. Beluga whales are known for their rich vocal repertoire which includes different sound types (Panova et al. 2012, Chmelnitsky and Ferguson 2012), such as:

- whistles
- pulsed tones
- click series
- noise vocalizations

Beluga whales vocalize using a frequency range of 0.2 to 150 kHz (Ketten 1992b), with the greatest sensitivity around 32 and 108 kHz, and the least sensitivity at 54 kHz (Klishin et al. 2000). A lower threshold of 8 kHz was reported by Awbrey et al. (1988) who also found that juvenile beluga whales were slightly more sensitive to low frequencies than the adults. There does not appear to be any between-year variation in the vocal repertoire (Sjare and Smith 1986). However, beluga whales have been experimentally shown to change their signal frequency, bandwidth and intensity in a noisy environment (Au et al. 1985).

10.11.3 BOWHEAD WHALE

10.11.3.1 Population Trend and Conservation Status

The Bering-Chukchi-Beaufort subpopulation of bowhead whales (*Balaena mysticetus*) is listed as a population of special concern by COSEWIC (COSEWIC 2009) and SARA. The US *Endangered Species Act* also identifies this species as endangered. The most recent estimate of this population’s size was 10,545 animals in 2001 (Zeh and Punt 2005). There does not appear to be more recent, rigorous population estimates (Allen and Angliss 2012). However, the population of bowhead whales throughout their range has generally increased, reflecting an annual rate of increase of 3.4% through the early 2000s (Zeh and Punt 2005, COSEWIC 2009). Harwood et al. (2010) estimated 4,884 to 5,280 bowhead whales in the Beaufort Sea in the summer of 2007.

10.11.3.2 Seasonal Distribution and Movement

Bowhead whales annually migrate from the Bering Sea, where they overwinter south of the heaviest polar pack ice through the Chukchi Sea, past Point Barrow, Alaska, and into the eastern Beaufort Sea (see Figure 10-14).

After spending the summer in the eastern Beaufort Sea, bowhead whales return to the Bering Sea in the fall. The eastward spring migration begins in March and continues through to May, with bowhead whales passing Point Barrow from April through June and arriving in the eastern Beaufort Sea in May through July (Thomson et al. 1986, Richardson et al. 1987, Moore and Clarke 1991). The nearshore ice cannot be passed early in the year because the ice is landfast and the pack ice seaward of the landfast ice usually has very little open water (Braham et al. 1980). The bowhead whale spring migration follows a northern offshore route, using predictable open-water leads (Fraker 1979, Braham et al. 1980). As spring progresses, there is increased lead development west of Banks Island and north of the Tuktoyaktuk Peninsula by May, and development of the large polynya in Amundsen Gulf (Fraker 1979).

Bowhead whales remain in the Beaufort Sea for up to four months (Fraker and Bockstoce 1980) until the return migration to the Bering Sea begins in August and runs through November, depending on ice conditions (Thomson et al. 1986, Moore and Clarke 1991, Treacy et al. 2006). The purpose of the migration is believed to be for feeding, taking advantage of the high seasonal plankton production (Fraker and Bockstoce 1980, Wursig et al. 1985). There appears to be a general, large-scale pattern of bowhead whales first occupying the eastern Beaufort Sea and Amundsen Gulf, then gradually moving westward as the summer progresses (Thomson et al. 1986, Richardson et al. 1987), although there is a large variability in this pattern on an annual basis. Several studies (McLaren and Davis 1985, Thomson et al. 1986, Ford et al. 1987, Richardson et al. 1987, Koski and Miller 2009) have reported large variations in bowhead whale distribution throughout the years, most likely attributed to the variable distribution of their food sources (copepods and zooplankton) whose abundance depends on oceanographic and meteorological conditions (McLaren and Davis 1985, Wursig et al. 1985, Richardson et al. 1987). Fraker and Bockstoce (1980) suggest that the turbid freshwater plume of the Mackenzie River might inhibit primary and secondary production because of the reduction of light, which might cause bowhead whales to avoid the influence of fresh water from the Mackenzie River (Thomson et al. 1986).

Despite the interannual variability in distribution of bowhead whales in the Beaufort Sea, the following specific locations have been consistently used:

- the western half of the Amundsen Gulf and Cape Bathurst (Fraker and Bockstoce 1980, Richardson et al. 1987)
- offshore of Shingle Point, the eastern Tuktoyaktuk Peninsula and Herschel Island (Ford et al. 1987, Mate et al. 2000)
- Demarcation Bay (Mate et al. 2000)

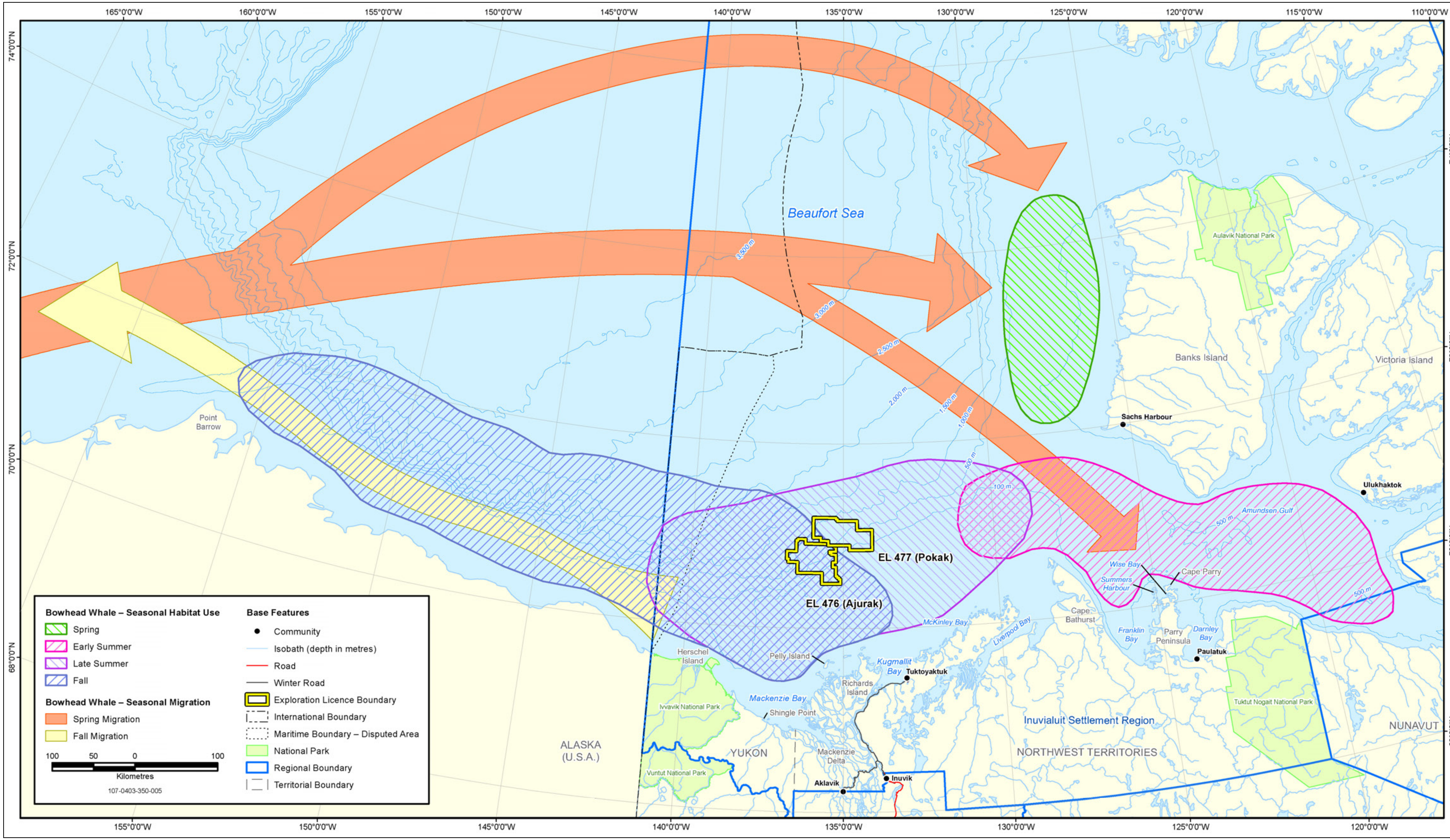


Figure 10-14: Bowhead Whale Migration Patterns and Seasonal Habitat Use in the Beaufort Sea

10.11.3.2 Seasonal Distribution and Movement (cont'd)

Offshore areas where water depth is greater than 200 m appear to be frequented more regularly than shallower waters, although younger bowhead whales tend to prefer the shallower nearshore waters (Koski and Miller 2009). Mate et al. (2000) made most (87%) of their bowhead whale observations in water less than 100 m deep. There is indication that bowhead whales select offshore waters in years of heavy ice conditions (Moore 2000). Consequently, ice conditions might be a determinate in explaining the variations in habitat selection.

During the return migration to the Bering Sea bowhead whales travel at a wide range of distances from shore (Koski and Miller 2009) because there is less obstruction from ice, and greater availability of open water. Ice conditions can modify this behaviour, where landfast ice limits availability of shallow nearshore access (Treacy et al. 2006). The length of time for bowhead whales to complete this migration to the Bering Sea varies among individuals (Mate et al. 2000). Bowhead whales are known to meander during this migratory transit, even reversing directions for short periods (Mate et al. 2000).

Aerial surveys conducted in 2007 through 2009 by Harwood et al. (2010) did not extend sufficiently offshore to encompass the EL areas. However, over the large survey area, the most consistently used feeding aggregations areas were north of Cape Dalhousie and northeast of Herschel Island (Harwood et al. 2010). Between 2008 and 2011, several vessel-based marine mammal surveys were conducted in the program area during the open-water season as part of the FDCPs. Although most sightings occurred outside the boundaries of the EL areas in water depths of less than 100 m, survey results demonstrated that bowhead whales were present in the program area during all years. During the summer and fall of 2010, Imperial worked with Cornell University to conduct a passive acoustic monitoring study at 12 underwater recording sites in the program area. Bowhead whales were detected at one or more of the recording sites in the program area during all 40 recording days (Cornell 2011).

Areas of higher sensitivity for bowhead whales during the open-water season from May 1 to October 31 are shown in Figure 10-15, as extracted from AECOM 2010. These areas are representative of key life stage and feeding areas, and movement and migratory corridors necessary for year-over-year survival (AECOM 2010).

10.11.3.3 Subsistence Harvest

Although harvested in the past, bowhead whales are not currently harvested for subsistence purposes by communities in the program area. However, bowhead whales are currently hunted by communities in Alaska and in the Canadian eastern Arctic.

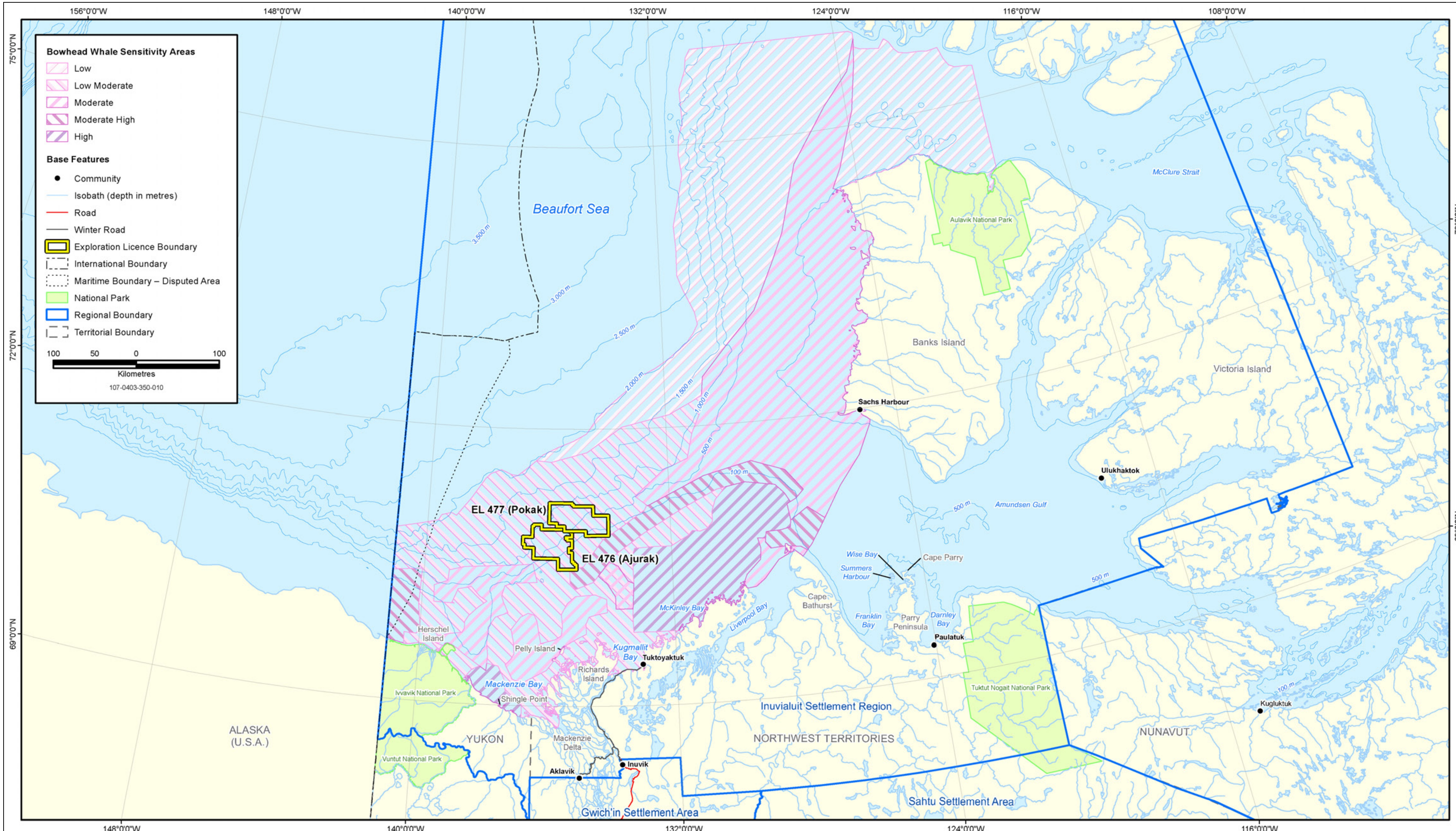


Figure 10-15: Bowhead Whale Sensitivity Areas During the Summer Season

10.11.3.4 Hearing Ability and Vocal Behaviour

All baleen whales, such as bowhead whales, vocalize at substantially lower frequencies than toothed whales, with bowhead whales using frequencies in the 0.1 to 0.8 kHz range (Ljungblad et al. 1982, Clark and Johnson 1984, Ketten 1992b), although they might perceive frequencies below 50 Hz (Ketten 1992b). However, trumpeting calls of up to 4 kHz have been recorded (Ljungblad et al. 1982, Clarke and Johnson 1984) but are infrequent.

Baleen whales are not thought to echolocate (Ketten 1992a). George et al. (1989) suggested that bowhead whales might use their calls to assess ice thickness in their path. Bowhead whale vocalizations are also used for maintaining contact between mothers and calves (Edds-Walton 1997). Bowhead whales are also known to sing, repeatedly producing one or two themes for up to 10 hours (Edds-Walton 1997). These songs appear to have a social function as they occur in winter and spring, during periods of social and sexual activity (Delarue et al. 2009, Edds-Walton 1997). There is individual variation in these songs and year-to-year variation (Edds-Walton 1997) indicating a high degree of acoustic sophistication.

10.11.4 RINGED SEAL

The ringed seal (*Phoca hispida*) was selected as a VEC because this species plays a key ecological role in the Arctic ecosystem. Ringed seals are the most abundant Arctic mammal and are the main food source for polar bears. They are also highly valued for subsistence harvesting and are of cultural significance to Inuvialuit (Bengston et al. 2005, Carlens et al. 2006, Harwood et al. 2012).

Because of the ringed seals’ strong dependence on sea ice, climate change is expected to have a significant effect on this species, affecting their distribution as related to the timing of ice development and melting (Carlens et al. 2006).

10.11.4.1 Population Trend and Conservation Status

There are five subspecies recognized globally, of which *P. hispida hispida* is the sole North American Arctic subspecies (Allen and Angliss 2011b). The ringed seal is listed as not at risk (1989) by COSEWIC and is not registered in the Species at Risk Public Registry. However, in 2011, this species was listed as threatened under the US *Endangered Species Act*.

Population surveys have been conducted in the past, but the reliability of the survey data is limited (Allen and Angliss 2011b). Current estimates of abundance or population trends are not available, with the most recent available survey information dating back to 1999–2000 (Bengston et al. 2005).

For the period of 1982 to 1986, Harwood and Stirling (1992) reported annual mean densities in this area of 0.08 to 0.42 seals/km^2.

10.11.4.2 Seasonal Distribution and Movement

The ringed seal has a circumpolar distribution that is closely associated with the distribution of landfast ice. They are present year-round in the southern Beaufort (Harwood and Stirling 1992). The ability of ringed seals to maintain breathing holes in the landfast ice enables them to occupy large areas that are inaccessible to other marine mammals. During ice formation in the fall, adult males and females establish territories which they maintain and defend throughout the winter (Harwood et al. 2012). In contrast, subadults are displaced to outer pack-ice regions or to other less preferred habitat areas (Crawford et al. 2012). Many of these animals will migrate great distances (greater than 2,000 km) to the Chukchi Sea and Bering Sea (Harwood et al. 2012). Ringed seal migration is relatively rapid, typically following a nearshore route (less than 100 km), with an average transit time from Cape Parry to Point Barrow of 32 days (Harwood et al. 2012).

During winter, the ringed seals' preferred habitat consists of ice leads and polynyas where breathing holes are easiest to maintain. Ringed seals are considered a keystone species (Ferguson et al. 2005). Primary predators to the ringed seal include polar bears, Arctic fox, walrus, wolves, humans and dogs (Hammill and Smith 1991).

Juvenile ringed seals prey mainly on crustaceans under the ice while adults prey on crustaceans and small fish (e.g., Arctic cod) (Richard et al. 2001).

In spring, breeding adults occur in highest densities in areas of stable landfast ice with good snow cover where they maintain birth lairs for pup rearing (Hamill and Smith 1991). Non-breeding adults are found at the ice floe edge or in the moving pack ice (Stewart and Lockhart 2005). Pups are born in early spring (March/April) and weaned before breakup of the sea ice in late June (Evans and Raga 2001). Pups will remain in dens located in or under the snow. Pups remain in the dens during a five to eight week lactation period to avoid detection from predators, such as polar bears (Evans and Raga 2001). During the open-water season (July to October), ringed seals are commonly observed in large numbers hauled out on the sea ice (Finley 1979, Bengston et al. 2005). Higher densities of seals during this basking period have been noted near the landfast ice edge, over water 5 to 35 m deep (Moulton et al. 2002, Frost et al. 2004). Juveniles might move offshore at this time, but adults remain associated with islands and within coastal bays and fiords (McLaren 1958, Dunbar and Moore 1980).

Between 2008 and 2011, several vessel-based and aerial-based marine mammal surveys were conducted in the program area during the open-water season (July to October) as part of the FDCPs. Survey results demonstrated that ringed seals were present in the program area during all years surveyed. Figure 10-16 provides an overview of ringed seal distribution in the Beaufort Sea region based on historical sightings, current scientific knowledge and Inuvialuit traditional knowledge studies.

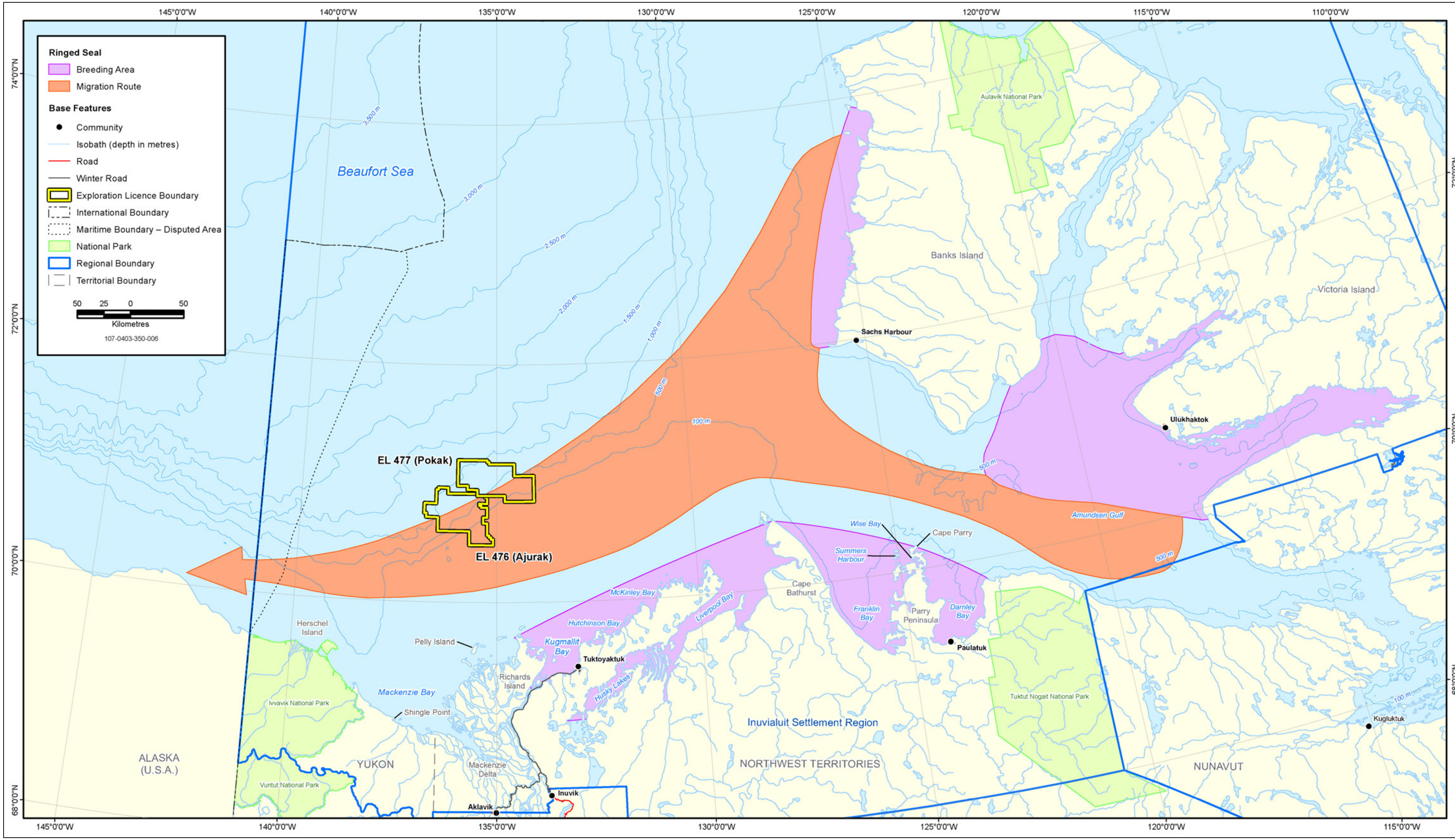


Figure 10-16: Ringed Seal Seasonal Movements in the Beaufort Sea

10.11.4.2 Seasonal Distribution and Movement (cont'd)

Areas of higher sensitivity for ringed seal during the open-water season from May 1 to October 31 are illustrated in Figure 10-17, as extracted from AECOM 2010. These areas are representative of key life stage areas, quality feeding areas, as well as movement and migratory corridors necessary for year-over-year survival (AECOM 2010).

10.11.4.3 Subsistence Harvest

The joint venture's traditional knowledge study identified ringed seals as one of the more important subsistence harvested species in the ISR because all communities are actively harvesting this species year round (Golder 2011a). The meat is considered a staple of the local diet, and seal hides are used for clothing and sold commercially. Key harvesting locations include Kugmallit Bay, the Husky Lakes Region, Hutchinson Bay and additional northern coastal areas of the Tuktoyaktuk Peninsula (Golder 2011a). The traditional knowledge study identified that the prevalence of seal hunting is declining in the region, particularly in the community of Paulatuk (Golder 2011b).

10.11.4.4 Hearing Ability and Vocal Behaviour

Underwater hearing sensitivity in seals falls between an estimated auditory bandwidth of 75 Hz and 75 kHz. Ringed seals have underwater hearing thresholds between 60 and 85 dB re 1µPa (Mohl 1968, Terhune and Ronald 1972 and 1975, Terhune 1981). Ringed seal vocalizations include barks, clicks and yelps, all of which occur in the 400 Hz to 16 kHz frequency range, with dominant frequencies concentrated above 5 kHz (Stirling 1973, Cummings et al. 1984).

10.11.5 POLAR BEAR

Polar bears (*Ursus maritimus*) occur throughout the polar basin, concentrating around more productive nearshore areas, polynyas and other areas where currents and upwellings increase productivity (Feldhamer et al. 2003). They are apex predators of the Arctic marine ecosystem feeding primarily on ringed seals (*Phoca hispida*), but their diet also includes bearded seals (*Erignatus barbatus*), harp seals (*Phoca groenlandicia*) and harbour seals (*Phoca vitulina*). They have been known to kill walruses (*Odobenus rosmarus*) and beluga whales (*Delphinapterus leucas*). They also feed on fish and carrion (Feldhamer et al. 2003). Terrestrial food (e.g., berries, human refuse) is not considered significant in the overall diet. Polar bear males and subadults have been reported to go into short-term dens (to find shelter in severe weather), but polar bears do not hibernate in the same manner as grizzly bears. The world population of polar bears is estimated to be between 22,000 and 27,000 animals in 19 separate populations. Canada has the largest population with an estimated 15,000 polar bears in 13 populations.

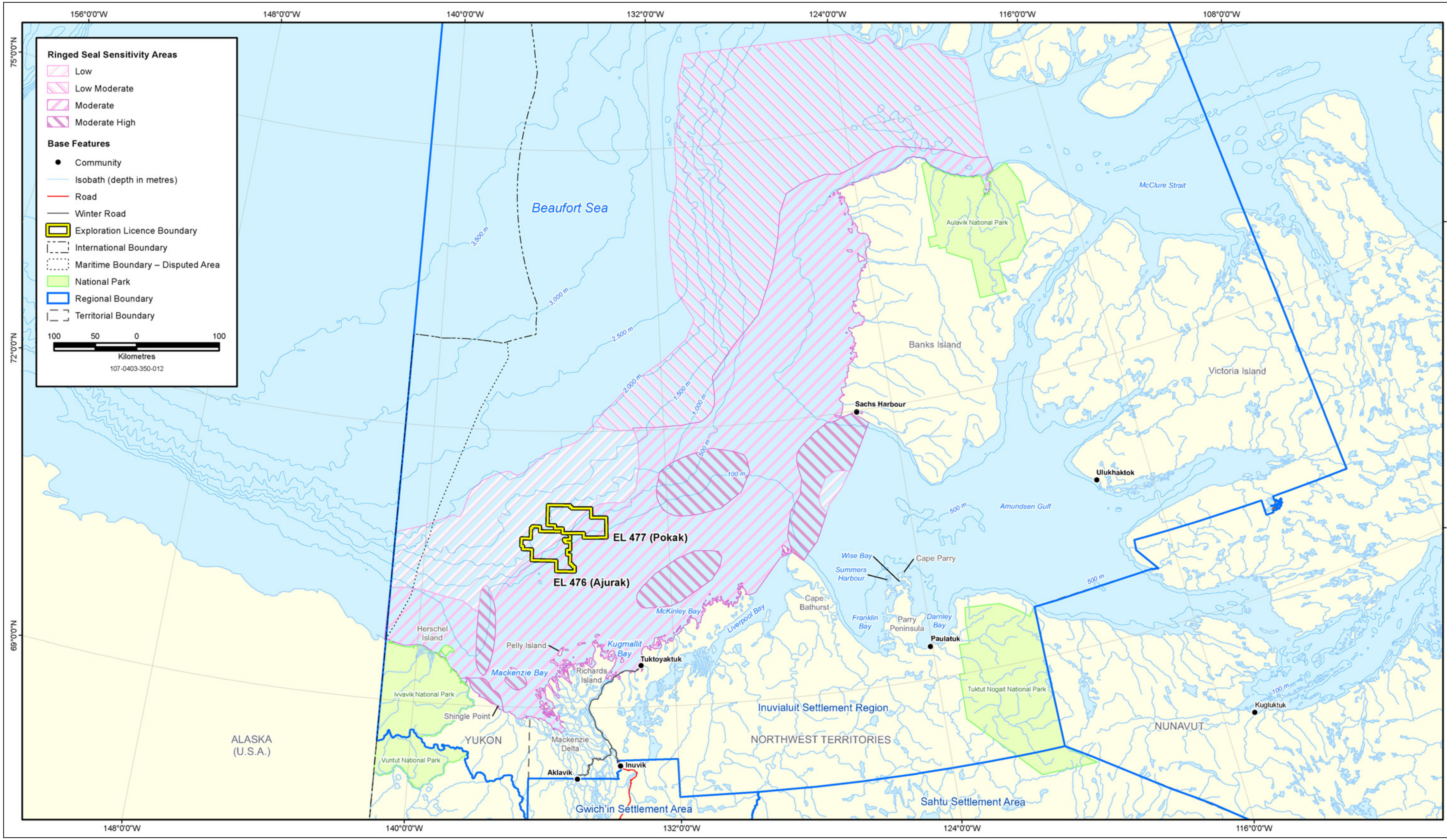


Figure 10-17: Ringed Seal Sensitivity Areas During the Summer Season

10.11.5.1 Southern and Northern Beaufort Sea Polar Bear Populations

Polar bears in the Canadian sector of the Beaufort Sea are considered to be part of two populations:

- the southern Beaufort Sea population
- the northern Beaufort Sea population

Their annual distribution is mainly linked to the distribution of multi-year pack ice and the availability of ringed seals.

For a map showing polar bear seasonal movements and denning locations, see Figure 10-18. For a map showing the polar bear population boundary, see Figure 10-19.

The southern Beaufort Sea polar bear population occupies a core area from Icy Cape, Alaska, in the west to Pearce Point, NWT (Schliebe et al. 2006), and management responsibility is shared between Alaska and Canada.

The northern Beaufort Sea population is distributed across the eastern and northeastern Amundsen Gulf, the southwest coast of Banks Island, western portions of M'Clure Strait and the west coast of Prince Patrick Island. The management responsibilities for this population are shared between the NWT and Nunavut (Stirling et al. 2011).

Recent studies suggest that the distribution of the two polar bear populations has changed so that the boundary has shifted westwards towards Tuktoyaktuk (Allen and Angliss 2010). If officially accepted by the co-management partners, this change would move a large portion of the range and about 311 bears from the southern Beaufort Sea population to the northern Beaufort Sea population.

Polar bears in the Beaufort Sea generally move north in summer, following the retreating pack ice where they concentrate along the edge of the persistent pack ice. In winter, the bears extend their range to the southern-most reach of the sea ice and to coastal areas. In early winter (between October and December), pregnant females build maternity dens from ice and snow. Most of the dens that are located onshore are situated in coastal and river banks or other pronounced landscape features, such as lake shores or slopes (Durner et al. 2003). Offshore, dens are located on landfast ice or drifting pack ice (Fischbach et al. 2007). Recent research indicates that there has been a shift in distribution of maternity dens towards terrestrial den sites (Gleason and Rode 2009). Females might give birth to one to three young in the dens between November and January and cubs emerge from dens during March and April (Amstrup and Gardner 1994). Denning is a crucial aspect of a polar bear's life cycle because the dens provide protection for the highly dependent newborns. Consequently, denning habitat protection is a critical aspect for the species' conservation.

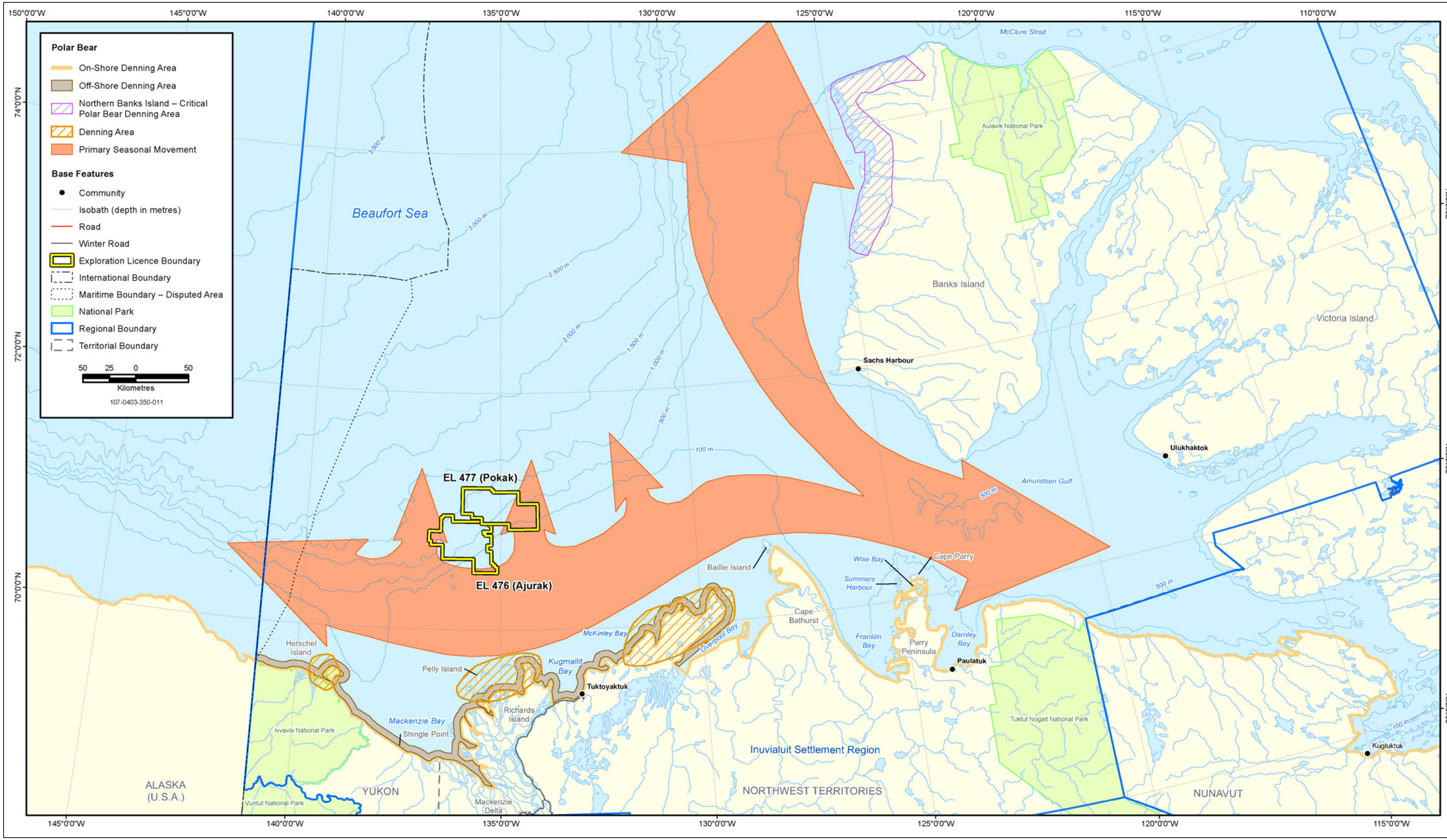


Figure 10-18: Polar Bear Seasonal Movements and Denning Locations

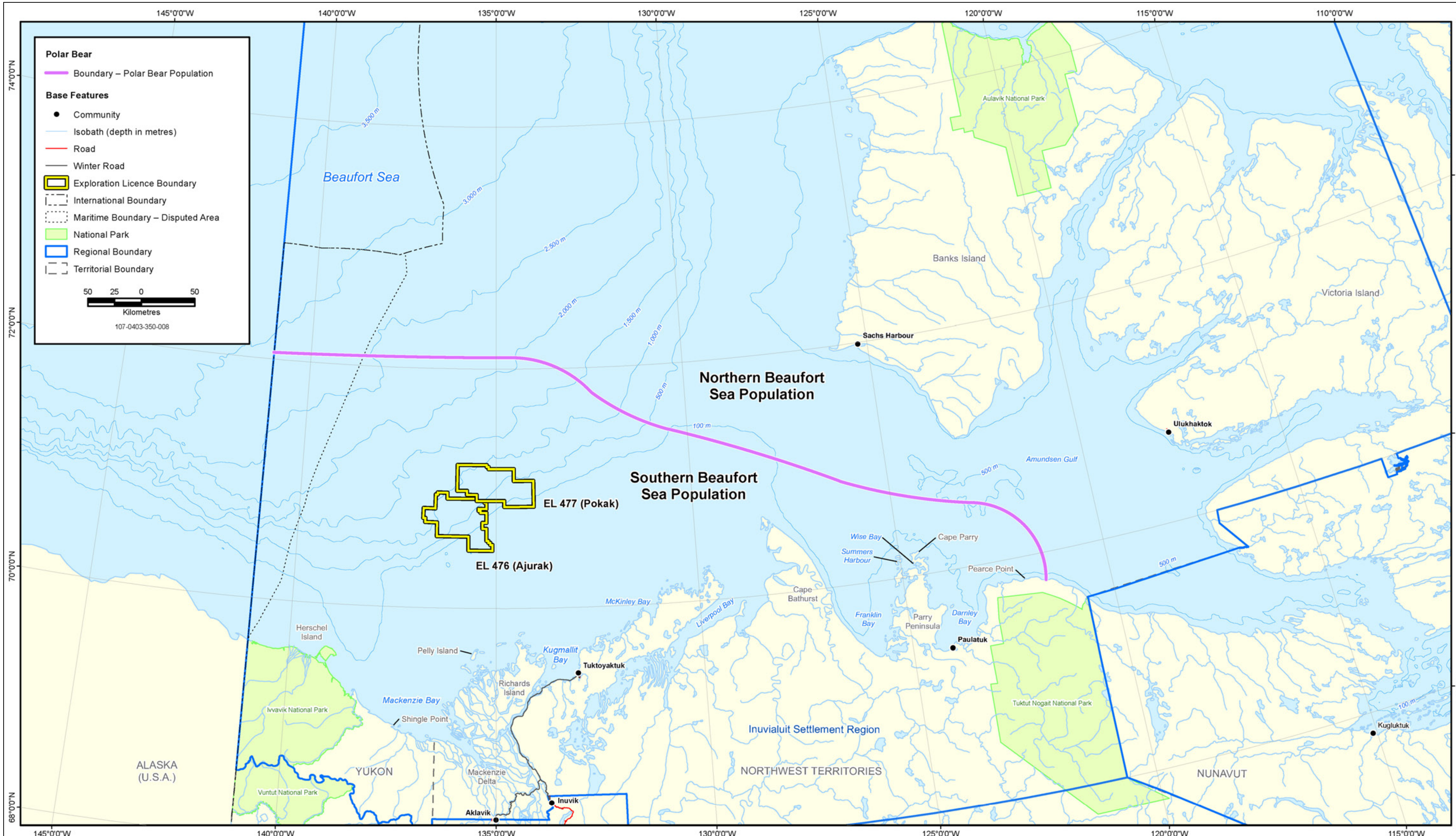


Figure 10-19: Polar Bear Population Boundary in the Beaufort Sea

10.11.5.2 Population Trend and Conservation Status

The southern Beaufort Sea population was believed to be stable with numbers of about 1,800 animals until Regehr et al. (2006) estimated it at around 1,500 animals. Regehr et al. (2006 and 2007) calculated declining survival and recruitment rates and reduced body size. Combined with low growth rates, the southern Beaufort Sea population is now believed to be declining.

The northern Beaufort Sea population was recently estimated at 1,200 and is believed to be stable or possibly increasing (Stirling et al. 2011).

Polar bears in Canada are protected under SARA, where they are listed as a species of special concern under Schedule 1. The main impact to the species is harvesting in combination with the effects of climate change (e.g., changes to their sea-ice habitat and reduction in the availability of prey).

In 2008, COSEWIC assessed the polar bear in Canada as a species of special concern. This listing is still in effect mainly because of harvesting issues and environmental changes that can affect their prey base or affect the thickness and distribution of sea ice.

The NWT Species Monitoring Infobase lists polar bears in the NWT as a sensitive species because of prominent threats to the population, such as potential overharvesting in some areas, oil spills, killing of problem bears and climate change (GNWT-ENR 2012).

Polar bears are also listed in Appendix II of the Convention on International Trade in Endangered Species, which regulates international trade in species that are or might become threatened by commercial trade.

The International Union for Conservation of Nature and Natural Resources' Red List lists polar bears worldwide as vulnerable and classifies their population trend as declining.

During the regulatory review of the Mackenzie Gas Project, the Joint Review Panel (JRP) issued two recommendations to mitigate potential impacts on polar bears from oil and gas exploration and development activities in the Beaufort Sea (JRP 2009). Recommendation 10-14 called for the development of a range management plan for the southern Beaufort Sea polar bear population, and recommendation 10-13 was to:

- *delineate potential maternity denning habitats and assessment of the potential for den disturbance*
- *assess the risk and potential impacts of offshore activities to the southern Beaufort Sea polar bear population*
- *assess the impact of nearshore activities on Inuvialuit polar bear hunting along the nearshore areas of the southern Beaufort Sea coast from Mackenzie Bay to the Tuktoyaktuk Peninsula*

10.11.5.2 Population Trend and Conservation Status (cont'd)

- *identify key feeding areas in nearshore areas that are used by family groups of polar bears, especially females with young of the year just out of their maternity dens, and prime seal and bear habitat near the outer edge of the landfast ice*
- *consider potential interaction of industrial development impacts with effects arising from climate variability and long-term climate change*
- *monitor the Beaufort Sea polar bear populations so that such data can inform the range management plan noted in Panel Recommendation 10-14*

Areas of higher sensitivity for polar bear during the open-water season are shown in Figure 10-20. These areas are representative of key life stage and foraging areas, as well as movement corridors necessary for year-over-year survival (AECOM 2010).

10.11.5.3 Seasonal Distribution and Movement

Beaufort Sea polar bears are known to use nearshore areas, but rarely venture onto the land (Amstrup et al. 2000 and 2007). Polar bears move into nearshore areas to forage when landfast ice is available. Recent trends indicate that an increasing number of polar bears have been observed on nearshore islands and the coastal mainland during open-water conditions when sea ice is far from shore (Schliebe et al. 2008, Gleason and Rode 2009). During the summer, when access to seals is limited, polar bears might fast, hunt alternative marine mammals or scavenge carrion or remains from subsistence harvests or community waste (Hansen 2004).

Studies that examined seasonal fidelity of polar bears to activity areas indicated that female polar bears in the entire Beaufort Sea region expressed the highest degree of fidelity in summer and the weakest during spring (Armstrup et al. 2000). This pattern might be explained by the distribution of seals, which is influenced by sea-ice conditions (Paetkau et al. 1995).

Female polar bears exhibit some degree of fidelity to general denning areas or substrates but not to the actual den sites, which are known to change every year because of variation in weather that influences the accumulation of drifted snow (Amstrup et al. 2000).

Between 2008 and 2011, several vessel-based and aerial-based marine mammal surveys were conducted in the program area during the open-water season (July to October) as part of the FDCPs. Survey results demonstrated that polar bears were present in the program area in 2008 and 2009.

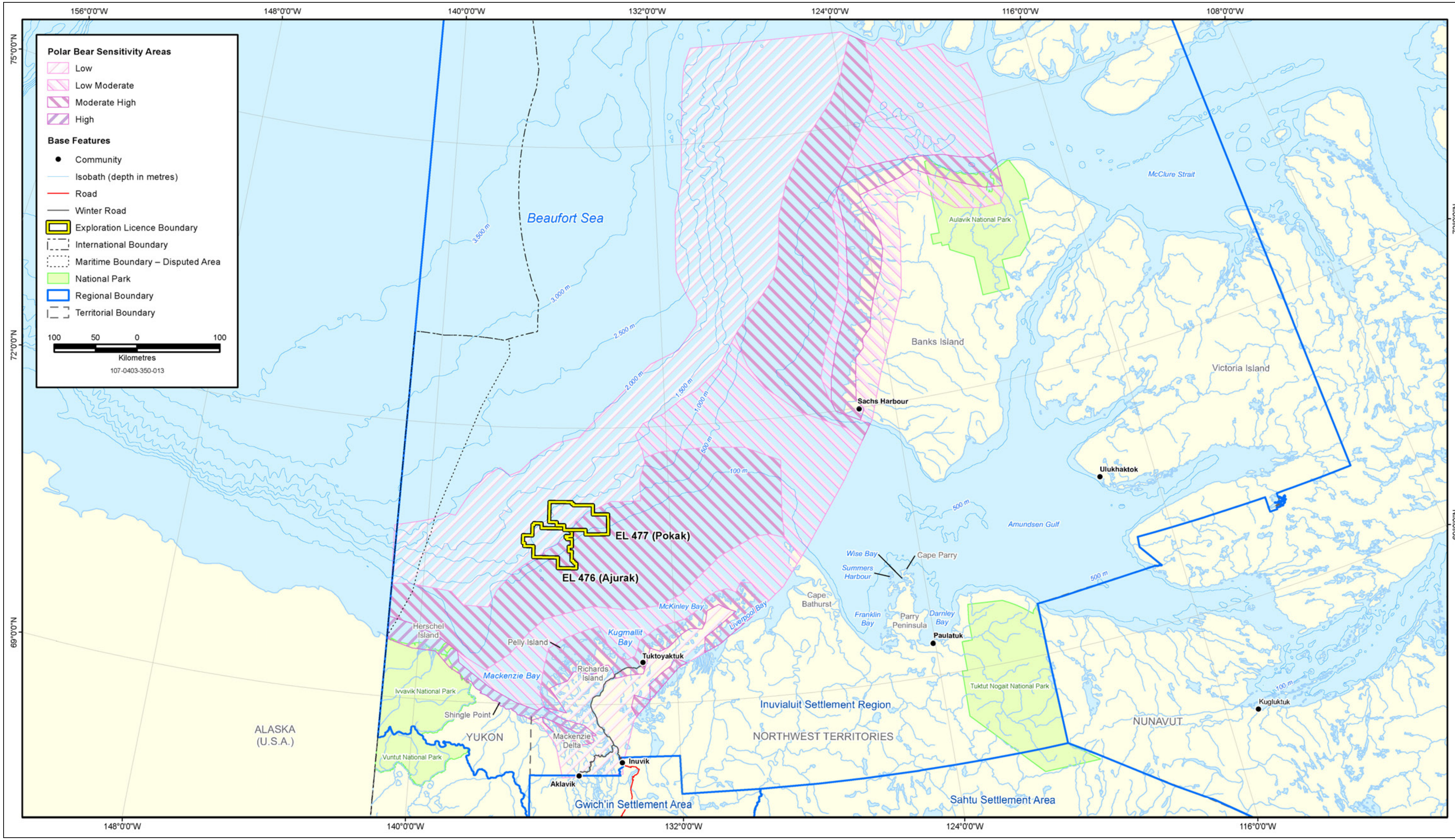


Figure 10-20: Polar Bear Sensitivity Areas During the Summer Season

10.11.5.3 Seasonal Distribution and Movement (cont'd)

Given the recent survey of results in information from the literature, there is a likelihood of encountering polar bears of both populations in the program area during all seasons. In addition, past studies have revealed suitable maternity denning habitat along the Tuktoyaktuk Peninsula and off the coast of Richards Island and Baillie Island. If program activities were to take place between November and April, it is possible that polar bear maternity dens might be present in the proposed marine resupply corridor between the drill sites and Tuktoyaktuk Harbour.

10.11.5.4 Subsistence Harvest

Polar bears are an important species for Inuvialuit subsistence harvesting, guided sport hunting and for use as clothing (Community of Inuvik et al. 2008). Sport hunts also contribute to Inuvialuit cultural identity by keeping travel by dog team active in the communities. Guided sport hunts are important sources of revenue for local communities, with an average polar bear sport hunt costing $15,000 (GNWT 2011b) and often up to $40,000 (CanWest News Services 2008).

The harvest of polar bears in the ISR is managed under annual quotas allocated to local hunters and trappers committees (HTCs). The quotas are based on a harvested sex ratio of two males to every female harvested. The HTCs can allocate 50% of the tags to locally guided sport (or trophy) hunters who are required to hunt by dog team (Freeman and Wenzel 2006). The total allowable harvest for the southern Beaufort Sea is currently 70 polar bears per year (4.5% of the population estimate) split between Alaska and the NWT. The sustainable harvest limit established for the northern Beaufort Sea population is 65 bears per year (split between NWT and Nunavut communities). However, the annual harvest has been less than 40 bears for more than 15 years (Stirling et al. 2011).

The current annual polar bear hunting seasons in the Inuvialuit Polar Bear Management Areas lasts from either October or December to May (coinciding with the maternity denning period and to protect females with cubs from being accidentally harvested). Inuvialuit hunters typically hunt polar bears in the months coinciding with the return of sunlight in February and March (Whittles 2005).

10.11.5.5 Hearing Ability and Vocal Behaviour

Little is known about the underwater hearing abilities in polar bears. Their in-air hearing has been studied on captive subjects (using auditory-evoked potentials to produce audiograms) demonstrating that polar bears can likely hear in air at a slightly wider range of frequencies than humans (up to 25 kHz) and have absolute hearing thresholds below 27 to 30 dB re 20 μPa (Nachtigall et al. 2007).

.

10.12.1 OVERVIEW

The LSA includes Tuktoyaktuk Harbour and adjacent areas, where some shore-based facilities exist, the Tuktoyaktuk James Gruben Airport and the local waste disposal facility. Program activities might interact with local terrestrial wildlife potentially using these areas. In addition, some terrestrial wildlife that might use the sea ice as travel corridors could interact with program activities if program components are carried out during winter or the shoulder seasons (e.g., during icebreaking activities).

The following species were identified as terrestrial wildlife that might be encountered during program activities in the Tuktoyaktuk area or on the frozen nearshore area:

- barren-ground caribou (*Rangifer tarandus groenlandicus*)
- Peary caribou (*Rangifer tarandus pearyi*)
- grizzly bear (*Ursus arctos*)
- wolf (*canis lupus*)
- Arctic fox (*Alopex lagopus*)

10.12.2 BARREN-GROUND CARIBOU

The Cape Bathurst and Bluenose West barren-ground caribou herds' fall rutting ranges (during October and November) and winter ranges (during December through March) include the southern portion of the Tuktoyaktuk Peninsula, including Tuktoyaktuk, the Liverpool Bay area and southern portions of Cape Bathurst (Nagy et al. 2005, Community of Tuktoyaktuk et al. 2008). Animals from both herds use this region from October through March. In the spring, during their pre-calving migration, the caribou begin to move east and south, away from the area.

The populations of both herds are reported to have declined drastically during the last decades (GNWT-ENR 2013):

- the Bluenose West herd declined from an estimated herd size of 107,000 in 1987 to about 18,000 animals in 2009 and increased again to about 20,000 animals in 2012

- the Cape Bathurst herd declined from an estimated 12,500 animals in 1987 to only about 1,900 animals in 2009 and increased to about 2,400 animals in 2012

10.12.2 BARREN-GROUND CARIBOU (cont'd)

In 2005, local residents and wildlife managers established that there is a third herd using the Tuktoyaktuk area, the Tuktoyaktuk Peninsula herd (GNWT-ENR 2013). These caribou are now known to be staying on the entire Tuktoyaktuk Peninsula all year. The caribou are thought to possibly have established their presence after the local semi-domestic reindeer (*Rangifer tarandus*) herd was moved off the peninsula. They are now recognized and managed as a separate herd. It is not known how many of the animals of this herd are reindeer or reindeer-caribou hybrids. The herd size was estimated at about 3,000 caribou in 2006, about 2,800 in 2009, and about 2,200 in 2012 (GNWT-ENR 2013).

Most hunting areas in the ISR are closed for barren-ground caribou hunting except for Inuvialuit subsistence harvest. Inuvialuit in Tuktoyaktuk harvest caribou from all three herds during the fall, winter and early spring.

It is possible that caribou might be encountered either during land-based activities or during aircraft support flights between the Tuktoyaktuk airport and the EL areas.

Barren-ground caribou are not listed by SARA (2012) but are listed as special concern by COSEWIC (2013). The GNWT Infobase lists them as sensitive because of the observed decline in all herds (GNWT-ENR 2012).

10.12.3 PEARY CARIBOU

Peary caribou occupy the islands of the Arctic Archipelago and are rarely found on the mainland (except on the Boothia Peninsula in Nunavut). There are two populations of Peary caribou in the ISR:

- the Banks Island population on Banks Island and northwestern Victoria Island
- the High Arctic population on the Queen Elizabeth Islands

It is estimated that there are about 7,250 Peary caribou in the ISR, which have suffered severe declines of up to 80% over the past five decades (SARA 2012).

High Arctic Peary caribou migrate annually and seasonally between Prince Patrick, Eglinton and Melville islands (AANDC 2012). Although most interisland movements occur on sea ice, some caribou are believed to swim during the open-water season (Miller 1995). Migration is also known to occur between Banks Island and northwestern Victoria Island. Peary caribou are especially sensitive during the fall, winter and early spring because of their need for interisland movement on the sea ice. On occasion, caribou movements might be impacted by seismic activities (AANDC 2012). The availability of winter forage under deep snow and ice is likely the main limiting factor for Peary caribou across their range. In addition, hunting, predation and disturbance resulting from human activities are considered factors contributing to their decline (SARA 2012). The Banks Island population is also believed to be impacted by competition for food with the growing muskox (*Ovibus moschatus*) population (Community of Sachs Harbour et al. 2008).

Male Peary caribou in the ISR are harvested under a quota system for subsistence purposes by Inuvialuit from Sachs Harbour and Ulukhaktok (Community of Sachs Harbour et al. 2008). No other hunting is permitted.

It is highly unlikely that Peary caribou (Banks Island population) would be encountered during program activities because most of the program activities will take place more than 200 km from Banks Island and Victoria Island. However, the winter movements of the Peary caribou (Banks Island population) could overlap with the regional study area (RSA).

The High Arctic and the Banks Island populations of Peary caribou are listed as endangered by SARA and COSEWIC (SARA 2012, COSEWIC 2013) because of the ongoing decline. The GNWT Infobase lists them as at risk because of low numbers and a high level of threats in the form of climate change, predation and human development (GNWT-ENR 2012).

10.12.4 GRIZZLY BEAR

Grizzly bears occur all year in low densities throughout the ISR, including the Mackenzie Delta and Tuktoyaktuk Peninsula (Community of Tuktoyaktuk et al. 2008). Grizzly bears in the western Arctic are known to reproduce extremely slowly because of poor habitat and weather conditions (McLoughlin et al. 1999). Availability of denning habitat and the avoidance of actual den sites by human activities are important aspects for a sustainable grizzly bear population in the ISR. Grizzly bears are known to avoid:

- wetlands
- tussock and hummock tundra
- boulder fields
- exposed bedrock

They den in areas with topographic relief, such as lake and channel banks. Typically, grizzly bear dens are found on south facing slopes in sandy soils (McLoughlin et al. 1999).

Grizzly bears typically hibernate from October or November to the end of April or early May. When grizzly bears emerge from their dens, they generally spend the first days and sometimes weeks close to their den (McLoughlin et al. 1999). Grizzly bears dig new dens in the fall because dens often collapse during the previous spring breakup. Grizzly bears are known to be attracted to shore-based facility waste and petroleum products, if not managed and stored appropriately.

Inuvialuit harvest grizzly bears in the area under a quota system (Community of Tuktoyaktuk et al. 2008).

10.12.4 GRIZZLY BEAR (cont'd)

There is a limited likelihood of encountering grizzly bears during land-based program activities or aircraft support, except for shore-based facility activities, which might attract bears.

The western grizzly bear population is not listed by SARA (2012) but is listed as special concern by COSEWIC (2013). The NWT Infobase designates them as sensitive and views human development as a threat to the bears' habitat (GNWT-ENR 2012).

10.12.5 WOLF

Wolves play a major role in the western Arctic ecosystem and are an important resource for Inuvialuit. Wolves are more common in areas that are regularly used by the animals they prey on, such as caribou. Wolves might use the Tuktoyaktuk Peninsula and Richardson Island, but they are not expected to occur frequently in the area (Community of Tuktoyaktuk et al. 2008). They might be attracted to shore-based facility waste, if not managed appropriately. Inuvialuit and other residents harvest wolves regularly for their fur in late winter and spring.

There is a limited likelihood of encountering wolves during land-based program activities or aircraft support, except for shore-based facility activities, which might attract wolves.

Northern grey wolves are not listed by SARA (2012) and are listed as not at risk by COSEWIC (2013). The NWT Infobase lists them as secure (GNWT-ENR 2012).

10.12.6 ARCTIC FOX

Although the Arctic fox is typically associated with tundra habitats above the treeline, it could move out onto nearshore ice during the winter, where they are known to travel long distances (Feldhamer et al. 2003). Arctic fox den construction occurs in sites with well-drained soils, often in hillside locations. Important denning habitat for this species is found throughout the Mackenzie Delta, on the Tuktoyaktuk Peninsula and Richards Island (IEG 2002). Arctic foxes are trapped for their fur across the ISR.

There is a likelihood of encountering Arctic foxes either during land-based program activities (e.g., shore-based facility activities) or during potential winter shoulder-season activities (e.g., while using icebreaking vessels) because these foxes are known to venture onto the sea ice and often travel for long distances.

Arctic foxes are not listed by SARA (2012) or COSEWIC (2013). They are designated as secure in the NWT Species Infobase (GNWT-ENR 2012).

10.13.1 PROTECTED SPECIES IN THE RSA

The COSEWIC and SARA-listed species potentially occurring within the RSA include:

- four marine bird species
- five marine mammal species

Species at risk in the RSA and their status in 2012 are listed in Table 10-6.

Table 10-6: Species at Risk Potentially Occurring in the RSA

Common Name	Species	COSEWIC Status 2012	SARA Status 2012
Marine and Anadromous Fish			
Bering cisco	*Coregonus laurettae*	Special concern (Yukon)	No status – no schedule
Blackline prickleback	*Acantholumpenus mackayi*	Data deficient	Special concern – Schedule 3
Dolly Varden	*Salvelinus malma malma*	Special concern	No status – no schedule
Northern wolffish	*Anarhichas denticulatus*	Threatened	Threatened – Schedule 1
Marne Avifauna			
Barrow's goldeneye	*Bucephala islandica*	Special concern	Special concern – Schedule 1
Buff-breasted sandpiper	*Tryngites subruficollis*	Special concern	No status – no schedule
Harlequin duck	*Histrionicus histrionicus*	Special concern	Special concern – Schedule 1
Horned grebe	*Podiceps auritus*	Special concern	No status – no schedule
Ivory gull	*Pagophila eburnea*	Endangered	Endangered – Schedule 1
Peregrine falcon	*Falco peregrinus tundrius*	Special concern	Special concern – Schedule 1
Red knot	*Calidris canutus*	Endangered – rufa ssp. Special concern – islandica ssp.	Endangered – rufa ssp. – Schedule 1 Special concern – islandica ssp. – Schedule 1
Ross's gull	*Rhodostethia rosea*	Threatened	Threatened – Schedule 1
Marine Mammals			
Beluga whale (Eastern Beaufort Sea population)	*Delphinapterus leucas*	Not at risk	No status – no schedule
Bowhead whale (Bering-Chukchi-Beaufort population)	*Balaena mysticetus*	Special concern	Special concern – Schedule 1
Polar bear	*Ursus maritimus*	Special concern	Special concern – Schedule 1
Terrestrial Wildlife			
Barren-ground caribou	*Rangifer tarandus groenlandicus*	Special concern	Special concern – Schedule 1
Grizzly bear	*Ursus arctos*	Special concern	No status – no schedule
Peary caribou	*Rangifer tarandus pearyi*	Endangered	Endangered – Schedule 1

10.13.1 PROTECTED SPECIES IN THE RSA (cont'd)

In addition to the information in Table 10-6, the following birds are noted by Salter et al. (1980) as using the coastal plain:

- listed by COSEWIC as threatened:
  - barn swallow (*Hirundo rustica*) (2011)
  - common nighthawk (*Chordeiles minor*) (2007)
- listed by COSEWIC as special concern:
  - peregrine falcon (*Falco peregrinus tundrius*) (2007)
  - rusty blackbird (Euphagus carolinus) (2006)
  - short-eared owl (Asio flammeus) (2008)
- listed by COSEWIC as not at risk:
  - bald eagle (*Haliaeetus leucocephalus*)
  - golden eagle (Aquila chrysaetos)
  - gyrfalcon (Falco rusticolus)
  - merlin (Falco columbarius)
  - red-tailed hawk (Buteo jamaicensis)
  - rough-legged hawk (Buteo lagopus)
  - sharp-shinned hawk (Accipiter striatus)

10.14.1 PROTECTED AREAS NEAR THE PROGRAM AREA

Measures have been taken by federal, provincial and territorial governments, non-governmental organizations, and international organizations to identify, evaluate and protect areas of biological importance in the ISR's marine and coastal environment. This subject provides an overview of these protected areas in relation to the proposed program activities.

10.14.2 NORTHWEST TERRITORIES WILDLIFE ACT

A draft of a new *Wildlife Act* to replace the (NWT) *Wildlife Act* (1988) has been introduced in the legislative assembly after extensive Aboriginal and public consultations between 2010 and 2012, in an effort to ensure that the concerns of the people of the NWT are appropriately addressed. It is expected that the act will pass in 2013.

In addition to maintaining provisions in the current legislation regarding respect for wildlife (e.g., disturbance and harassment, retrieval of dead or wounded wildlife), possession of wildlife and protection of habitat, the proposed new draft *Wildlife Act* introduces the requirement for wildlife monitoring and management plans. Under subsection 95(1) of the proposed new draft *Wildlife Act*, wildlife monitoring and management plans will be required if a development, proposed development or other activity might significantly:

- disturb wildlife
- destroy or pose a threat of seriously harming habitat
- contribute to cumulative impacts on wildlife or habitat

10.14.3 TARIUM NIRYUTAIT MARINE PROTECTED AREA

The Tarium Niryutait Marine Protected Area (MPA) is the only MPA in Arctic Canada. The MPA was established in 2010 under *Tarium Niryutait Marine Protected Areas Regulations*, pursuant to Subsection 35 (3) of the *Oceans Act* (1996). The MPA covers an area of 1,800 km² in the Mackenzie Delta and estuary in the Beaufort Sea (about the area of the former beluga management zones) and is subdivided into three units:

- Niaqunnaq MPA
- Okeevik MPA
- Kittigaryuit MPA

10.14.3 TARIUM NIRYUTAIT MARINE PROTECTED AREA (cont'd)

The motivation for creating the Tarium Niryutait MPA was to conserve and protect beluga whales and other marine species, their habitats and ecosystem and to preserve Inuvialuit traditional harvesting. Stakeholders that participated in the creation of the MPA included the Inuvialuit, private industry and government.

10.15.1 BACKGROUND DATA

Evidence shows that the physical properties of the Beaufort Sea are being affected by climate change. Ice and oceanographic conditions in the Canadian sector of the Beaufort Sea are strongly influenced by oceanic and sea ice exchanges with neighbouring regions. Reductions in the areal extent and concentration of sea ice in the Canada Basin are similar to those of the full Arctic Ocean with the largest reductions resulting from the loss of old ice (second-year and multi-year ice). In the late summer and fall months, old ice concentrations are decreasing between 8 and 11% per decade as computed from Canadian Ice Service digital ice charts over the past 45 years (Fissel et al. 2013).

10.15.1.1 Changes in the Mackenzie Shelf Region

In four sub-regions of the Mackenzie Shelf region (slope, mid-outer shelf, inner shelf and Kugmallit Bay) the largest reductions for all sub-regions occurred in mid-October, with the largest reduction in the slope region of nearly 10% in sea-ice concentration per decade. The least amount of change per decade occurred in Kugmallit Bay, with mid-October results showing less than 2% reduction in sea-ice concentration. There has been no significant trend detected for significant changes in ice thickness on the Mackenzie Shelf and any trend would likely be overshadowed by year-to-year and short-term variability (Melling 2012 personal communication, Niemi et al. 2012).

10.15.1.2 Beaufort Sea Gyre

Mechanical deformation of first-year ice can create ice drafts as large as old ice. It is possible that under conditions of divergence, first-year ice thickness might be increasing. Reversals of ice in the Beaufort Sea gyre suggest that more divergence has occurred in the Beaufort Sea pack ice than occurred more than 30 years ago and that this will also increase the rate of reduction in thickness and areal extent of sea ice (Rampal et al. 2009).

10.15.1.3 Changes Over the Last 50 Years

Environment Canada weather data for Tuktoyaktuk and Sachs Harbour has shown that mean air temperatures have increased in each month over the last 50 years with the largest increase in warming occurring during the fall and winter. In the fall and winter for both Tuktoyaktuk and Sachs Harbour, there has been an increase of 0.8°C every 10 years for a total increase of 4°C over the last 50 years (Fissel et al. 2013). In addition, precipitation levels have also been increasing, but at a much reduced rate than air temperature, with a 1% increase in

10.15.1.3 Changes Over the Last 50 Years (cont'd)

precipitation every decade. The observation systems at climate stations have a relatively low precision. Consequently, this small change in precipitation should be interpreted with caution. Of greater importance than precipitation in general is accumulated snow, which might increase, especially in spring and fall, in coastal areas. Determining the amount of snow accumulation over the ocean is more complicated because of the amount of sea ice present and the losses of snow into the ocean.

Surface winds have shown only small positive or negative trends over the last 50 years. Surface wind data from coastal weather stations, available over the last 50 years or more, indicate little or no increase in wind speeds and storm frequencies along the coastline of the Beaufort Sea (Hudak and Young 2002, Atkinson 2005, Manson and Solomon 2007). A recent study of monthly Beaufort Sea winds (measured at Tuktoyaktuk and the marine weather station at Pelly Island) revealed only small trends for most months. The long-term trends in the monthly average coastal wind speeds as computed for the March-April and October-November periods had a net change of about -20% from 1958 to 2007 (Fissel et al. 2009). The analysis of monthly wind stress from reanalyzed numerical model wind results over the years 1948 to 2006 (Hakkinen et al. 2008) are consistent with negative trends for the inshore shelf waters of the western Arctic Ocean. Overall, the monthly mean wind speeds in coastal areas appear to have decreased over the past five decades. However, wind speeds might be increasing in offshore areas (Hakkinen et al. 2008). There is an increase in the depth of offshore low-pressure systems but not an increase in the frequency of cyclones (Lukovich and Barber 2006). More cyclones tend to follow the sea ice-ocean interface. Consequently, these storms are moving further offshore as the ice edge retreats. The Beaufort Sea high-pressure system has become stronger between 1996 and 2011 (Moore and Pickart 2012) leading to enhanced easterly winds in the Beaufort Sea with larger increases at more offshore locations.

Changes in ocean wave properties have occurred over the past decade as a consequence of reduced ice concentration and areal extent, resulting in a longer duration of ocean wave activity (Fissel et al. 2012a). In recent years, evidence indicates that moderate to large wave events start in early June and extend into November as compared to the previous wave season in the 1980s of mid-June to late October (Fissel et al. 2012a).

10.15.1.4 Recent Climate Changes

The FDCPs have provided evidence of moderate to large wave events starting in early June and extending into November as noted by Fissel et al. (2012a). These trends are expected to continue and increase in the future because of the expected future reduction in sea-ice cover. Long-period swell waves originating from distant storms have only rarely occurred in past decades but might become more frequent in the future (Barber et al. 2008). These waves increase the loss rates of sea ice by breaking up floes into smaller sizes, which are more mobile and melt more rapidly (Asplin et al. 2012). In addition to increased surface waves, it is thought that internal waves (i.e., within the Beaufort Sea) will increase in size and frequency as sea-ice cover decreases (Rainville and Woodgate 2009).

The considerable changes in the late summer sea-ice cover of the Arctic Ocean as a whole, and in the deep water area of the Canada Basin adjoining the program area, might be related to a change in the atmospheric circulation patterns of the western Arctic Ocean. Sea ice and ocean observations from 2001 to 2011 suggest that the characteristics of the Arctic Ocean climate are different in recent years as compared to those of 1979 to 2000 (Proshutinsky 2011). In particular, there is less sea ice and the upper part of the ocean is warmer and fresher. These changes appear to be related to "the anticyclonic (clockwise) wind-driven circulation regime (which) has dominated the Arctic Ocean for at least 14 years (1997 to 2011), in contrast to the typical 5 to 8 year pattern of anticyclonic/cyclonic circulation shifts observed from 1948 to 1996" (Proshutinsky 2011).

The decline in sea-ice extent and the large reduction in multi-year ice in the form of melting ice and other mechanisms have increased the amount of fresh water in the upper ocean in the offshore Beaufort Gyre area. Over the shelf areas, the trend of increased fresh water has not occurred (Melling 2012 personal communication). Ocean heat content typically affects the melt flux to the sea ice either through upwelling of warmer water from depth or through solar insolation heating the ocean surface mixed layer, which then adds heat to the base of the sea ice. Warming will increase the heat flux to the lower atmosphere, creating a higher probability for more intense storms, particularly in the fall and early winter period (Raddatz et al. 2011).

Enhanced upwelling at the shelf edge has been observed since 2003 under the combined effect of reduced ice extent and the increased prevalence of the anticyclonic atmospheric circulation of the western Arctic Ocean (Pickart et al. 2011 and 2013, Moore and Pickart 2012). The underlying atmospheric circulation processes are not well understood, but appear to be a combination of overall strengthening of the Beaufort Sea high (anticyclonic) pressure system and more intense cyclones penetrating the Arctic from the Pacific and Atlantic oceans (Lukovich and Barber 2006).

10.15.2 EFFECTS RELATED TO PRIMARY PRODUCTIVITY

Changes in the timing and magnitude of river discharge and sea-ice coverage, as well as fresh water nutrient concentrations and wind mixing, are predicted to have effects on primary production. During the growing season the fresh surface layer is typically nutrient depleted, with the main source of nutrients originating from the deeper Pacific water. As a result, there is a subsurface chlorophyll maximum at the top of Pacific water (Carmack et al. 2004). Increases in fresh water content will strengthen stratification, although in the nearshore environment increases in river flow will support stronger estuarine entrainment of nutrients from deeper water. With decreased ice cover, wind-driven mixing will work against the increased stratification and affect productivity in coastal, shelf and basin waters (McClelland et al. 2012). A deepening of the chlorophyll maximum in the Canada Basin from 45 m in 2003 to an average of 61 m in 2008

10.15.2 EFFECTS RELATED TO PRIMARY PRODUCTIVITY (cont'd)

has been observed (Jackson et al. 2010) and is associated with the deepening of the nutricline (McLaughlin and Carmack 2010).

With decreasing sea-ice coverage there is expected to be an increase in primary production, but this is expected to manifest mostly in nutrient-rich (diatom-dominated) regions such as the Amundsen Gulf (Ardyna et al. 2011). Evidence of this appears in a recent report by Arrigo et al. (2012) who described "massive blooms" of phytoplankton under thinning sea ice in the Chukchi Sea. However, with increased stratification, overall function and structure might shift to characteristics of more oligotrophic regions (flagellate-based). There is recent evidence that picophytoplankton-based systems are becoming more prevalent in the Arctic Ocean (Li et al. 2009). This has implications for energy transfer to higher trophic levels (Kirchman et al. 2009).

Carmack et al. (2006) argue that, should the seasonal ice cover retreat beyond the shelf break, this would set up conditions for the onset of shelf-break upwelling (Carmack and Chapman 2003), which would then draw nutrient-rich waters onto the shelf where they can be mixed into the euphotic zone, with attendant stimulation of primary production.

10.15.3 EFFECTS RELATED TO SEA-LEVEL RISE, STORM SURGES AND COASTAL EROSION

Landfast ice changes with air temperature and snow accumulation. Dumas et al. (2005) found that an increase of 4°C in annual average temperature and of 20 to 100% in snow accumulation rate will result in a 24 to 39 cm reduction in the mean maximum ice thickness and a three-week reduction in the duration of landfast ice at coastal locations in the Canadian sector of the Beaufort Sea. A recent study by Galley et al. (2012) on landfast sea-ice conditions in the Canadian Arctic reveals that the formation of landfast ice in the coastal margins of the Mackenzie Delta area of the Beaufort has undergone a delay of 2.8 weeks per decade from 1983 to 2009, which is statistically significant. Over this same 26-year period, the breakup dates of the landfast ice have advanced at 0.65 weeks per decade, also at a statistically significant level.

Coastal zone erosion in Arctic regions is a complex process affected by (Anisimov et al. 2007):

- factors common to all parts of the world, such as:
  - exposure
  - relative change in sea level
  - climate and soil properties
- factors specific to the high latitudes, such as:
  - low temperatures
  - ground ice
  - sea ice

The most severe erosion problems arise in areas of rising sea level, where warming coincides with areas that are seasonally free of sea ice or where there is widespread ice-rich permafrost (Forbes 2005 and 2011). Changes in the Beaufort Sea level are also complicated to interpret, because of the processes that increase or decrease water levels over different time scales, including:

- compaction of deltaic sediments
- ocean warming
- the possibility of larger and more frequent storm surges
- changes to fresh water input from the Mackenzie River
- changes from melting of glacial ice, which reduces the fresh water input (i.e., the Greenland ice cap)
- glacio-isostatic rebound
- monthly and longer period changes to ocean tides
- changes to atmospheric pressure patterns

Based on evidence over the past decades, it appears that sea-level rises resulting from oceanic conditions are outpacing the geological factors (Forbes 2005 and 2011). Environmental parameters that contribute to shoreline retreat are:

- wave erosion
- high summer air temperatures

Areas with bedrock near the surface of the ground, which includes much of the Canadian Arctic islands, or areas where glacio-isostatic rebound is occurring, are less vulnerable to erosion. On the north side of the Amundsen Gulf and further west, for example, at Sachs Harbour and Tuktoyaktuk, James et al. (2011) reported that subsidence is occurring at a rate of about 1 mm/yr and 2.5 mm/yr. These scientists also calculated that for every 1 mm of global sea level contributed by melting of the Greenland ice cap, the rise in sea level around Tuktoyaktuk could range between 20 cm and 1 m by 2100.

Despite common concerns expressed by community residents of increased erosion rates in the western Arctic, a regional analysis for the southern Beaufort Sea detected no significant increase in the trend in areas of rapid erosion for the 1972 to 2000 time interval. Typical erosion rates of 1.0 to 2.0 m/yr have been reasonably consistent over the past 30 years (Manson and Solomon 2007). However, further warming, combined with sea-level rise, can be expected to maintain or increase the rate of coastal subsidence (Prowse et al. 2009). This will increase the area of coastal and low-lying land that could be subject to flooding or inundation during storm surges.

10.15.3.1 Potential Effects on Oil and Gas Activities

The potential effects on oil and gas activities from climate change related to sea-level rise, storm surges and coastal erosion in a nearshore or onshore settings include:

- construction-related issues if infrastructure in Tuktoyaktuk Harbour needs to be refurbished or modified for the program
- possible increased frequency of dredging required to maintain entrances and anchorages, such as McKinley Bay (not currently used by ships) and Tuktoyaktuk Harbour

It is possible that a rise in sea level combined with coastal subsidence could lead to more onshore areas being affected by spills because nearshore or offshore spills could drift into these areas. This might occur during large storm surges that flood a greater amount of low-lying land along the shore than in the past.

11.1.1 OVERVIEW

The program has the potential to affect people and communities in the NWT, particularly the six communities in the ISR and might include effects on:

- traditional harvesting (i.e., fishing and hunting of marine mammals)
- culture
- the economy
- demographics

In addition to effects on ISR communities, non-community users of the sea and coast might also be affected.

The program is located in the Beaufort Sea about 125 km north-northwest of Tuktoyaktuk (see Figure 6-2, shown previously) within the administrative boundaries of the ISR, which includes the northern portion of the Yukon and the northwest portion of the NWT. In accordance with the IFA, the ISR is administered by the Inuvialuit Regional Corporation (IRC) on behalf of Inuvialuit beneficiaries.

The six ISR communities are located within the boundaries of the NWT. The communities of Tuktoyaktuk, Paulatuk, Ulukhaktok and Sachs Harbour are coastal communities, Inuvik and Aklavik are located inland. Of the six communities, Tuktoyaktuk is located closest to the program area. The ISR communities all have municipal hamlet status, except the Town of Inuvik. The nearest coastal community outside of the ISR is Kugluktuk, Nunavut.

11.1.2 NORTHWEST TERRITORIES

According to the NWT Bureau of Statistics (NWTBS), on January 1, 2013, the population of the NWT was estimated to be 43,407, a decrease of 0.1% of the total population over the last three years. However, over the last decade the population of the NWT has grown. This growth is attributed to natural increase (i.e., births less deaths) rather than to in-migration (between 2001 and 2011, the NWT net migration was negative with 3,000 more people migrating out of the NWT than in).

Nearly half (45.6%) of the NWT population resides in Yellowknife, the territorial capital, and the remainder live in smaller communities (NWTBS 2013b). Roughly half (51%) of the NWT population is Aboriginal, with a much higher proportion living in smaller communities (NWTBS 2013c).

11.1.2 NORTHWEST TERRITORIES (cont'd)

Compared to the Canadian national average, the NWT has a high employment participation rate, even during the bottom of seasonal employment cycles. Smaller communities tend to experience higher seasonal variation (NWTBS 2013d). The March 2013 unemployment rate in the NWT was 7.7% (NWTBS 2013e) or about 3,000 unemployed individuals.

The NWT has high income levels and the gross domestic product per capita is considerably higher than in the rest of Canada (Statistics Canada 2012a, b). Nevertheless, even with high income levels and economic growth, the NWT faces challenges in terms of housing and infrastructure. Educational attainment lags behind the rest of Canada, especially in the small communities (NWTBS 2012a).

11.1.3 INUVIALUIT SETTLEMENT REGION

11.1.3.1 Overview

In 2009 and 2010, Imperial undertook extensive community consultation with the six ISR communities. The following socio-economic key issues were identified through this consultation:

- cultural effects relating to effects on wildlife (e.g., whales and polar bears), resulting from drilling and ice management activities
- loss or impairment of traditional harvesting and access to traditional hunting and fishing areas
- compensation for losses under the IFA and the claims process
- collection of traditional knowledge and integration into the exploration program
- business and employment opportunities (i.e., availability and access)
- training needs and opportunities, such as apprenticeship
- education, such as fostering interest in technical fields

Overall, there is a general consensus in the ISR that oil and gas companies could have increased their efforts to involve local residents and businesses in the planning phase of projects. There is also optimism that this effort is changing for ongoing and upcoming projects.

The six ISR communities have prepared and adopted CCPs to guide land use and land management in the region. The CCPs define five land and sea use management categories and make recommendations for future development. For further information on the management zone categories, see Section 11.4, Management Zones and Special Designated Lands.

A portion of the program area, shipping supply routes and onshore activities fall within Category C zones of the Tuktoyaktuk, Aklavik, Inuvik and Paulatuk CCPs. In addition, the LSA overlaps the bowhead and beluga whale summer aggregation area. This area might also be important to polar bears and seals. The Tuktoyaktuk Peninsula coastal zone has been identified as important habitat for fish and beluga whales. The coastal zone covers the area up to 10 km offshore of the Tuktoyaktuk Peninsula.

11.1.3.2 Culture and Demographics

In 2011, the population of the ISR was 6,049. The populations of Tuktoyaktuk and Aklavik decreased between 2001 and 2011, but other communities grew. Ulukhaktok had the highest population growth at almost 15% (NWTBS 2012a).

Traditional activities and knowledge are important in all ISR communities. However, traditional activities and knowledge of Aboriginal languages are usually more important in smaller communities (NWTBS 2012a).

Except for Inuvik, the ISR communities tend to score lower on certain socio-economic indicators as compared to the NWT as a whole. Except for Sachs Harbour and Inuvik, education levels are lower in the ISR communities than the rest of the NWT (NWTBS 2012a).

11.1.3.3 Economy

In recent decades, the ISR communities have changed from having traditional economies that relied on resource harvesting to having wage-based economies. New sectors include government services, tourism, transportation services and services related to oil and gas exploration. However, hunting, trapping, fishing, commercial game harvesting and traditional arts and crafts also continue to generate income and cultural value for many Inuvialuit and non-Inuvialuit residents.

Except for Inuvik, incomes are considerably lower in the ISR communities than in the rest of the NWT. This difference is likely caused in part by the importance that traditional activities still hold in the smaller ISR communities. The high cost of living and generally lower income levels in the ISR likely contribute to quality of life issues in ISR communities. The March 2013 unemployment rate in the ISR was 7.7% and has been stable over the last few years (NWTBS 2013f).

The Inuvialuit, through the IFA, are responsible for the management of financial assets, land and marine mammals, fish and wildlife. Multiple agencies have been created to perform these functions, including the IRC, Inuvialuit Land Administration, the Inuvialuit Game Council (IGC) and community corporations.

Tourism is a growing industry in the ISR, with a variety of tours available by land, water and air. Most tourists visit the ISR in the summer. Tourism companies are mainly located in Inuvik and Tuktoyaktuk.

11.1.3.3 Economy (cont'd)

Transportation activities play a growing role in the ISR. Community resupply primarily occurs when vessels can travel in ice-free seas. Regional transportation terminals are located in Inuvik and Tuktoyaktuk. Several companies provide air transportation services in the ISR. These businesses are mainly based in Inuvik and provide supply or charter services for government, industry, local residents and tourists.

Oil and gas activities and related services, have gained economic importance in recent years. Given the number of approved exploration and production licences, the related onshore and offshore activities are expected to increase in the coming years.

Within the ISR, the traditional economy and traditional culture are closely related, and changes in one can have effects on the other. For example, decreased participation in traditional activities can have an effect on the practice and transmission of traditional culture. The IRC has taken measures to increase the use of Aboriginal languages and participation in cultural activities, such as establishing the Inuvialuit Cultural Resource Centre.

11.1.3.4 Traditional Harvesting

All of the ISR communities are involved in traditional harvesting practices. Marine species harvested include:

- marine mammals, such as beluga whales, polar bears and seals
- marine birds
- fish

Typically, marine species are harvested at various locations along the ISR coastline. Overviews of traditional harvesting have been prepared for each of the ISR communities and are presented in Section 11.2, Community Profiles.

Sources of harvesting information include the traditional knowledge studies undertaken by the joint venture partners (Imperial, ExxonMobil and BP) in 2010 (Golder 2011a, b, c, d, e, f) and the CCPs prepared by Inuvialuit communities (Aklavik 2008, Inuvik 2008, Paulatuk 2008, Sachs Harbour 2008, Tuktoyaktuk 2008, Ulukhaktok 2008).

11.2.1 SOCIO-ECONOMIC DATA

The quantitative socio-economic data referred to in the community profiles is provided in Table 11-1.

Table 11-1: Socio-Economic Data for ISR Communities and NWT

Indicator	Tuktoyaktuk	Inuvik	Paulatuk	Ulukhaktok	Sachs Harbour	Aklavik	NWT
Population estimates (2011)	935	3,504	341	479	135	655	43,675
Population growth (2001 – 2011)	-6.4	3.2	6.9	14.9	8.0	-4.7	6.9
Percentage of population that is Aboriginal (2008)	84.2	63.8	83.9	89.1	88.9	89.0	50.9
Percentage of population that hunt and fish (2008)	54.4	40.8	68.7	66.9	72.6	53.7	39.4
Percentage of population that trap (2008)	5.8	7.9	9.9	7.8	10.5	18.3	6.2
Percentage of population that produce arts and crafts (2009)	11.7	10.6	16.0	30.8	20.0	16.1	8.7
Percentage of houses that consume country foods (2008)	63.3	25.2	74.7	62.9	61.7	51.3	28.1
Percentage of community that speak an Aboriginal language (2009)	22.3	16.2	23.4	60.1	40.0	19.2	38.0
Percentage of community with high school diploma or more	46.1	68.6	37.0	36.0	66.3	38.0	69.3
Percentage of community that is unemployed (2009)	26.0	10.1	15.2	19.9	13.2	32.3	10.3
Employment rate (%) (2009)	44.4	71.2	46.9	42.9	69.5	36.2	67.3
Percentage of population that smokes (2009)	65.2	43.4	63.2	60.4	56.8	60.1	35.2
Cost of living differential (Edmonton =100) (2009)	172.5	147.5	177.5	177.5	177.5	167.5	n/a
Percentage of homes with Internet access (2008)	43.1	76.6	61.3	47.9	68.1	32.9	73.5
Average personal income ($) (2009)	32,228	51,867	27,375	28,600	n/a	31,174	52,998

Note: n/a = data not available
Source: NWTBS 2012b

11.2.2 TUKTOYAKTUK

11.2.2.1 Overview

Tuktoyaktuk is the nearest community to the program EL areas. This coastal community is located on Kugmallit Bay about 140 km north of Inuvik and 125 km south of the program EL areas. Tuktoyaktuk is the second largest community in the ISR and is accessible by air, winter ice road, and by water during the ice-free season.

11.2.2.2 Culture and Demographics

Despite an increase in oil and gas-related activity, the population of Tuktoyaktuk decreased between 2001 and 2011. Furthermore, during this period, the number of people 60 years and older increased. Current population projections predict a continued population decrease in Tuktoyaktuk (NWTBS 2012b).

Relatively few people in Tuktoyaktuk speak an Aboriginal language. However, some traditional activities are still common.

11.2.2.3 Economy

Tuktoyaktuk first became involved in oil and gas-related services in the 1970s. However, these activities decreased significantly during the 1980s. Recently, resource development activities in the Beaufort Sea and Mackenzie Delta have reawakened the oil and gas service sector in Tuktoyaktuk. The community’s location on the Beaufort Sea and the available harbour would make it a possible location for shore-based activities, if this option were selected for the program. Tourism, transportation and government services are also important economic contributors to the community.

Unemployment levels in Tuktoyaktuk are high, even with the recent oil and gas activities (NWTBS 2012b).

According to an April 2013 news release from the Canadian Environmental Assessment Agency, plans to build a highway between Tuktoyaktuk and Inuvik could lead to substantial decreases in the cost of living in Tuktoyaktuk because of potentially lower transportation costs for goods and supplies.

11.2.2.4 Traditional Harvesting

As part of the joint venture’s traditional knowledge studies, harvesting information was collected for harp, ringed and bearded seals. The information collected identified important harvesting locations used in the spring and fall at several areas, including Kugmallit Bay, the Husky Lakes region, Hutchinson Bay and other northern coastal areas of the Tuktoyaktuk Peninsula (Golder 2011a).

During the winter, seals and polar bears have extensive ranges that include the entire offshore of the Tuktoyaktuk Planning Area, and are harvested throughout this area (Tuktoyaktuk 2008).

During the summer, the residents of Tuktoyaktuk, Inuvik and Aklavik harvest beluga whales in an area where these whales historically concentrate (the Beluga Management Zone 1A designated in the Tuktoyaktuk CCP) (Tuktoyaktuk 2008). The joint venture's traditional knowledge studies identified that beluga whale harvesting also occurs in Kugmallit Bay, Shallow Bay and the Mackenzie River Delta (Tuktoyaktuk 2008, Golder 2011a). The beluga whale harvest is particularly important for residents of Tuktoyaktuk, as the harvested muktuk (the outer skin and blubber) is used for subsistence and as a currency for barter with other communities for Arctic char and caribou (Golder 2011a).

The joint venture's traditional knowledge studies identified that subsistence fishing occurs year-round at various sites within the program area, including Kugmallit Bay, Tuktoyaktuk Harbour and along the coastal areas of Tuktoyaktuk Peninsula (Golder 2011a). Many of these sites have documented past and present harvesting activities for Arctic char, whitefish and Pacific herring (Tuktoyaktuk 2008).

Birds, especially geese, are also traditionally harvested and their eggs are collected along the coastline around Tuktoyaktuk, the Mackenzie River Delta, and the Mackenzie Bay and Shallow Bay areas (Tuktoyaktuk 2008, Golder 2011a).

The Tuktoyaktuk Peninsula coastal and nearshore areas also provide important winter habitat and harvesting areas for the Bluenose-West caribou herd (Tuktoyaktuk 2008).

The Tuktoyaktuk CCP (Tuktoyaktuk 2008) designates several key habitat areas considered to be of high importance because these locations provide feeding, breeding, spawning, migration or staging grounds for animals harvested at other locations. The Tuktoyaktuk CCP also identifies important grizzly bear denning habitats along the coastal areas of the Tuktoyaktuk Peninsula. The management zone categories and special designated lands identified in the Tuktoyaktuk CCP are provided in Section 11.4, Management Zones and Special Designated Lands.

11.2.3 INUVIK

11.2.3.1 Overview

Inuvik is located about 1,100 km north of Yellowknife and is the regional centre of the ISR. Inuvik is accessible year-round by air and road and by the Mackenzie River during the ice-free summer months. Inuvik is the largest community in the ISR and the only community that has a town status.

11.2.3.2 Culture and Demographics

Because of its larger population and smaller proportion of Aboriginal people, traditional activities are less common in Inuvik than in other ISR communities. Inuvik tends to score relatively well on socio-economic indicators.

11.2.3.3 Economy

Inuvik's relatively large size and developed transportation infrastructure contribute to its status as the regional governmental, commercial and recreational hub for the Canadian Western Arctic. Government services include both federal and territorial representation, the IRC and Gwich'in Tribal Council. Local businesses include various services for resource-based industrial development, including oil and gas exploration.

Recently, the Government of Canada announced plans to build a new highway link between Inuvik and Tuktoyaktuk. This would further strengthen Inuvik's status as the primary service hub for oil and gas development in the Canadian Arctic (Canadian Environmental Assessment Agency 2013).

11.2.3.4 Traditional Harvesting

During the summer, the residents of Inuvik, Tuktoyaktuk and Aklavik harvest beluga whales in an area where these whales historically concentrate (the Beluga Management Zone 1A designated in the Inuvik CCP) (Inuvik 2008). The joint venture's traditional knowledge studies identified that beluga whale harvesting also occurs in Kugmallit Bay, the Mackenzie River Delta and near Kendall and Garry islands (Inuvik 2008, Golder 2011b). All of these locations were also identified as important areas for conducting traditional harvesting activities related to whaling and fishing, which are often harvested at the same time (Golder 2011b).

The joint venture's traditional knowledge studies identified that subsistence fish harvesting is conducted year-round in Kugmallit Bay, near Kendall Island, the Husky Lakes region and the headwaters of the Fish River for such marine species as Pacific herring, char and whitefish (Inuvik 2008, Golder 2011b). Historically, Fish Hole and Big Fish River were important in the harvesting of Arctic char (Inuvik 2008).

Birds, including geese and ptarmigan, are harvested and their eggs collected from various locations within the Mackenzie River Delta, Mackenzie Bay and Shallow Bay areas, Kendall Island, Egg Island and Ellice Island in spring and fall (Inuvik 2008, Golder 2011b).

The joint venture's traditional knowledge studies identified that while Inuvik residents do not hunt polar bears as frequently as those in other communities, polar bear harvesting does occur along the ice floe edge between Mackenzie Bay and Kugmallit Bay (Golder 2011b). Similarly, the prevalence of seal hunting by Inuvialuit residents of Inuvik has diminished (Golder 2011b).

Caribou hunting is currently limited because of low population numbers, but hunting does occur within the coastal areas of the Yukon Territory near Herschel Island (Golder 2011b).

The Inuvik CCP (Inuvik 2008) designates several key habitat areas considered to be of high importance because these locations provide feeding, breeding, spawning, migration or staging grounds for animals harvested at other locations.

The management zone categories and special designated lands identified in the Inuvik CCP are provided in Section 11.4, Management Zones and Special Designated Lands.

11.2.4 PAULATUK

11.2.4.1 Overview

Paulatuk is the second smallest community within the ISR and is located about 400 km east of Inuvik on Darnley Bay.

11.2.4.2 Culture and Demographics

Paulatuk has experienced substantial population growth over the last decade. It has a relatively high emphasis on traditional lifestyle. For example, no other ISR community has a higher number of households that consume country foods.

11.2.4.3 Economy

Paulatuk's economy is primarily focused on traditional harvesting activities, such as hunting, fishing and trapping. Other traditional activities, such as locally produced arts and crafts are also important economic contributors. Wage-based sectors include governmental and retail operations and some oil and gas-related services. Of the six ISR communities, Paulatuk has the lowest income levels.

11.2.4.4 Traditional Harvesting

The joint venture's traditional knowledge studies identified that the harvesting of Arctic char is one of the most important food resources for the community of Paulatuk, along with Arctic cod, herring and whitefish, which are all harvested along the coast of Darnley Bay east to Pearce Point (Golder 2011c).

Polar bears are hunted in the winter and spring, mostly by sport hunters, on the coastline and ice floe edge between Baillie Island and Clinton Point. Traditional polar bear harvesting still occurs, primarily for hides and occasionally as a source of food (Golder 2011c).

Although the popularity of hunting seals is diminishing, subsistence hunting for ringed and bearded seals occurs from January to May and August to September. Seal hunting generally occurs while hunting for other wildlife, such as polar bears, in areas east of Baille Island (Golder 2011c).

The joint venture's traditional knowledge studies identified that Inuvialuit residents of Paulatuk harvest beluga whales as important food source during the summer months along the coast from Balaena Bay toward Brock Lagoon. These harvesting activities primarily occur close to shore. However, if the weather is favourable, these activities occur further offshore in Darnley Bay (Golder 2011c). Currently, Paulatuk residents do not hunt bowhead whales because they are not licenced to do so (Golder 2011c).

11.2.4.4 Traditional Harvesting (cont'd)

Bird harvesting and egg collecting activities are undertaken on the Parry Peninsula and in the coastal area near the Brock River and often focuses on non-marine species (Golder 2011c). In addition to caribou and fish, geese are considered a main food source for the community (Golder 2011c).

The Paulatuk CCP (Paulatuk 2008) designates several key habitat areas considered to be of high importance because these locations provide feeding, breeding, spawning, migration or staging grounds for animals harvested at other locations. The management zone categories and special designated lands identified in the Paulatuk CCP are provided in Section 11.4, Management Zones and Special Designated Lands.

11.2.5 ULUKHAKTOK

11.2.5.1 Overview

Ulukhaktok is a mid-size community in the ISR and is located on the western shore of Victoria Island about 650 km northeast of Inuvik.

11.2.5.2 Culture and Demographics

Compared to other ISR communities, Ulukhaktok has experienced the fastest growth over the last decade (14.9%). It has a high proportion of Aboriginal people in the community and over 60% speak an Aboriginal language, the highest proportion in the ISR (NWTBS 2012b).

11.2.5.3 Economy

The economy in Ulukhaktok is primarily based on employment from governmental and retail operations, and industries related to traditional arts and culture. In 2009, almost one-third of residents produced arts and crafts, such as prints and tapestries (NWTBS 2012b).

11.2.5.4 Traditional Harvesting

The Emangyok Sound coastline is traditionally and culturally significant to the people of Ulukhaktok and Sachs Harbour based on historical use and present-day traditional harvesting activities for subsistence hunting of polar bears and seals. Polar bear hunting also occurs along the Kangikhokyoak (Liddon) Gulf, offshore in the marine and coastal areas at the northern end of Victoria Island and around Nelson Head (Banks Island) (Ulukhaktok 2008, Golder 2011d).

Offshore areas of Minto Inlet, Prince Albert Sound and into the Amundsen Gulf, as far west as Nelson's Head, are important locations for harvesting seals, polar bears, beluga whales, birds and Arctic char (Ulukhaktok 2008). Beluga whale harvesting only occurs on an opportunistic basis, when the whales are found in shallow waters, and even then they are not commonly harvested by the residents of Ulukhaktok (Golder 2011d).

The Olokhaktomiut CCP (Ulukhaktok 2008) designates several habitat areas considered to be of high importance because these locations provide feeding, breeding, spawning, migration or staging grounds for animals harvested at other locations. The management zone categories and special designated lands identified in the Olokhaktomiut CCP are provided in Section 11.4, Management Zones and Special Designated Lands.

11.2.6 SACHS HARBOUR

11.2.6.1 Overview

Sachs Harbour is the smallest community in the ISR and is located on the southwestern shore of Banks Island about 523 km northeast of Inuvik.

11.2.6.2 Culture and Demographics

Proportionally, Sachs Harbour had a relatively substantial population growth over the last decade. A large proportion of the residents are Aboriginal and the community maintains a strong traditional culture (NWTBS 2012b).

11.2.6.3 Economy

The economy of Sachs Harbour is largely based on traditional harvesting activities, such as hunting, fishing and trapping. The annual muskox harvest provides an important source of income for the community. Tourism and the production of local arts and crafts provide a more limited contribution to the community economy. The importance of employment opportunities relating to oil and gas exploration has increased in recent years.

Sachs Harbour has the second lowest unemployment rate in the ISR.

11.2.6.4 Traditional Harvesting

Local residents conduct year-round seal substance harvesting in the offshore and onshore areas north, west and south of Banks Island. Fish and birds are also harvested in this area, and polar bears are hunted for both sport and subsistence. Past and present subsistence fishing for trout, Arctic char and cod occurs in the shallow offshore areas west of the community (Sachs Harbour 2008).

The joint venture’s traditional knowledge studies identified that beluga whales have been occasionally harvested in Sachs Harbour, and residents have shown interest in the future possibility of hunting beluga whales in the waters of De Salis Bay at Banks Island and Jesse Bay at Victoria Island (Sachs Harbour 2008, Golder 2011e).

The joint venture’s traditional knowledge studies identified that bowhead whales are not generally harvested by this community, although the whales are present at this location. Walrus are occasionally observed and harvested around Sachs Harbour (Golder 2011e). Seals are harvested along the Kangikhokyoak (Liddon)

11.2.6.4 Traditional Harvesting (cont'd)

Gulf shore area between December and May along with polar bear harvesting within the Prince of Wales Strait (Sachs Harbour 2008).

The Sachs Harbour CCP (Sachs Harbour 2008) designates several key habitat areas considered to be of high importance because these locations provide feeding, breeding, spawning, migration or staging grounds for animals harvested at other locations. The management zone categories and special designated lands identified in the Sachs Harbour CCP are provided in Section 11.4, Management Zones and Special Designated Lands.

11.2.7 AKLAVIK

11.2.7.1 Overview

Aklavik is a mid-sized community in the ISR, located on the west shore of Peel Channel in the Mackenzie Delta about 58 km west of Inuvik.

11.2.7.2 Culture and Demographics

The population of Aklavik has decreased in the last decade. The proportion of Aboriginal residents is high and traditional activities are important, particularly trapping. Education achievements are low compared to other ISR communities.

11.2.7.3 Economy

The Aklavik economy is primarily focused on traditional activities and tourism, including eco-tourism. Unemployment is high.

11.2.7.4 Traditional Harvesting

During the summer, the residents of Aklavik, Inuvik and Tuktoyaktuk harvest beluga whales in an area where these whales historically concentrate (the Beluga Management Zone 1A designated in the Aklavik CCP) (Aklavik 2008). Beluga whale subsistence harvesting also occurs in Kugmallit Bay and the Mackenzie River Delta (Golder 2011f).

Bowhead whales were traditionally harvested along the Yukon North Slope coastal zone. This area continues to be important habitat location for this species (Aklavik 2008).

The Husky Lakes region and associated shoreline and islands south and east of Tuktoyaktuk have been, and still are, used for year-round subsistence fishing. Mackenzie Bay, the inner Mackenzie Delta, and Shallow Bay are also important traditional fishing areas. Birds are harvested from Mackenzie Bay, the Mackenzie Delta and Shallow Bay areas (Aklavik 2008).

Although seals are occasionally harvested, the joint venture's traditional knowledge studies identified that seal hunting has become less commonplace among Aklavik residents. Polar bear hunting still occurs on the ice off coastal areas during spring (Golder 2011f).

The Aklavik CCP (Aklavik 2008) designates several key habitat areas considered to be of high importance because these locations provide feeding, breeding, spawning, migration or staging grounds for animals harvested at other locations. The management zone categories and special designated lands identified in the Aklavik CCP are provided in Section 11.4, Management Zones and Special Designated Lands.

11.3.1 OTHER USERS

The sea around the program ELs is used by various non-community members that could potentially be affected by the program.

During the life of the proposed program, it is possible that at least three companies (i.e., ConocoPhillips, Chevron and Franklin Petroleum) could be active near the program EL areas and supply routes. Industrial activities might include seismic surveys, geological and geophysical surveys, and drilling.

From a maritime perspective, other types of land and sea use include:

- travel along the coast by non-ISR residents in small vessels during the summer
- coastal trade involving ships and river- and ocean-going barges to resupply communities along the coast (these vessels can originate from the west coast of Canada or, more commonly, from Inuvik and extend as far east as Paulatuk and Kugluktuk, Nunavut, and as far north as Sachs Harbour and Ulukhaktok)
- a port and road project has been proposed at Bathurst Inlet. If this project is pursued, relatively large bulk carriers could be transiting the Beaufort Sea (presumably through deeper waters).
- a fibre-optic communication cable could be installed on the seafloor between Alaska and southern Greenland, which would involve using ships for site and route surveys, laying cable to some ISR communities and ongoing maintenance. A Canadian company (Arctic Fibre Inc.) is actively pursuing design, construction, installation and operation of this cable.
- CCG operations in the Beaufort Sea, including scientific surveys, search and rescue, sovereignty patrol, oil spill response, navigational aid and support to civil authorities
- cruise ships and adventure tourism, which will likely become an important economic input in the future increasing the frequency of vessel traffic (this tourism has historically included motor yachts, large and small sailing boats, icebreakers acting as cruise ships and small ice-strengthened cruise ships attempting to transit the Northwest Passage)
- scientific surveys by other vessels not related to oil and gas activity, including fishing and seismic surveys
- Canadian and American surface and submarine naval operations

11.4.1 RELATIONSHIP TO STUDY AREAS

The LSA and RSA partially overlap several areas designated within Inuvialuit CCPs as special regions, including management zones and special designated lands. As stated in each CCP, there are five management categories, four of which identify areas of particular ecological or cultural importance (see Table 11-2 and Figure 11-1).

Table 11-2: Definition of Management Categories

Management Category	Description
A	Lands and waters where there are no known significant and sensitive cultural or renewable resources. These lands and waters will be managed according to current regulatory practices.
B	Lands and waters where there are cultural or renewable resources of some significance and sensitivity but where terms and conditions associated with permits and leases shall assure the conservation of these resources.
C	Lands and waters where cultural or renewable resources are of particular significance and sensitivity during specific times of the year. These lands and waters shall be managed to eliminate, to the greatest extent possible, potential damage and disruption.
D	Lands and waters where cultural or renewable resources are of particular significance and sensitivity throughout the year. As with Category C, these areas shall be managed to eliminate, to the greatest extent possible, potential damage and disruption.
E	Lands and waters where cultural or renewable resources are of extreme significance and sensitivity. There shall be no development on these areas. These lands and waters shall be managed to eliminate, to the greatest extent possible, potential damage and disruption.

Within these management categories, special designated lands have been recognized, which identify specific harvesting or habitat areas. The special designated lands that overlap the RSA and LSA are listed in Table 11-3 and a description of these areas is provided in Table 11-4.

Table 11-3: Special Designated Lands Overlapping the RSA and LSA

ISR Community	Special Designated Land Number	
	RSA Overlap	**LSA Overlap**
Tuktoyaktuk	301C, 305C, 307C, 310C, 311C, 313C, 316C, 322C and 323C (9 areas)	301C, 305C, 307C, 310C, 311C, 313C, 316C, 322C and 323C (9 areas)
Paulatuk	403C, 409C, 410C, 414C, 418E, 419C, 420C, 422D, and 424C (9 areas)	403C, 410C, 414C, 418E, 419C, 420C, 422D, and 424C (8 areas)
Ulukhaktok	502B, 503B, 508C, 509BE, 510D, 512E, 517E, 522C, 523D 524C, 525C, and 528E (12 areas)	None
Sachs Harbour	601C, 603D, 609E, 610B, 615C, and 616D (6 areas)	None
Inuvik, Tuktoyaktuk, Aklavik	701E, 703D, 704C, 705E, 706D, 707D, 710CD, 711E, 712C, 714CDE, 715C, 716CE, 718D, 719C, 721D, 726E, 733C and 734C (18 areas)	701E, 704C, 710CD, 711E, 712C, 714CDE and 726E (7 areas)

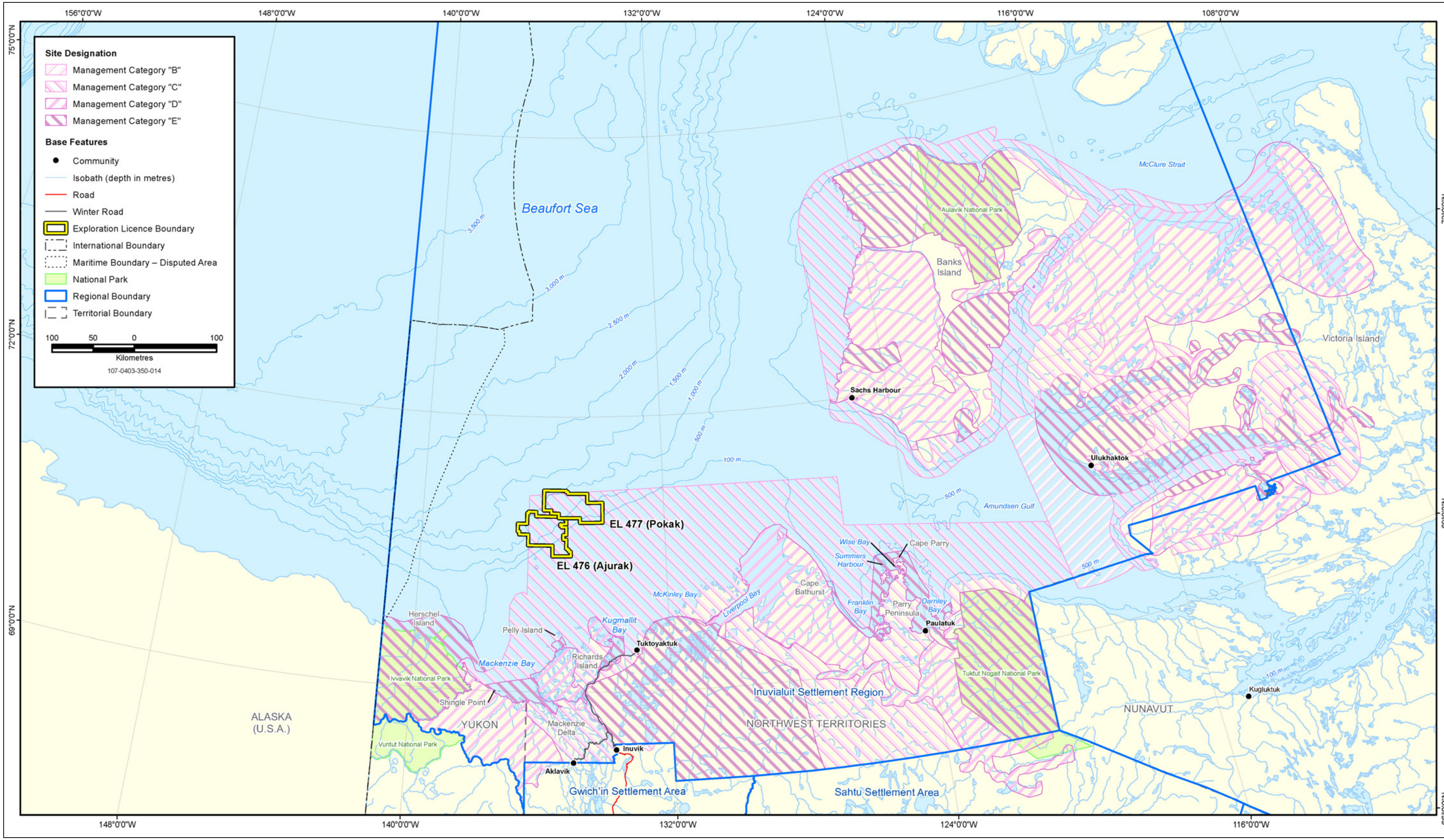


Figure 11-1: Land Use Categories in the Beaufort Sea Region

Table 11-4: Description of Special Designated Lands

Site No.	Site Name	CCP Report	Importance	Species Affected	Time Period	Description
301C	Spring Seal Harvesting Areas	Tuktoyaktuk	Harvesting: marine mammal	Seal	April to June	Husky Lakes region just inside Finger Lakes.
305C	Spring Fishing Areas	Tuktoyaktuk	Harvesting: marine fish	Not identified	Spring	Various sites.
307C	Summer Fishing Areas	Tuktoyaktuk	Harvesting: marine fish	Not identified	Summer	Various sites.
310C	Fall Fishing Areas	Tuktoyaktuk	Harvesting: marine fish	Not identified	Fall	Various sites.
311C	Fall Seal Harvesting Areas	Tuktoyaktuk	Harvesting: marine mammal	Seal	Fall	Various sites.
313C	Winter Seal and Polar Bear Harvesting Areas	Tuktoyaktuk	Harvesting: marine mammal	Polar bear	Winter	Entire offshore within the Tuktoyaktuk Planning Area.
316C	Winter Fishing Areas	Tuktoyaktuk	Harvesting: marine fish	Not identified	Winter	Various sites.
322C	Critical Grizzly Bear Denning Areas	Tuktoyaktuk	Habitat area: terrestrial mammal	Grizzly bear	October to May	Coastal areas from the western portion of Richards Island, east to Fingers Area and northeast to include the Tuktoyaktuk Peninsula. Second area from the mouth of Anderson River along the coast of Wood Bay to the mouth of the Horton River.
323C	Mainland Coastal Polar Bear Denning Areas	Tuktoyaktuk	Habitat area: marine mammal	Polar bear	October to March	Three coastal areas: Kay Point to Summer Island, northeast portion of the Tuktoyaktuk Peninsula, northern portion of Cape Bathurst and Baillie Islands.
403C	Spring Polar Bear/Seal Harvesting Areas	Paulatuk	Harvesting: marine mammal	Polar bear, ringed seal	Year-round	Nearshore and offshore waters of Franklin Bay and Darnley Bay east to the west side of Clinton Point.
409C	Summer/Fall Fish Harvesting Areas	Paulatuk	Harvesting: marine fish	Char, herring, whitefish	Summer	Coastal waters in Darnley Bay from mouth of Bennett Point to Pearce Point.
410C	Summer/Fall Beluga Whale Harvesting Areas	Paulatuk	Harvesting and habitat area: marine mammal	Beluga and bowhead whale habitat areas	Summer	Mouth of Horton River, following coast around Darnley Bay to Brock Lagoon.

Table 11-4: Description of Special Designated Lands (cont'd)

Site No.	Site Name	CCP Report	Importance	Species Affected	Time Period	Description
414C	Winter Polar Bear/Seal Harvesting Areas	Paulatuk	Harvesting: marine mammal	Polar bear, seal	January to September	Nearshore and offshore waters of Franklin Bay and Darnley Bay, east to the west side of Clinton Point.
418E	Beluga Management Plan Zone 1B	Paulatuk	Harvesting: marine mammal	Beluga whale	Not identified	Encircles Parry Peninsula and includes Darnley Bay to Brock Lagoon.
419C	Parry Peninsula and Offshore Islands	Paulatuk	Habitat area: bird and waterfowl	Eiders, gulls, Brant, Canada geese	Not identified	Offshore islands and all of Parry Peninsula south to Langton Bay (west side) and Argo Bay (east side).
420C	Franklin Bay, Darnley Bay, Amundsen Gulf-Offshore	Paulatuk	Habitat area: marine mammal Harvesting: various	Bearded seal, ringed seal, beluga and bowhead whales	Year-round	Offshore from Cape Bathurst, including Franklin Bay, Darnley Bay and north into the Amundsen Gulf for 150 km.
422D	Cape Parry Migratory Bird Sanctuary	Paulatuk	Habitat area: bird and waterfowl	King eider, common eider, mergansers, oldsquaw	May to August	Coastal cliffs of the northern tip at Cape Parry.
424C	Coastal Areas of Parry Peninsula, Franklin Bay, Darnley Bay	Paulatuk	Habitat area: marine mammal, marine fish	Beluga whale, Arctic cod, saffron cod, Arctic cisco	Not identified	Waters bordering the coast of the Paulatuk Planning Area for a distance of 3 km offshore.
502B	Emangyok Sound Coastline	Ulukhaktok	Harvesting and habitat area: marine mammal	Beluga whale, ringed seal, bearded seal, polar bear	Year-round	Coastline and offshore areas of the Liddon Gulf, extending 10-15 km offshore into M’Clure Strait and Emangyok Sound over to Byam Martin Island.
503B	Kangikhokyoak (Liddon) Gulf Coastline	Ulukhaktok	Harvesting and habitat area: marine mammal	Polar bear	November to May	A 10 km area at Emankyoak (Cape Smith) and an additional area extending from Kangikhoalok (Hardy Bay) around Murray Inlet, Knagikhokyoak (Liddon) Gulf and all of Dundas Peninsula.
508C	Richard Collinson Inlet and Glenelg Bay	Ulukhaktok	Harvesting and habitat area: marine mammal	Polar bear, travel and feeding route for beluga and bowhead whales	Year-round	Marine and coastal areas at the northern end of Victoria Island. Includes all of Glenelg Bay, Richard Collinson Inlet and extends about 10 km offshore.

Table 11-4: Description of Special Designated Lands (cont'd)

Site No.	Site Name	CCP Report	Importance	Species Affected	Time Period	Description
509BE	Prince Albert Sound and Minto Inlet and Shoreline	Ulukhaktok	Harvesting: marine mammal, marine fish, birds and waterfowl	Bearded seal, ringed seal, polar bear, beluga whale, migratory birds, char	Year-round	Offshore areas of Minto Inlet, Prince Albert Sound and extends into the Amundsen Gulf. Also includes the southern coastal area of Prince Albert Sound.
510D	Tahioyak (Safety Channel)	Ulukhaktok	Harvesting: marine mammal, marine fish, birds and waterfowl	Seals, beluga whale, migratory birds, various fish and shellfish	Year-round	The shallow marine areas known as Tahioyak (Safety Channel), including Albert Island and Ulukhaktok Island, among others.
512E	Kuukyuak River and Diamond Jenness Coastal Zone	Ulukhaktok	Harvesting: marine fish, birds and waterfowl	Whitefish, char, flatfish, ducks, geese, swans	Year-round	Coastal region along north shore of Prince Albert Sound, extending about 5 km offshore. Head of the sound near Kaglokyuak River and extending around the tip of the Diamond Jenness Peninsula from southeast Eulukhaktok to the mouth of Kuukuak River in Minto Inlet.
517E	Habitat and Harvesting Areas Around Minto Inlet	Ulukhaktok	Harvesting: marine fish, birds and waterfowl	Migratory birds, char, whitefish	Year-round	Six areas: Kikitalok Island at the east end of Prince Albert Sound, Tahikyohok on the north shore of Minto Inlet, the Tahiyoak north area at the end of Minto Inlet, Pingokyoak, the area surrounding Walker Bay, Nigiyok Naghak on the south side of the Kuukuak River and Akolgotak, southwest of Tatik Lakes.
522C	Southwest Victoria Island Coastal Zone	Ulukhaktok	Harvesting and habitat areas: marine mammal, marine fish	Arctic char, ringed seal	Not identified	Waters of Prince Albert Sound south to William Point, Minto Inlet, North to Ramsey Island and across to Victoria Island shoreline.
523D	Hadley Bay Wildlife Area of Special Interest	Ulukhaktok	Habitat area: marine mammal	Polar bear	Year-round	Encompassing Richard Collison Inlet, Glenelg Bay and the land between the two bodies of water, to the eastern ISR boundary.
524C	Prince Albert Peninsula Wildlife Area of Special Interest	Ulukhaktok	Habitat area: marine mammal	Polar bear, seals	Not identified	Encompassing the northern and eastern portion of Prince Albert Peninsula, bordering Deans Dundas Bay to the west and Richard Collinson Inlet to the east.

Table 11-4: Description of Special Designated Lands (cont'd)

Site No.	Site Name	CCP Report	Importance	Species Affected	Time Period	Description
525C	Minto Inlet Wildlife Area of Special Interest	Ulukhaktok	Habitat area: marine mammal, birds and waterfowl	Polar bear, peregrine falcon	Year-round	Circular area encompassing Minto Inlet, Ulukhaktok and the western portion of Diamond Jenness Peninsula.
528E	Beluga Management Plan Zone 1B – Prince Albert Sound	Ulukhaktok	Harvesting: marine mammal	Beluga whale	Summer	Includes Walker Bay, Minto Inlet and the northern half of Prince Albert Sound.
601C	Offshore and Onshore Banks Island	Sachs Harbour	Harvesting and habitat areas: marine mammal, marine fish, birds and waterfowl	Ringed seal, bearded seal, various fish, waterfowl, polar bear	Year-round	Offshore and onshore areas of north, west and south Banks Island except along Prince of Wales Strait. Ends at Treadwell Point at the south end of Prince of Wales Strait.
603D	Areas near or on Sachs, Kellett and Lennie rivers, including Siksik and Survey Lakes	Sachs Harbour	Harvesting: marine fish, birds and waterfowl	Char, cod, Brant, snow geese	Year-round	Includes the islands in the shallow offshore area located west of the community of Sachs Harbour and extends along the Sachs River to Raddi Lake, then north to include part of Kellet River.
609E	Beluga Management Zone 1B Sites – De Salis Bay and Jesse Bay	Sachs Harbour	Harvesting: marine mammal (prospective)	Beluga whale	August to September	Includes the waters of De Salis Bay at Banks Island and Jesse Bay at Victoria Island, situated on the Prince of Wales Strait.
610B	Beluga Management Plan Zone 3 – waters greater than 20 m deep in Beaufort Sea, Amundsen Gulf	Sachs Harbour	Habitat area: marine mammal	Beluga whale	Summer	Includes the remaining geographic range of beluga whales in the Canadian sector of the Beaufort Sea and Amundsen Gulf (waters greater than 20 m deep).
615C	Banks Island coastal areas adjacent to rivers supporting Arctic char	Sachs Harbour	Habitat area: marine fish	Arctic char, Greenland cod	Not identified	Includes the coastal waters of southwestern, northwestern, and northern Banks Island, Thesiger Bay and Prince of Wales Strait.

Table 11-4: Description of Special Designated Lands (cont'd)

Site No.	Site Name	CCP Report	Importance	Species Affected	Time Period	Description
616D	Offshore Amundsen Gulf and Beaufort Sea	Sachs Harbour	Habitat area: marine mammal, marine fish	Beluga and bowhead whales, bearded seal, ringed seal, various fish	Year-round	Beaufort Sea Transition Zone – from 10 km offshore to permanent ice pack, Cape Bathurst Polynya – located in Amundsen Gulf.
701E	Bluenose-West Caribou Herd Winter Range	Inuvik, Tuktoyaktuk, Aklavik	Harvesting and habitat area: terrestrial mammal	Caribou	Winter	From southern ISR boundary to Tununuk, northeast to include the western portion of Tuktoyaktuk Peninsula, southeast to include the Anderson River and south to the ISR boundary.
703D	Kugaluk River Estuary	Inuvik, Tuktoyaktuk, Aklavik	Habitat area: marine mammal, marine fish, birds and waterfowl	Seal, beluga whale, grizzly bear, Pacific herring, snow geese, Brant, white-fronted geese, tundra swans, mergansers, glaucous gulls, scoters, scaup, oldsquaw	Year-round	From Liverpool Bay, southward, including Kugaluk and Miner river estuaries, linking the Husky Lakes and Liverpool Bay.
704C	Fish Lakes and Rivers	Inuvik, Tuktoyaktuk	Harvesting: marine fish	Not identified	Not identified	Rivers and lakes along the shoreline west of Tuktoyaktuk, inland to their headwaters, including Parsons and Yaya lakes.
705E	Husky Lakes	Inuvik, Tuktoyaktuk, Aklavik	Habitat area: marine mammal Harvesting: marine fish	Beluga whale, Pacific herring	Year-round	Includes the bays, islands and shorelines of the Husky Lakes, beginning at Sitidgi Creek and extending northeastward to Liverpool Bay.

Table 11-4: Description of Special Designated Lands (cont'd)

Site No.	Site Name	CCP Report	Importance	Species Affected	Time Period	Description
706D	Kendall Island Bird Sanctuary	Inuvik, Tuktoyaktuk, Aklavik	Habitat area: birds and waterfowl	Greater white-fronted geese, black Brants, lesser snow geese, tundra swans, sandhill cranes, ducks, shorebirds	Breeding season May to August (wetland is sensitive year-round)	Area of land and sea from Middle Channel and Harry Channels to southern tip of Garry Island.
707D	Anderson River Migratory Bird Sanctuary	Inuvik, Tuktoyaktuk, Aklavik	Habitat area: birds and waterfowl	Lesser snow geese, black Brants, greater white-fronted geese, Canada geese, tundra swans, oldsquaw, scaup, scoters	Spring to October (wetland is sensitive year-round)	Delta of low alluvial islands, channels and lakes surrounding lower Anderson River and extending northward into the shallows of Wood Bay.
710CD	Coastal Zones of the Tuktoyaktuk Peninsula, Liverpool Bay, Wood Bay, Baillie Islands	Inuvik, Tuktoyaktuk, Aklavik	Habitat area: marine mammal, marine fish	Beluga whale, Pacific herring, additional anadromous and marine fish species	Beluga whale – summer Fish – fall and winter	10 km coastline buffer, from Toker Point east to Baillie Islands, including Liverpool Bay, Wood Bay and Harrowby Bay.
711E	Beluga Management Plan Zone 1A	Inuvik, Tuktoyaktuk, Aklavik	Harvesting: marine mammal	Beluga whale	Summer (June to August)	Shallow waters at the mouth of Mackenzie River. Traditional beluga whale harvesting/concentration area.
712C	Beluga Management Plan Zone 2 – all Mackenzie Shelf waters shallower than 20 m	Inuvik, Tuktoyaktuk, Aklavik	Habitat area: marine mammal	Beluga whale	Summer (June to August)	From Baillie Islands to Kay Point. Major beluga whale travel corridor.
714CDE	Kugmallit Bay	Inuvik, Tuktoyaktuk, Aklavik	Harvesting: marine mammal	Beluga whale	Summer (June to August)	Kugmallit Bay, coastline and coastal waters east to Warren Point. Southwards to Richards Island.

Table 11-4: Description of Special Designated Lands (cont'd)

Site No.	Site Name	CCP Report	Importance	Species Affected	Time Period	Description
715C	Mackenzie River Delta Key Migratory Bird Habitat	Inuvik, Tuktoyaktuk, Aklavik	Harvesting: marine mammal, birds and waterfowl	Beluga whale, waterfowl	June to September	Shallow Bay, Olivier and Ellice islands, Pelly Island and part of Richards Island and surrounding waters.
716CE	Mackenzie Bay and Shallow Bay	Inuvik, Tuktoyaktuk, Aklavik	Harvesting: marine mammal, marine fish, birds and waterfowl	Beluga whale, various waterfowl, anadromous fish and coregonids	Beluga whale – June to August Fish – overwintering area	Important traditional fishing area and Beluga whale harvesting.
718D	Central Mackenzie Estuary	Inuvik, Tuktoyaktuk, Aklavik	Habitat area: marine mammal, marine fish	Beluga whale, various fish, including anadromous and coregonids	Not identified	Beluga whale concentration area, feeding area for anadromous coregonids, overwintering and nursery areas for various fish.
719C	Inner Mackenzie Delta	Tuktoyaktuk, Aklavik, Inuvik	Habitat area: marine fish	Arctic char, coregonids	Not identified	Migration route for anadromous Arctic char and coregonids, spawning areas and overwintering.
721D	Firth River and Babbage River Watersheds	Aklavik	Harvesting: marine fish	Char	Not identified	Fish hole at the top of the Babbage River is traditionally frequented for subsistence harvesting.
726E	Yukon North Slope Coastal Zone	Inuvik, Aklavik	Habitat area: marine mammal, marine fish	Bowhead whale, Arctic char, cisco	Bowhead whale: June to September	16 km area of coastal waters from the Yukon/Alaska boundary to the eastern border of Escape Reef in Mackenzie Bay.
733C	Southwestern Melville Island and Kangikhokyoak (Liddon) Gulf Coastline	Sachs Harbour, Ulukhaktok	Harvesting and habitat area: marine mammal	Polar Bear, ringed seal	November to May	Includes Liddon Gulf, Murray Inlet, Hardy Bay, Warrington Bay and part of Kellet Strait on Melville Island.
734C	Prince of Wales Strait	Sachs Harbour, Ulukhaktok	Harvesting and habitat area: marine mammal	Ringed seal, bearded seal, polar bear, beluga whale migration area	Year-round	Offshore from Treadwell Point to Russell Point, along entire length of Prince of Wales Strait, between Banks and Victoria islands.

RECENT INUVIALUIT CONSULTATION

12.1.1 BACKGROUND

Beginning in 2007, through communication and consultation, Imperial has sought the insights and concerns of the six ISR communities, Inuvialuit organizations and regulatory authorities affected by the exploration program. Imperial values these contributions.

The communication and consultation program reflects Imperial's commitment to open discussion with northerners on the exploration program planning process, including providing feedback and comments on socio-economic and environmental assessments, related mitigation plans and the Canada Benefits Plan.

12.1.2 OBJECTIVES

The objectives of the communication and consultation program are to:

- solicit and receive insights from northerners
- identify key issues and concerns early in the plans for a possible exploration program

12.1.3 SCOPE

Imperial and BP have conducted extensive consultation activities to learn about the Inuvialuit traditional way of life and to incorporate this knowledge into the planning for a potential exploration program. In addition to collecting information through consultation, Imperial provided information on potential exploration program activities to stakeholders, including:

- Imperial's consultation activities for EL 476 (Ajurak), beginning in 2007
- BP's consultation activities for EL 477 (Pokak), beginning in 2008
- joint consultation activities conducted under the Joint Operating Agreement for Ajurak and Pokak, beginning in September 2010

12.1.4 COMMUNICATION AND CONSULTATION METHODS

The communication and consultation process involves a variety of techniques that are effective in facilitating two-way dialogue and takes into consideration the particular nature and needs of the interested parties and the issues in question.

12.1.4 COMMUNICATION AND CONSULTATION METHODS (cont'd)

This process has included:

- meetings
- formal presentations
- workshops
- open houses
- participation in the Inuvik Petroleum Show
- informal discussions

Language interpretation services are often used at community meetings. The techniques used to communicate program information at these events include:

- brochures
- fact sheets
- newsletters
- digital presentations
- videos

Other media used to disseminate exploration program information include:

- newspapers and magazines
- radio and television
- email
- websites

12.1.5 CONSULTATION WORKSHOPS AND RECENT PROGRAM ACTIVITIES

Section 12.1.6, Summary of Recent Issues Identified During Consultation, provides summary tables listing the questions regarding issues and concerns that were raised at the meetings and Imperial's response to the questions. In some cases, Imperial has added clarification to its initial response, since not all questions could be responded to completely during the meetings. To obtain information on the consultation activities contact:

Wendy Smith, Inuvialuit Regional Liaison
Bag Service #14
Inuvik, NT X0E 0T0
Phone: (867) 678-6104
Email: wendy.a.smith@esso.ca

12.1.5.1 Information Workshops

In 2009 and 2010, Imperial conducted a series of multi-day workshops in Inuvik and Tuktoyaktuk. Imperial developed the workshops with input from the IGC and designed the workshops to provide information on aspects of drilling an offshore exploration well in the Beaufort Sea. The workshop topics included:

- deepwater drilling well control (September 2009)

- ice management (December 2009)
- waste management (January 2010)
- wildlife harvesting (February 2010)
- spill prevention and response (April 2010)

12.1.5.2 Inuvialuit Co-Management Body Meetings

In December 2012, as the operator of the Beaufort Sea Exploration Joint Venture, Imperial released a PIP. The PIP described the potential plans for drilling one or more offshore exploration wells within EL 476 (Ajurak) or EL 477 (Pokak). The PIP provided information on:

- the early stages of well design
- operational considerations
- consultation activities and plans
- potential benefits for northern residents
- safe work and environmental management plans

In March and April of 2013, Imperial and other joint venture representatives met directly with Inuvialuit co-management bodies to review the potential plans described in the PIP and seek feedback on these potential plans. The groups met with were:

- the Wildlife Management Advisory Council – North Slope (WMAC NS) – met with full members in Whitehorse, Yukon, on March 19, 2013

- the WMAC NWT – met with full members in Inuvik, NWT, on March 21, 2013

- the FJMC – met with full members in Edmonton, Alberta, on April 10, 2013

12.1.5.3 Committee and Community Meetings

In February 2013, Imperial and other joint venture representatives conducted meetings in the six ISR communities. The purpose of the meetings was to review the potential plans described in the PIP and seek feedback on these potential plans. A community consultation report for winter 2013 included information compiled from the meetings conducted, including questions and answers. Copies of this report were sent to the community committees for review. To obtain a copy of this report, contact Imperial's Inuvialuit regional liaison (see Section 12.1.5).

The following meetings were held:

- February 12, 2013 – a combined committee meeting with the Tuktoyaktuk HTC, Tuktoyaktuk Community Corporation and Tuktoyaktuk Elders Committee., followed by a public dinner. The total committee and community attendance was 35 people.

- February 13, 2013 – a combined committee meeting with the Inuvik HTC and Inuvik Community Corporation, followed by a public dinner. A public

12.1.5.3 Committee and Community Meetings (cont'd)

information session was held after the dinner. The total committee and community attendance was 45 people.

- February 14, 2013 – a combined committee meeting with the Aklavik HTC, Aklavik Community Corporation and Aklavik Elders Committee, followed by a public dinner. A public information session was held after the meeting. The total committee and community attendance was 44 people.
- February 26, 2013 – a combined committee meeting with the Sachs Harbour HTC, Sachs Harbour Community Corporation and Sachs Harbour Elders Committee, followed by a public dinner. A public information session was held after the dinner. The total committee and community attendance was nine people.
- February 27, 2013 – a combined committee meeting with the Olikhaktomuit HTC, Ulukhaktok Community Corporation and Ulukhaktok Elders Committee, followed by a public dinner. A public information session was held after the dinner. The total committee and community attendance was 41 people.
- February 28, 2013 – a combined committee meeting combined with a public information session, including the Paulatuk HTC, Paulatuk Community Corporation and Paulatuk Elders Committee. The total committee and community attendance was 18 people.

12.1.5.4 Inuvialuit Game Council Meetings

Imperial and joint venture representatives held the following meetings with the IGC:

- September 28, 2012, to provide an update on the former Ajurak program, now the Beaufort Sea Exploration Joint Venture for EL 476 and EL 477
- December 13, 2012, to:
  - provide timely information on Imperial's potential plans
  - describe the PIP that Imperial would use for reviews with the HTCs and Inuvialuit communities
  - seek feedback and comments from the IGC on the PIP
- March 25, 2013, to:
  - provide an update on the February 2013 community consultation meetings in the ISR regarding the program
  - outline plans for ISR community engagement

12.1.5.5 Inuvialuit Regional Corporation Meetings

Imperial and joint venture representatives meet directly with the IRC twice a year to provide:

- updates on recent activities
- information on Inuvialuit benefits and opportunities resulting from activities of the exploration program

Meetings with the IRC would typically involve the participation of the chair, chief executive officer and support staff. The IRC directors might participate at the request of the IRC chair when opportunities are available. Directors of the IRC are also community corporation chairpersons in the communities and privy to invitations to community committee meetings as well as community public meetings.

Imperial and joint venture representatives met with the IRC on November 27, 2012, to review the Beaufort Sea Exploration Joint Venture for EL 476 and EL 477 to:

- update the IRC on Imperial's potential plans
- describe the work necessary to:
    - complete the regulatory approval process
    - make a decision to acquire a drilling system
    - drill an exploration well
- outline possible community activities involving Inuvialuit organizations
- seek IRC comments and ideas regarding all potential plans

Imperial and joint venture representatives met with the IRC on April 18, 2013, to:

- provide a program update, including:
    - a summary of recent activities
    - an outline challenges ahead
    - an outline of Imperial's key principles and strategies for employment and business opportunities
- seek input from IRC regarding potential benefits

12.1.6 SUMMARY OF RECENT ISSUES IDENTIFIED DURING CONSULTATION

Recent consultation activities involved:

- the six Inuvialuit communities
- the IGC
- Inuvialuit co-management bodies
- Inuvialuit HTCs
- Inuvialuit community corporations
- the IRC
- other northern stakeholders

12.1.6 SUMMARY OF RECENT ISSUES IDENTIFIED DURING CONSULTATION (cont'd)

For summaries of issues identified during consultation and the concerns or feedback provided from Inuvialuit and northern stakeholders, see:

- Table 12-1, for the September 28, 2012, IGC meeting
- Table 12-2, for the November 27, 2012, IRC meeting
- Table 12-3, for the December 13, 2012, IGC meeting
- Table 12-4, for the February 2013 ISR committee and community meeting tour
- Table 12-5, for the March 19, 2013, WMAC NS meeting
- Table 12-6, for the March 21, 2013, WMAC NWT meeting
- Table 12-7, for the March 25, 2013, IGC meeting
- Table 12-8, for the April 9, 2013, FJMC meeting
- Table 12-9, for the IRC – April 18, 2013

Table 12-1: Consultation Issues Summary – IGC Meeting (September 28, 2012)

Question or Comment	Imperial's Response
Those two parcels are so close to each other. Would you need to file two different project descriptions?	Imperial's PD would describe all of the activities it might undertake. For instance, Imperial might describe two or three potential well locations on the two licences, but a separate well authorization would be required for each well. The well authorization would be for one well in one EL area.
Need more information on your BOP and capping stack for pressure testing and design.	Imperial would like this to be part of the discussions with all of you to talk about the BOP and different options. Note: In 2013, Imperial has talked to about conducting a workshop on well control to answer these questions.
Where will the capping stack be placed?	Through ExxonMobil, Imperial has access to a variety of capping devices and supporting equipment strategically placed around the world to provide a rapid response to an incident. The specific capping strategy will be included in future regulatory submissions.
We want to be training our people now and in full-time employment.	Imperial has had Inuvialuit participation in its field programs as marine mammal observers, research assistants working with scientists and environmental technicians, as well as ice observers during ice studies. The Inuvialuit regional liaison for Imperial is an Inuvialuit beneficiary. In 2013, Imperial has talked to the communities about the possibility of hosting a business, training and employment workshop to look at opportunities.
The containment system you had before Macondo is the same version you have now.	Through ExxonMobil, Imperial has access to a variety of capping devices and supporting equipment placed strategically around the world to provide a rapid response to an incident. The specific capping strategy will be included in future regulatory submissions.

Table 12-2: Consultation Issues Summary – IRC Meeting (November 27, 2012)

Question or Comment	Imperial's Response
Is there equipment available given your time schedule?	If there are no unexpected delays in the regulatory process, there should be enough time to get the necessary drilling system. Imperial will make a decision on this following the OA ruling.
Imperial question to IRC: Given the IRC's perspective on the environmental reviews, does the IRC feel that the EISC and EIRB processes are fully capable of encompassing our needs here and do they respect the input of firstly and foremost the people that are affected by any proposed plans? Imperial is not in support of CEAA and the notion of having a joint review panel for a one-well application.	The IRC's response to Imperial: The IRC are confident that Inuvialuit environmental agencies, the EISC and the EIRB, can do a great job of assessing the potential for environmental impacts from your exploration program. The IRC supports the principles of the federal government that there should be only one review for one project.
What are your training timeline plans for operations?	Imperial's training plans would be part of the Canada Benefits Plan likely to be submitted in late 2013 or early 2014. The actual training for operations could come just before operations in the 2020 drilling season.
We want to know as soon as possible what kinds of training people will need to qualify for work.	Imperial would outline in the PIP a listing of possible jobs that would be needed. The PIP would describe Imperial's potential plans. Imperial would like Inuvialuit to participate fully where possible. Imperial would be responsible for the contractors to meet its obligations.
We have always wanted to look at a comprehensive cooperation and benefits agreement. It is clearer on expectations and a way to move forward.	Imperial will have a Canada Benefits Plan that includes northern benefits. Imperial would like to work with Inuvialuit to be sure that Imperial has a clear and accurate understanding of what the expectations are.
We would like Imperial to work with the schools to get students to push for a higher degree of education. We would like to see this message in the communities, schools and at workshops. We want to prepare to work with you.	Imperial agrees on the importance of education and training and always looks for opportunities. Training opportunities will be described in the Canada Benefits Plan.
We want to know as early as possible when, and if, there will be designs for onshore activities or facilities. We would want to have those opportunities.	Imperial would be able to describe this as part of the filing for the drilling OA and how it will support the drilling operations. Imperial has collected information and visited Tuktoyaktuk to assess the infrastructure capability, meeting with those existing companies. Imperial has a lot of confidence in Inuvialuit companies.
Do you have collaboration with Alaskan projects?	Imperial and ExxonMobil regularly exchange best practices on Arctic technology.

Table 12-3: Consultation Issues Summary – IGC Meeting (December 13, 2012)

Question or Comment	Imperial's Response
Will you be looking at two BOP types and capping stack?	Imperial will evaluate all options and bring them forward for discussion. Imperial will comply with both internal and industry standards. Information on well control plans will be included in the drilling OA application.
Are the drilling fluids you are going to use the same as fluids used with land-based wells?	Imperial will include information on drilling fluids in the drilling OA application. The drilling fluids used will meet or exceed the NEB regulations.
In 2009 Imperial was looking at designing and building a new drillship, but now you are looking at existing ships.	The selected drilling unit will have the capability to operate safely in Arctic conditions.
Do you partner in under ice testing in oil spill response?	Imperial is part of the Environmental Studies and Research Funds' working group and part of the Arctic Joint Industry Partnership. These working groups have initiatives in developing techniques and testing.
We would like to see the under ice initiative information on the tours.	Imperial would like to share current knowledge during the tours and proposed workshops. This will be a focus on consultations for the drilling OA application filing. Imperial will provide up-to-date information on oil spill response and describe how Imperial participates in this research.
Will the BOP be left cemented to the seafloor or do you pull it out?	The BOP is in place during drilling and will be removed in the off-season. Imperial will comply with both internal and industry standards.
How will drillship integrity be determined?	Imperial will look at the sea state and ice conditions to ensure that vessels are designed for the range of potential conditions. Imperial will provide details on the proposed equipment in its future regulatory submissions.
We want Imperial to share its data on the lessons learned from Macondo in regards to dispersants. In particular, what are the emerging environmental effects of using dispersants in the Gulf of Mexico?	Research in the area of surface and subsea dispersants continues. Imperial will draw upon ExxonMobil expertise worldwide. Imperial will provide further information on dispersants during its proposed spill response workshop.

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013)

Question or Comment	Imperial's Response
ISR	
It is important that an exploration program result in benefits for ISR residents in training, job opportunities and business opportunities.	Imperial will consider hosting a business, training and employment workshop to communicate and understand possible opportunities to provide long-term benefits to Inuvialuit communities. Imperial will work with the IRC to understand these potential benefits with the program as it develops. Imperial is committed to consulting and communicating on potential opportunities.
What are some of the ways Inuvialuit businesses can participate?	Imperial will work with the communities to understand the wants and needs of working with the IRC in these opportunities. A potential business, training and employment workshop might include a discussion on services for waste management, supplies and oil spill response.

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013) (cont'd)

Question or Comment	Imperial's Response
ISR (cont'd)	
Need more understanding of spill response plans.	Imperial will consider hosting a workshop on the OSRP that might include topics on joint programs and recent research developments on Artic oil spill response.
There is an overall need for more information on the use of dispersants in oil spill response.	Imperial will consider hosting a workshop on the OSRP that includes research on dispersant effectiveness.
More information is needed on dispersants regarding: • effects on bowhead whales and other baleen feeders • effects on polar bears • how natural bacteria work with dispersants • how much dispersant was used in the Gulf of Mexico at Macondo • dispersant use in cold water	Imperial will consider hosting a workshop on the OSRP that includes: • effects on baleen feeders • effects on polar bears • natural bacteria • research on dispersants • dispersant use in the Gulf of Mexico • dispersant use in cold water
It is a long time to 2020 when potential drilling would start and this should provide a period for opportunity to train northern people for jobs and contracts.	Imperial will consider hosting a business, training and employment workshop to communicate and understand possible opportunities to plan for training programs and job opportunities.
Imperial should continue to work in schools in the ISR and promote education.	Imperial will continue to conduct school visits, attend career fairs, partner and invest in educational activities.
Who will be financially responsible for a cleanup of an oil spill and have those financial securities for a program to proceed?	Imperial recommended to the NEB that rather than have security deposits, it is more important to look at the experience of the operator and its resources. Imperial has been a responsible operator in Canada and can draw on resources through its joint venture partners to add to its financial strength. In the event of an oil spill, the IFA states that companies have an unlimited liability.
Aklavik	
Whales migrate in the spring and DFO knows these patterns. How do you mitigate whales going into a spill area?	Imperial's focus is to prevent an oil spill. Further details will be provided in the EPP.
We think Aklavik will be hardest hit if there is an oil spill because it will likely hit the Yukon coast. We would like to see a spill response team near and how can Aklavik be a part of this?	Imperial will consider hosting a business development workshop to ensure that the business community is aware and involved.
Need to see shoreline protection plans in spill response.	Imperial will consider hosting a workshop on the OSRP, including a discussion on shoreline protection plans.
What do you have on ice data?	Imperial worked with the DFO to look at under ice conditions and monitoring ice keels. In addition to the DFO work and Imperial's work with ArcticNet, Imperial has had its own ice data collection programs over a three-year period at the potential drilling sites. However, Imperial wants to better understand: • winter ridges • pressure ridges • less multi-year ice now • movement of first-year ice ArcticNet has more data on multi-year ice. They could not find multi-year ice in the licence areas, only at the top of Banks Island off Sachs Harbour.

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013) (cont'd)

Question or Comment	Imperial's Response
Aklavik (cont'd)	
We would like to see models and pictures of your well design. It is good to see anything visual, as it is hard for Elders to read your books.	Imperial is considering hosting a well control workshop and will consider the request to bring forward visual aids on well design. Imperial has heard these comments in the past and produced posters for this tour.
Aklavik – Sachs Harbour	
How do we shorten an unnecessarily long regulatory process?	Imperial will continue to work with the regulatory process to meet its obligations.
Inuvik	
We do not want the whale migration path affected.	Imperial will avoid the Beluga Management Zone 1A and will have a Wildlife Compensation Plan in place in the unlikely event that harvesting is affected.
Will Imperial have an assurance of a benefits agreement with Inuvialuit Regional Corporation?	Imperial's regulatory filing with the NEB must show that AANDC has approved Imperial's Canada Benefits Plan. The Canada Benefits Plan would include benefits for the ISR and Canada. This would include training and job plans. Imperial will consider a workshop on business, training and employment and discuss what these opportunities might be.
We like to see your poster material in smaller format.	Imperial can work on further communication material in a smaller format with this advice.
We want to understand your waste management plan. We do not want to see things left behind for years.	The WMP will meet or exceed all industry standards and regulatory requirements.
We like to see Imperial's emergency response plans.	Imperial will address the subject of the ERP in the PD filing that will be part of the regulatory process. There are four components to the regulatory process, with each submission providing more detail. They are the: • PD • EIS • OA • WA Imperial will be communicating with many parties, including the communities. As part of community involvement, Imperial will discuss the potential role of the HTCs in emergency response.
Inuvik – Aklavik	
We would like to ensure that we have opportunity and time to understand management plans and have real input to them.	Imperial will consult with communities on all components of the management plans. Imperial will consider a review of the management plans during the NEB drilling OA regulatory process.
Want to have spill response equipment in the area. We think that having the equipment in Tuktoyaktuk will be too far away (knowing that a spill will likely go to the North Slope).	Imperial will consider hosting a workshop on the OSRP that might include topics on joint programs and recent research developments on Arctic oil spill response.
Inuvik – Aklavik – Ulukhaktok	
General support for development of exploration program, if the environment is protected and it is a safe program.	Imperial will continue to review details for environmental protection plans in the regulatory filings for the PD and EIS.

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013) (cont'd)

Question or Comment	Imperial's Response
Inuvik – Aklavik – Ulukhaktok (cont'd)	
Protection of marine mammals and fish for harvesting is most important, including the habitat in their ecosystems.	Again, Imperial will review details of plans for environmental protection in the regulatory filings for the PD and EIS. Imperial will continue consultation with the communities in these filings. Imperial will avoid the Beluga Management Zone 1A. The EIS will demonstrate an understanding of how important it is to look at every component of the ecosystem. Imperial will have a Wildlife Compensation Plan in the unlikely event that harvesting is affected. Imperial will consult with communities on these plans.
Inuvik – Sachs Harbour – Paulatuk	
Imperial may not even need an Ice Management Plan since the ice is less and less every year.	Imperial will still consider the temperature range illustration from the PIP as the basis for the potential drilling season.
Inuvik – Ulukhaktok	
What will be your drill cutting disposal plans?	Disposal of drill cuttings will be described in the WMP.
Paulatuk	
Need more understanding of in situ burning and pollution.	Imperial will bring forward more details on in situ burning at a possible spill response workshop.
I went to Louisiana for a workshop on dispersants and saw the impact of the Macondo spill. The effect of dispersants is quick but environmental impact is huge. Types of dispersants are biodegradable but it takes longer to work. We did not see anyone Canadian at this workshop or hear about Arctic issues and this concerns me.	Imperial was unable to attend these workshops and relied on ExxonMobil to get those lessons learned. Imperial will continue to look at attending or participating at relevant forums in research.
Concern about the spill response plan for oil under ice.	Imperial will be ready with solutions for under ice response if an oil spill were to occur. Imperial will continue to develop options throughout the regulatory process and to discuss these options. The primary focus will be on preventing a spill, but Imperial will look at options to respond with dispersants at the wellhead and in situ burning during ice melting periods. Imperial will also: • consider holding a workshop on oil spill response • review the management plans during the NEB OA regulatory process
I went to Louisiana for a workshop on dispersants and saw the impact of the Macondo spill. It makes me understand how the compensation process worked in the Gulf of Mexico and the importance of financial securities. We will always ask what the abilities of companies are to pay because payments need to be noticeable in all communities impacted.	Imperial understands that as the program operator it is financially responsible for all costs associated with a spill. In the event of an oil spill, the IFA states that companies have an unlimited liability. In the case of an incident in the ISR, the IGC and HTCs would hear claims and make decisions about distribution of compensation. Imperial would need the help of the IGC and HTCs for that.
We want to see your waste management plans to see your bilge water policy.	Imperial's potential plans for waste management are described in the PIP. Waste will be disposed according to applicable waste disposal regulations.

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013) (cont'd)

Question or Comment	Imperial's Response
Paulatuk (cont'd)	
Concern on impacts of devolution.	Imperial will work within the new Aboriginal relationships and frameworks that develop because of devolution. Devolution is the mandate of the federal and territorial governments and Inuvialuit agencies.
Would like to see hamlet councils included in the consultations.	Imperial is including the hamlet councils in the consultation process. Imperial sent documentation on the PIP to them and Imperial would like their feedback on the potential plans.
It is comforting that the NEB will review filings and plans. It is their job to approve or not?	Imperial encourages communities to ask questions of the NEB, especially concerning the drilling OA process.
Sachs Harbour	
We want to see all Inuvialuit communities have equal employment opportunities. We need jobs. Perhaps there is opportunity to provide muskox meat and utilize the community COOP.	Imperial wants your opinions for employment and on contracting opportunities with Inuvialuit. Imperial will explore that and move forward. Imperial has examples of hiring Inuvialuit for its FDCPs. Imperial will look at this and consider hosting a business, employment and training workshop to look at potential opportunities for services and employment.
Can you have a liaison in every community?	Imperial has not made a business decision yet on this issue. Right now, Imperial has been liaising through the IGC and HTCs. Imperial will consider this feedback when the program's plans are more definite.
Will you point the fingers away to contractors or subcontractors if there is an oil spill?	Imperial will be responsible as the program operator. The answer is no.
Tuktoyaktuk	
We do not like the wording of "routine" oil spills in the PIP. Can you change this wording to refer to spills as "tiers"?	Imperial's focus will always be to have no spills. Imperial will consider this feedback.
From the oil spill in the Gulf of Mexico, we heard 90% is gone but only 10% recovered. How do we know what happened to the 90%?	Imperial will develop a comprehensive OSRP that will be submitted to the NEB. This plan will detail how Imperial plans to clean up a potential oil spill.
Have Imperial's plans changed since the 2010 spill response workshop because of lessons learned from Macondo?	Imperial's Operations Integrity Management System is the cornerstone of maintaining safe operations. This system is dynamic and updated through a vigorous continuous improvement cycle. The continuous improvement cycle is as a critical part of the system and incorporates internal and external (industry) lessons learned.
Possible use of shore-based facility in Tuktoyaktuk may be favourable to residents for opportunities to participate in exploration plans.	Imperial will consider options with the feedback from communities. As Imperial has the potential to move further through the regulatory process details of potential plans will be provided in the: • EIS • OA • WA At each stage of the regulatory process, Imperial is committed to listening to the communities' and hamlet councils' wishes and to consider what opportunities might be possible.

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013) (cont'd)

Question or Comment	Imperial's Response
Tuktoyaktuk (cont'd)	
Needs to be consideration for the changing of traditional knowledge as it is today. What the Elders may have considered as normal weather patterns may not be what it is today.	Imperial will continue to listen to community feedback on traditional knowledge.
We may need to re-establish an oil spill response co-operative.	Imperial is looking at Beaufort Sea initiatives through the BREA studies and through the Beaufort Sea Partnership working group. Imperial will consider this for potential business opportunities for Inuvialuit in further consultations.
We need to understand spill trajectory. We understand there are different types of oils and that the gyre goes west. Will you get a sample of the oil to understand how to predict potential impacts?	Imperial could use a sample from the North Slope to create an analog and this might help in understanding where oil might go. Imperial's work will consider spill trajectory models.
We want to be able to share in the benefits and opportunities if a program proceeds and not just the community of Inuvik being the regional centre.	Imperial understands the desire to share benefits, and Imperial will work with the IRC on this issue. Imperial will continue to consult on these opportunities and consider this as part of a possible business, employment and training workshop.
We want to ensure your workers are culturally sensitive to our traditions and respected.	Imperial agrees that this is very important and will consider cultural training to be a high priority. During the 3-D seismic program, vessel crews were required to take cultural training from an Inuvialuit company.
What are the challenges now compared to earlier shallow water experience in drilling operations?	Imperial would need to look at deepwater ice management considering multi-year ice as a factor. Imperial will have more consultations on the IMP. Logistics plans are also more challenging.
Expand on ice management.	Imperial would use icebreakers to manage ice. Ice will be broken into manageable pieces that do not exceed the design limit of the drilling unit. Imperial will consult with communities on the IMP.
Tuktoyaktuk – Aklavik – Ulukhaktok	
Need to understand what Imperial considers as same season relief well equivalency.	Imperial would like to consider hosting a drilling and well control workshop that would include an update on SSRW equivalency.
Tuktoyaktuk – Inuvik	
Communities would like to see the integration of traditional knowledge in the environmental protection plans.	Imperial completed a traditional knowledge study in 2010 in each of the six ISR communities that will be incorporated into the EIS. In addition, Imperial will continue to listen to traditional knowledge from the communities.
Wildlife management needs to be considered, such as polar bears.	Imperial understands that polar bear management is a concern and how ice management is a factor in interactions with drilling activities and wildlife. Imperial participated in ice studies in the Fram Strait, Svalbard Island in 2009. The study was about ice management and the impact on polar bears. The EIS will look at possible ways to reduce the impact on polar bears. Imperial will continue to consult and take feedback for this filing.

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013) (cont'd)

Question or Comment	Imperial's Response
Tuktoyaktuk – Inuvik (cont'd)	
Communities would like to share information between each other to see what other communities are saying.	Imperial has tried to consider different formats for consultations to ensure that different meeting requests benefit all. First, Imperial will conduct meetings in the communities with committees (i.e., HTCs, community corporations and Elders committees) and hosting public meetings in these communities. Secondly, Imperial will meet with the relevant Inuvialuit agency, like the IGC that is representative of the six ISR communities. Thirdly, Imperial hosted workshops for a broader representation of stakeholders selected by the communities. Imperial is committed to bringing information in a transparent, open and timely manner.
Tuktoyaktuk – Inuvik – Sachs Harbour	
We want to understand who is responsible for the safety of a program and who is responsible to monitor and report.	As program operator, Imperial is responsible for the program's safety, monitoring and reporting. There are different regulators to review and approve plans before drilling starts. The regulatory process within the ISR includes filing a PD to the EISC. The EISC may recommend to the EIRB that a project be reviewed. The EIRB can make recommendations to the NEB on an application to drill an exploration well in a drilling OA and WA. The environmental monitoring plans would describe the monitoring and reporting process. If drilling proceeds, there will also be an inspections and reporting process, which would be described in the environmental monitoring plans.
Ulukhaktok	
Will there be training at each college in the ISR, so people do not have to travel for trades education?	Imperial understands this concern and will consider opportunities to work with Aurora College and the IRC. Some training will be on demand and facilities needed. Imperial will continue to work with the schools and college looking at curriculum and encourage further education. Imperial's community investment program has taken opportunities to invest in these programs, including the 2012-2013 Trades Access Program and other opportunities with the Beaufort Delta Education Council.
Will we see your spill response plan later in the process?	An OSRP is one of the management plans discussed in the PIP. As the regulatory process progresses, Imperial will lay out a range of potential scenarios and explain how it would respond. Imperial will develop, discuss and share this information with communities. Imperial will work with community concerns to be sure that the communities are confident that Imperial is prepared. However, the focus is on prevention. Imperial will consult with communities on the OSRP as part of the regulatory filings for the drilling OA.
The response vessels for Macondo were far away and we need assurance you will be prepared. The government needs to have something in place.	In the unlikely event of an oil spill, Imperial will be completely responsible for spill cleanup. The NEB is responsible for making sure Imperial is compliant with the relevant regulations by reviewing Imperial's plans, including the monitoring and reporting processes before, during and after drilling. Imperial is developing an OSRP

Table 12-4: Consultation Issues Summary – ISR Committee and Community Meeting Tour (February 2013) (cont'd)

Question or Comment	Imperial's Response
Ulukhaktok (cont'd)	
	for the program and will consider feasible options in the development of this plan. Imperial will consult with communities before filing its OSRP with the NEB. Oil spill preparedness will be covered in the OSRP. Imperial will discuss these options at a possible spill response workshop.
If an oil spill occurred like Macondo, there is a concern about losing culture and the traditional lifestyle for future generations.	Imperial understands that sustainability of traditional culture and lifestyle is most important. Imperial is studying the environment to develop the program to eliminate or lessen impacts. Foremost, Imperial communicates that effort goes into prevention to make sure a spill does not happen. Furthermore, if Imperial's analysis is that the program cannot be carried out safely, then Imperial will not proceed with the program. Consultations and communication is very important through the regulatory process and Imperial will need to work through the EISC and EIRB. These are part of the processes to decide what activities are appropriate. It is part of the process to hear community concerns and to make decisions based on what everyone is saying. Imperial's environmental team is looking at the traditional knowledge studies and science to know how not to have impacts.
Concerned about the BOP and if there are improvements.	Imperial will select equipment and design wells in accordance with internal standards, which will meet or exceed regulatory requirements. Imperial will consider holding a drilling and well control workshop that will include an update on SSRW equivalency.
It is very important that you provide translators at all your meetings.	Imperial understands this need and will provide interpretation as the communities see the need.
Will you translate the PIP into Inuvialuktun?	Imperial will look at ways to provide translation or interpretation of documents and during meetings.
Concerned about exposure to potential earthquakes and tsunamis.	Imperial looks at emergency response plans as described in the PIP. These plans would include response to weather and describe emergency evacuation plans and when they would be triggered. Imperial will have a review on hazards in the EIS and drilling OA regulatory filings.
Concerned about pollutants from the south to the Beaufort Sea and potential impact on marine wildlife and fish.	Imperial is talking to people to understand lifestyle and harvesting to reduce or eliminate possible impacts. Imperial is following some testing that GNWT-ENR is doing with samples of seal and fish. Imperial will continue to follow the results of this testing to further understand the Beaufort Sea environment.

Table 12-5: Summary of Issues Identified During Consultation Activities – WMAC NS Meeting (March 19, 2013)

Question or Comment	Imperial's Response
Within the length of the licence terms, the start of drilling is considered meeting the terms of the licence and you do not have to complete the drilling correct?	Imperial believes this is correct. The NEB said that if a company starts drilling before its licence expires it can continue working on the licence until drilling is complete.
Does the NEB become involved in the panel for the EIRB?	Imperial believes the regulatory bodies are quite distinct. The NEB is a federal agency with responsibilities under the CEAA, 2012. They would look at the scope of the EIRB and the IFA. It would be surprising if the NEB would want to be part of the EIRB panel. However, the NEB might want to have the EIRB supported by a technical representative, but that would be a better question for the NEB.
Need more information on the traditional knowledge collection program.	The traditional knowledge collection program was conducted in 2010 by BP through IMG Golder and was released in March 2011 through the joint venture. Imperial will look at taking this information and incorporating it into the PD submission. Imperial also conducted a fish study on traditional use and harvesting. There is also the information from the BREA fish studies. This is a good combination of traditional knowledge and science-based information. Imperial does not own this information, it is held by the community HTCs and Imperial has been asked by the communities to ensure that it is only disclosed with their permission.
We are apprehensive about Imperial hosting a one- or two-day workshop on spill response because it requires a lot of attention. We want a workshop to inform and educate people. This topic is important and is suggest that a series of workshops be held.	Imperial understands it is important that people have multiple opportunities to understand this information. Imperial relies on workshop attendees to go back to their communities or groups and share the information from the workshops. Imperial asks the HTCs to nominate people to attend the workshops.
More comfortable with two drillships.	Imperial appreciates the feedback and there will be opportunities to discuss well control plans in a well control workshop. Consultation for filings for management plans will be conducted throughout the regulatory process.
Need to understand the financial capability of a company to pay for an oil spill and compensation.	This concern was brought up by many of the communities during the February 2013 ISR tour. Imperial's response was that it would be financially capable to respond to a spill. The NEB requires Imperial to be financially capable of such compensation.
Need to understand SSRW capability and if this is a cost factor.	The NEB stated that the objective of an SSRW is to stop an uncontrolled well flow in the same season. The NEB has determined that goal-based regulations allow companies to propose an equivalency approach to stopping the flow in the same season. Imperial will have more opportunities to consult on the SSRW issue in meetings and during a proposed well control workshop.
Regarding equivalency to SSRW capability and what came out of the Arctic Offshore Drilling Review, there is a distinction on perceived risk to statistical risk. In looking at intervention techniques, can we focus on the studied statistical risk to navigate through this challenge? It would be interesting to look at models on probability. May not be fully understood, but you need to at least start at being able to guess.	Imperial's focus is on prevention, and - if a blowout occurs - to stop the flow in the same season. Imperial can discuss its risk assessment approach during the proposed well control workshop.

Table 12-5: Summary of Issues Identified During Consultation Activities – WMAC NS Meeting (March 19, 2013) (cont'd)

Question or Comment	Imperial's Response
How far along are your intervention plans?	Imperial indicated in the PIP that a capping stack or BOP is a potential option. If a capping stack were used, it would be available to deploy and regain well control in the same season. Imperial will consult with stakeholders further on this and will discuss options in its meetings and workshops on well control.
Placement of capping stack and how long will it take to put into place.	Imperial is working on oil spill response, which will include capping stack contingency plans. Detailed plans will be included in future regulatory submissions and in a proposed on well control workshop.
There are many relevant studies going on right now to assist in the best plans.	Imperial is staying aware of the current studies and would like to plan its program with the current state of knowledge. Imperial is participating on some of the committees with BREA and participates in joint industry programs.
Will your ship be anchored or using engines?	Imperial has not yet decided on the drilling unit and the use of an anchoring system, engines for stationkeeping or both. Imperial will look at existing and new drilling unit availability. As the program develops, Imperial will have these discussions with stakeholders. Drilling unit availability will become an important factor in a decision to proceed.
Need more information on your ice management plans.	This is not the only time Imperial will meet with the communities during the development of the program. Imperial looks forward to its next visit and will provide more information on the progress of the IMP.

Table 12-6: Summary of Issues Identified During Consultation Activities – WMAC NWT Meeting (March 21, 2013)

Question or Comment	Imperial's Response
More detail on when you are filing an application to drill an exploration well. An article in *The Globe and Mail* talks about Minister Ramsey of the territorial government disclosing information on when Imperial will file.	Imperial will be filing as described in the timeline of the PIP, about mid-year.
Need more information on Shell's containment system in Alaska.	This information is available in the US government's report.
There are too many unknowns regarding dispersants, SSRW and spill response methods. How can it be a safe program?	Imperial is talking to communities and to the public to understand what the needs are and get feedback on the PIP. Imperial is working on achieving SSRW equivalency. Imperial will continue to discuss these issues and provide more information to stakeholders as the program progresses. Imperial has stated in its engagement with the communities that if it cannot safely execute program, then it will not do it. Imperial will provide more information concerning these issues in the proposed workshops.
Imperial will need to prove to the NEB the SSRW equivalencies, and it is NEB's job to approve it or not. Not worried that it is my job to do that.	Imperial understands this feedback.
We do not have the capacity to respond with people or infrastructure. The emergency preparedness is not there.	Imperial believes it can build a safe program and when it comes to a decision, Imperial must believe that it has a safe program or it will not proceed.

Table 12-7: Summary of Issues Identified During Consultation Activities – IGC Meeting (March 25, 2013)

Question or Comment	Imperial's Response
The concern Tuktoyaktuk talked about on dispersants is that of using dispersants as a primary response to an oil spill.	That was a good clarification.
Good idea to have a business development workshop because ideas might be overlooked and we want opportunities.	Imperial did not get to hold the business and employment workshop planned for 2010. Imperial wants to provide these opportunities and will make an effort to understand what is needed in the communities. Imperial is considering a business, training and education workshop.
In referring to the general support that you have, we should also say that when it gets closer to drilling there would be more anxiety from community members. Although it is a common thing here at this time, concerns will heighten. Unless you can be certain to make the public feel safe about your program the concern will be there.	Imperial would like to reiterate that unless it can do the program safely, then it would not proceed. Yes, Imperial understands that it will see concerns heighten, as it gets closer to drilling.
Need information on timing of filing. Concern brought forward from an article in the news.	In regards to the timing of the PD, Imperial expects to file in the mid-year time frame as outlined in the PIP.
Need information on the containment system that Shell operated in Alaska that collapsed.	This information is available in the US government's report.

Table 12-8: Summary of Issues Identified During Consultation Activities – FJMC Meeting (April 9, 2013)

Question or Comment	Imperial's Response
What well depth are you looking at?	Imperial has not identified specific well design and reservoir targets yet. These details and the resulting well depths will be provided in future regulatory applications.
In the licence term, there is a commitment to initiate exploration drilling but not to produce?	There is no commitment to produce. For that, AANDC would require testing to show geological formations supporting Imperial's theories. Then the SDL is good for perpetuity. This is an attractive aspect of Canada's systems because it takes technology and economic feasibility and time to bring hydrocarbons into production. Canada's systems allow for this time as an SDL.
FJMC believes it is important to chart through the potential timeline. FJMC will be involved in the screening decision and likely intervener status with EIRB.	Imperial will continue to consult with FJMC at every phase of the regulatory process to ensure to understand the concerns of the FJMC.
FJMC would be interested in being involved in your workshops.	Imperial will consider the interest of the FJMC in future workshops where participation would be appropriate.
Interested in what you would present as the state of the biophysical affairs of the Beaufort Sea and what your monitoring process through the drilling program. I was surprised the monitoring of the biophysical environment was not a concern in your community slides from the ISR tour.	Monitoring was a concern in the communities. There was monitoring and Imperial tried to represent that on the slides, but the slide relating to biophysical environment was not used. There were additional comments made from the communities about monitoring and reporting.

Table 12-8: Summary of Issues Identified During Consultation Activities – FJMC Meeting (April 9, 2013) (cont'd)

Question or Comment	Imperial's Response
Will you put resources into monitoring before and during drilling to test for impacts?	Imperial will devote a section in the PD to summarize baseline biophysical data, but most of it will come during the referral to the EIRB. In the PIP, Section 7, Management Plans, Imperial outlines more clearly the monitoring and work of the environmental monitors, including one plan called the Environmental Monitoring Plan. The NEB will be committed to reviewing these plans.
We have had a focus in the past two years on the capacity and development of communities to understand what this means to community based monitoring. Imperial was complimenting in assisting in bringing data during the seismic programs and hoping we can have the same approach.	Imperial will continue to look at opportunities of mutual benefit to program activities and research in the Beaufort Sea region.
We hope at the spill response workshop that you will indicate what investment Imperial will make to spill response and answer that.	Details of the OSRP will be included in proposed future workshops and regulatory filings.
What is your build time?	Arctic-class vessels have lengthy procurement lead times, which will vary significantly depending on the demand in the market and the type of vessel. Build time will also depend on the timely progress through the regulatory process.
Have you done any work on the stability of the seabed?	Yes, Imperial has done work on this with the Bedford Institute gaining information on the immediate vicinity. Imperial will also rely on data gathered from a good one- or two-year summer survey.
For your research, do you still have buoys out there and data for climate change?	Imperial is looking at more open water and a longer fetch. Imperial has gathered a lot of data through government and academia. Imperial will retrieve the buoys to provide more data.
You are responsible in the EIS for cumulative effects as a precursor for more development, perhaps pipeline and tanker traffic. I consider them to be cumulative effects. This is a big concern even though your program is small in nature.	Talking about cumulative effects for 2020 is difficult to do. Presently the focus is on an exploration program and not potential development. If there were to be future development, it would go through its own regulatory approval.
We like to see a good plan on the development approach.	If the exploration drilling finds hydrocarbons, the next step is for application for an SDL, which will allow the licence to be used by Imperial for the perpetuity of the development. Companies develop business plans taking into consideration technological challenges and market conditions.
Will you be overwintering in McKinley Bay?	The planning basis is not to overwinter vessels.
What about your fuel tankers?	If fuel tankers were used, they would likely be double-hulled fuel tankers.
We are hoping Imperial is talking to ISR resource committee about how to conduct a program in a safe and effective manner to protect the environment. We are hoping to see a resource development program working in conjunction with community investments in community-based programs.	Imperial will continue to consult with all Inuvialuit stakeholders and learn how to participate in supporting community-based programs.

Table 12-9: Summary of Issues Identified During Consultation Activities – IRC (April 18, 2013)

Question or Comment	Imperial's Response
What are the financial responsibility requirements?	During the AODR, Imperial recommended that companies be able to prove to the NEB their company's financial capability on their own, based on their strengths. It is expected that the NEB is going to come out with the ruling or requirement for this in May 2013. The IFA already stipulates unlimited liability to companies if there is an oil spill.
Interest in the discussion of the Community Co-Operations and Benefits Agreement with industry. People need to have an idea of how they will benefit and what those possibilities are in social and economic measures. Inuvialuit do not see these opportunities as a small thing. The IRC wants to talk about what the plans are in more detail. Employment needs a good base for education. Business can do some of the jobs but need capacity.	Imperial is here to listen and seek input. Imperial will submit a Canada Benefits Plan for benefits for the North and Canada. This will include benefits to Inuvialuit. Imperial can discuss where the IRC's interests lie. Imperial will provide details of opportunities at the earliest possible time for involvement with Inuvialuit businesses. Imperial will also consider holding a business, training and employment workshop.
Interest in spill response collectively with other industry active in the ISR in the worst-case scenario.	Imperial might have synergies with those that are currently active in the ISR. Imperial is working on providing more detail in future filings in the EIS and the OA submission. Imperial will continue to provide more information during a potential spill response workshop.
Within the next seven to ten years, business may look at investing. Each entity finds what may be appropriate opportunities to upgrade capacity. As well as understanding skills and how to fit into the potential timeline. Interest may be in opportunities with support vessels.	Imperial understands that timing is important and intends to have further discussions to in relation to the potential schedule. Imperial will need to communicate how and when the decision point is regarding making a financial commitment in investing in vessels. Imperial will further communicate options in the IMP and on vessel support.
Interest in seeing the Canada Benefits Plan for the 2008 Ajurak seismic program.	Imperial will provide a copy of the Canada Benefits Plan to the IRC on the Ajurak 2008 seismic program.
When you talk about general support, I understand the feeling is general reluctance. It is crucial to agree on work for Inuvialuit and crucial on the side for social support. From the east and west, we see the pressure on the IRC not to support the offshore. Communities and people in general have to see the opportunities.	Imperial understands that benefits must be communicated with real participation of Inuvialuit. Imperial will need to provide information on protecting the environment and showing benefits. Imperial will be meeting again for further discussion during future community consultations and will be considering a business, training and employment workshop.
Would like to see Imperial support investments in research studies with community participation to get ground truth input. Furthermore, like to see initiatives through the IGC and communities in an ongoing basis. Research with not just the science based approach but to include traditional knowledge. Like partners to make real actual working institutions and have accountabilities.	Imperial understands from the traditional knowledge collection program the importance of integrating it into environmental plans. Imperial also heard from Tuktoyaktuk people that even traditional knowledge is changing now. Imperial will ensure to listen to communities on traditional knowledge. Imperial is participating in joint industry initiatives in developing research studies. Imperial is a participating committee member on the research conducted through BREA. Imperial is committed to support through community investments initiatives to foster community participation in environmental study fields.
Suggestion to industry in offshore projects and the social responsibility to work with people to think broader in community support. It would go far to demonstrate this support by sending workers to go to Alberta to work in the fields and show them skills. This could enhance drilling skills on different levels.	Imperial will consider this feedback for future opportunities or suggestions from Inuvialuit.

Table 12-9: Summary of Issues Identified During Consultation Activities – IRC (April 18, 2013) (cont'd)

Question or Comment	Imperial's Response
Imperial needs to identify the habitat sensitivity around beluga management zones, Herschel Island and the Kendall Island Bird Sanctuary to fulfill the requirements for submissions.	Imperial will consider this feedback for its EPP in the EIS and in how to be sensitive to those areas.
Suggestion to invest or support the Inuvialuit Harvest Study, if possible. It shows different adaptations from communities because they are from different areas.	Imperial will continue to support initiatives from community leaders in the community investment program where possible.
There is a lot of discussion on the Beaufort Sea Plan of Action with the Canadian Association of Petroleum Producers representing industry, but they are very silent. We need more action from the Canadian Association of Petroleum Producers.	Imperial will find more information on the participation of the Canadian Association of Petroleum Producers at this forum to look for opportunities for more involvement.
More information needed on dispersants and how dispersants work in cold water.	Research is ongoing on the use of dispersants in cold water. Imperial will draw upon ExxonMobil expertise worldwide. Imperial will provide further information on dispersants during its proposed spill response workshop.

CONSULTATION RESULTS WITH REGULATORY AGENCIES

13.1.1 BACKGROUND

Consultation with regulatory agencies on the proposed Beaufort Sea Exploration Joint Venture was conducted in March and April 2013. This section provides summaries of the meetings held and the questions and concerns that were raised during the meetings. Consultation with co-management boards and Inuvialuit organizations is discussed in Section 12, Community Engagement and Consultation.

13.1.2 JOINT REGULATORY AGENCY MEETING – YELLOWKNIFE

On March 27, 2013, Imperial held a joint-regulatory agency meeting in Yellowknife to discuss the proposed program. The agencies represented at that meeting included:

- EC, four representatives
- DFO, two representatives
- GNWT, three representatives
- NEB, two representatives
- NPMO, one representative
- TC, one representative

Key concerns raised by participating agency representatives included:

- ice management
- waste management
- well control
- the need for a robust operation management system

Table 13-1 is a summary of the comments and responses from the Yellowknife meeting. Agency representatives also provided input on the program's regulatory approvals. These comments are provided in Section 4, Approvals – Regulatory and Other Authorizations, Table 4-1.

The Parks Canada representative in Inuvik was unable to participate in the Yellowknife meeting, but Imperial received comments from Parks Canada, after the meeting. Parks Canada is primarily concerned about the potential use of Herschel Basin and marine traffic in and around that area, which is immediately adjacent to Ivvavik National Park. In the past, oil and gas operators have used this area for staging and overwintering. The area has even been used in recent years by Shell's Kullak program and Dome Petroleum's single steel drilling caisson program.

13.1.2 JOINT REGULATORY AGENCY MEETING – YELLOWKNIFE (cont'd)

Although Imperial is not planning to overwinter the drilling unit in the Beaufort Sea, the Parks Canada representative expressed concerns about all the other vessels involved and ancillary activities associated with the program's offshore drilling activity.

Table 13-1: Record of Agency Questions – Yellowknife (March 27, 2013)

Agency	Question/Comment	Imperial's Response
DFO	Ice does not always move in one direction. How will Imperial manage ice moving in from multiple directions?	Imperial has extensive data and research on ice movement that has been obtained from TC, satellites and field studies. Imperial will use this data to design its IMP, which will include planning for the wide range of conditions that could occur. Transport Canada will provide regulatory oversight.
EC	My understanding is that same season relief wells are backstops should other methods not work. What is Imperial's plan if not a same season relief well?	Imperial's position is that a relief well is not a same season well control measure. It is not possible to drill a well in a single season, given the short drilling season in the Arctic. Faster options exist to bring the well under control.
	The new approval process under CEAA, 2012 is new including "one project, one review." This project's timelines will put pressure on regulators.	NEB representatives were present at the meeting and discussed the Project Specific Agreement that would be executed between the NEB and the EIRB, should the EISC refer the program for review. The goal would be to hear evidence once. However, the EIRB would have to make a decision before the NEB could make its decision or issue the OA.
	What information will be available, when?	Imperial plans to submit the OA application after the EIS because more detailed engineering work is required for the OA application, which will take time to prepare.
	Were the outcomes of the community workshops held in 2009 broadly shared?	The workshop outcomes were shared with the participants. Also, the comments and questions received during the workshop will be captured in the community consultation records in the PD submission.
GNWT	The government needs long lead times to allow for investment in infrastructure in the North. A shore-based facility in Tuktoyaktuk would require investment and regulatory approval to allow for the project to use the services.	Agreed. Imperial would not use any onshore services unless they are in full compliance with regulatory requirements. Nor would Imperial have any onshore activities unless there is community support to do so.
	A root cause of the *Deepwater Horizon* accident in the Gulf of Mexico was a lack of a management system. How did that incident effect Imperial's operations?	Imperial's Operations Integrity Management System is the cornerstone of maintaining safe operations. This system is dynamic and updated through a vigorous continuous improvement cycle. The continuous improvement cycle is a critical part of the system and incorporates internal and external (industry) lessons learned.
	The communities do not have the authority to bring outside waste from industry into the community landfills. The communities would need to apply for new approvals for facilities that would be capable of managing these waste streams. The GNWT is working on defining waste streams a regional waste management strategy.	Imperial appreciates these insights. Neither Imperial nor its contractors will use waste services that are not in full regulatory compliance. Imperial will make this clear to the communities, potential contractors and, where feasible, Imperial will provide assistance to enable potential businesses to overcome these hurdles.

13.1.3 JOINT REGULATORY AGENCY MEETING – OTTAWA

On April 9, 2013, Imperial met with representatives from several regulatory agencies in Ottawa to discuss the proposed program. The agencies represented at that meeting included:

- AANDC, six representatives
- EC, one representative
- CCG, one representative
- Canadian Environmental Assessment Agency, one representative
- DFO, two representatives
- NEB, two representatives
- NRCan, two representatives
- TC, three representatives

Key concerns raised by participating agency representatives included:

- how will Imperial obtain social licence to operate
- the need to ensure local community support for the program
- what the program's operation management system would contain

Table 13-2 is a summary of the comments and responses from the Ottawa meeting. Agency representatives also provided input on the program's regulatory approvals. These comments are provided in Section 4, Approvals – Regulatory and Other Authorizations, Table 4-1.

13.1.3.1 National Energy Board

On April 8, 2013, Imperial met with NEB representatives in Calgary. This meeting was a pre-application meeting to discuss the scope of the program and the NEB's review process, including potential areas of coordination with the EIRB, if the EISC chooses to refer the program to the EIRB.

13.1.3.2 Government of Yukon

On March 19, 2013, Imperial met with representatives of the Government of Yukon in Whitehorse.

Key concerns raised by Yukon government representatives included a need to:

- gain a greater understanding of the approval process
- ensure that the Yukon government is included in the process

Table 13-3 is a summary of the comments and responses from the Whitehorse meeting.

13.1.3.3 Ongoing Consultation with Regulatory Agencies

Imperial is committed to continued engagement with regulatory agencies through all stages of the program.

Table 13-2: Record of Agency Questions – Ottawa (April 9, 2013)

Agency	Comment/Question	Imperial's Response
AANDC	What conditions determine how fast you can drill a well?	The speed of drilling depends on a variety of factors, including: • well design • the nature of rock formations penetrated • rig capabilities Wells drilled by Imperial will be estimated by using offset well information and global experience in floating drilling operations.
	Was there interest in the program on behalf of the communities that were consulted?	Yes, there has generally been good engagement on behalf of the communities. During the last tour in February 2013, there was very good community engagement. The PIP was very helpful in providing the community with an organized information package up front. The PIP has been very well received by the communities.
	How will you assess whether you have a social licence to operate?	Imperial needs to ensure that it has a structured process in place when it comes to community engagement. The communities have been very supportive, provided that their concerns are being addressed. Common concerns have included: • protecting wildlife • wildlife harvesting • preserving each community's way of life Imperial needs to provide the communities with a general sense of Imperial's diligence on these and other issues of concern.
	Will there be reports available on the community consultations that have been conducted?	Information on community consultation will be included in future regulatory filings, such as the PD.
	Will these questions be addressed in the Project Description?	Yes, the issues raised during the consultation process and the responses will be included in the PD.
	Have the communities that have been consulted had concerns regarding spill response prevention and expectations?	Yes, this issue has been addressed at almost every meeting. Imperial intends to work through BREA to provide opportunities to the communities and to meet expectations in terms of spill response. The communities want to be a part of the spill response planning effort. While Imperial's primary focus is on prevention, it is committed to involving the communities in the spill response planning.
	Can proponents submit to the NEB and to the EISC concurrently?	An NEB representative answered this question as follows: "No, the proponent must submit to the screening committee first. The screening committee can refer the application to just the NEB, and/or to the review board, and to other applicable groups. There is a 45-day comment period during which the NEB can provide comments to the screening committee. It should be noted that the NEB does not address social issues. This is left to AANDC."
	Do you intend to use water-based drilling fluids?	Yes, water-based drilling fluid will be used during drilling of the first and shallow-depth sections of the well.
	Your partners have been active since the Gulf of Mexico incident. What best management practices have been learned? What improvements have been made?	Imperial's Operations Integrity Management System is the cornerstone of maintaining safe operations. This system is dynamic and updated through a vigorous continuous improvement cycle. The continuous improvement cycle is a critical part of the system and incorporates internal and external (industry) lessons learned.

Table 13-2: Record of Agency Questions – Ottawa (April 9, 2013) (cont'd)

Agency	Comment/Question	Imperial's Response
DFO	I heard that dispersants do not work well in cold environments. Would you be planning to use different types of dispersants than those that would be used in warmer water?	The main factor affecting dispersant effectiveness is the characteristics of the oil to which the dispersant is applied. There are many types of dispersants available and Imperial will select the dispersant that is most appropriate for the type of oil expected. Imperial has conducted experiments on dispersants applied at the surface, and these experiments were successful in dispersing oil in cold temperatures. Also, in situ burning can be used where dispersants are not effective (e.g., in conditions where there is little wave action to aid in dispersing the oil).
TC	There has been opposition to resource development in northern communities in the past. What lessons have been learned in terms of consultation with communities, with the public and with non-governmental organizations?	Imperial needs to engage those stakeholder groups that are open to negotiation. The chairman of the IGC submitted a discussion on resource development to the Arctic Frontiers Conference stating "The IGC is not against industrial development. It is important to approach development with a better understanding and knowledge of the challenges. Developers must be respectful of the way of life of the Inuvialuit people. There must be benefits to the Inuvialuit, and there must be no adverse impacts. Provided that these conditions are met, the IGC is supportive of development in the Arctic."

Table 13-3: Record of Questions from the Yukon Government – Whitehorse (March 19, 2013)

Concerns or Feedback Comments	Responses to Community Concerns
Does Imperial have confidence in the data collected? Are there information gaps?	Imperial is confident about the data and research collected to date and in Imperial's potential designs and planning. Imperial also has metocean data, environmental baseline data and traditional knowledge data, which Imperial believes is sufficient data. This is a one-well exploration program, so for this purpose, Imperial believes that it has enough data and information to move forward. Data collection is ongoing and it will be important that Imperial continues to collect data to enrich its regional understanding.
Are there coastal elements to the program?	Imperial did bathymetry work, looked at Tuktoyaktuk channel for potential use, and looked at Wise Bay for overwintering to the east. There are no coastal elements and no plans for Herschel Island either.
We would like more information on the SDL process.	Imperial currently holds ELs. If, as a result of this program Imperial discovers hydrocarbons, it can apply to the NEB for an SDL and the NEB would advise the AANDC. Imperial will submit its application based on the drilling program findings and the prospects of geology. The NEB would make the decision to award an SDL or not.
Can you provide information on the regulatory process?	There are two agencies under the IFA. One is the EISC to which Imperial will submit a project description. The EISC will assess the PD for potential environmental impacts and might refer it to the EIRB for further review. Imperial plans to file the project description by mid-year 2013 and will likely submit the EIS in December 2013 or early 2014. Imperial expects that there will likely be a public hearing through the EIRB. Imperial expects that the EIRB will make recommendations to the NEB in 2014 and the third filing would be the drilling OA, which would be submitted to the NEB. The NEB might have an additional public process, but it is not known what that will look like. Imperial plans to file the OA end of 2014. By the end of 2015, Imperial hopes to have a decision to commit.
Would like a chart on consultation process through the regulatory phases showing the Yukon government.	Imperial is developing a chart for consultation with the regulatory agencies throughout the regulatory process. Imperial will send it to the Yukon government when the chart has been completed.

Table 13-3: Record of Questions from the Yukon Government – Whitehorse (March 19, 2013) (cont'd)

Concerns or Feedback Comments	Responses to Community Concerns
We need a dialogue to go forward. We don't see ourselves in your documents.	Imperial will record this feedback. Every document will provide more detail as Imperial receives more input. Imperial continues to include the Yukon government in the program consultations.
We need more information on your environmental protection plans.	The NEB will write conditions before any drilling starts. Imperial will provide the NEB with all the critical documents, including its management plans. Imperial will review these management plans with everyone before filing them. Imperial will consult on these plans as early as possible. Imperial expects there to be NEB hearings during the OA submission in 2014. Some of the management plans will be out for review during the environmental review with the EIRB.
We need to understand the SSRW conditions, are you getting the flexibility to propose equivalency?	Imperial will propose SSRW equivalency as outlined in the NEB report. The NEB has reaffirmed goal-based regulations and the goal is to regain well control in the same season. Imperial's application will describe how it plans to regain well control in the same season.
Are there options available for capping stacks?	Through ExxonMobil, Imperial has access to a variety of capping devices and supporting equipment strategically placed around the world to provide a rapid response to an incident. The specific capping strategy will be included in future regulatory submissions.
What is the mood in the Inuvialuit region?	During the February 2013 ISR tour the mood was somewhat supportive. Imperial heard a number of times in communities that people are not against development and they want the benefits, but that a program must be done with environmental protection and it must be done safely.
Would like participate in training and business opportunities from Whitehorse and in Whitehorse. This would include hosting workshops in Whitehorse.	Imperial is meeting with as many communities and groups as possible to get their input, including the IRC, which will have its own views and Imperial will consider all of the feedback given. The challenge for business opportunities is that the work will be done over three years and during three short drilling seasons.
Whitehorse has engineering expertise and a college training facility, which you might be interested in. We'd like to make those connections and to make sense if it is real. We want to understand the opportunities and have Yukon be a part of that.	Imperial will evaluate: • all options for northern residents to participate in the program • potential training opportunities for residents
Are there any plans for King Point?	Imperial will finalize its OSRP in the EIS and OA application. This plan will outline Imperial's commitments and logistics for spill response, including shoreline protection. Once Imperial has evaluated its infrastructure and equipment needs it will consult with the appropriate agencies and stakeholders regarding the details of its plans.
Supportive of the Arctic Council and the chair being placed with Canada this term starting in 2013. The Arctic Council should consider talking with industry in their research and development.	Imperial has not been invited to speak at the Arctic Council. However, Imperial will consider the Arctic Council's developments to assist Imperial in developing its program plans.
We are happy with devolution.	Imperial will continue to follow the progress of devolution understanding that this will have less effect on the offshore licence areas.
We support your company if it is done right and we would like to participate.	Imperial will record this as feedback.

14.1.1 PURPOSE

This PD has been compiled to meet the requirements of the EISC and the NEB for the purposes of screening the program for significant environmental effects, and to determine if the program should be referred for public review.

The EISC's *Environmental Impact Screening Guidelines* state that analysis of significant effects should:

- *'Identify those elements of the proposed development that could negatively impact on the important biophysical resources.*
- *Identify those elements of the proposed development that could negatively impact on resource harvesting activities.*
- *Assess the significance of the potential environmental impacts, including impacts on wildlife and wildlife habitat, before and after mitigation measures are implemented.*
- *Assess the significance of the potential impacts on wildlife and resource harvesting before and after mitigation measures are implemented.*
- *Rate the residual environmental and resource harvesting impacts to assess whether the proposed development could have a significant negative environmental impact or significant negative impacts on resource harvesting.'*

14.1.2 APPROACH

The effects assessment approach outlined in this section provides a systematic methodology for identifying, predicting and assessing the potential effects of the program on the environment, before implementation. The approach:

- focuses on issues of greatest concern
- addresses regulatory requirements
- addresses issues raised by the public and other stakeholders
- integrates engineering design and mitigation and monitoring programs into a comprehensive environmental management planning process

14.1.2 APPROACH (cont'd)

The assessment methodology includes an evaluation of the potential effects of program activities on valued ecosystem and socio-economic components (collectively referred to as VECs). Program-related effects are assessed within the context of spatial and temporal boundaries established for the purpose of this assessment, including direct and indirect environmental effects. The significance of residual effects is then determined and follow-up programs proposed.

The environmental assessment for the program involves the following steps:

- scoping of the overall assessment, including:
    - selecting VECs
    - describing temporal and spatial boundaries
    - defining parameters that will be used to characterize program-related environmental effects and the cumulative environmental effects
    - identifying standards or thresholds that will be used to determine the significance of environmental effects
- assessing program-related environmental effects, including:
    - describing the environmental pathways for effects and considering the likelihood and consequence of an effect
    - proposing mitigation and environmental protection measures to reduce or eliminate the environmental effect
    - evaluating and characterizing residual program-related environmental effects (i.e., the consequence of the environmental effects remaining after application of mitigation measures)
    - determining the significance of program-related residual environmental effects and taking into account the consequence and risk of the effect
    - recommending follow-up actions and monitoring to verify environmental effects predictions and assess the effectiveness of mitigation
- assessing cumulative effects – addressing changes to the biophysical or human environment that are caused by program activities, in combination with other past, present and future programs, projects and activities

14.1.3 VALUED ECOSYSTEM COMPONENTS

While all components of the environment are important, it is neither practical nor necessary to assess the potential effects of the program on every component. This PD focuses on the VECs that have the greatest value and sensitivity and, therefore, have the greatest degree of sensitivity to program-related activities.

Valued ecosystem components are defined as components of the environment considered to be of ecological, scientific, resource, socio-economic, cultural, health, aesthetic or spiritual importance, which have a potential to be adversely affected by the program. The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. The VECs identified are surrogates to focus or structure the environmental effects assessment, with an understanding that effects on other related components of the environment would be similar.

The VECs were identified through a relevant literature review, local knowledge of the potentially affected area, the results of baseline studies, previous environmental assessment experience and from lists of generally accepted VECs among discipline experts (i.e., VECs known to be strong indicators of change). The VECs selected for this assessment and the rationale for their inclusion are listed in Table 14-1.

Table 14-1: Selected VECs

VEC	Description	Rational for Selection
Atmospheric environment	• Includes ambient air quality and ambient noise levels (expressed in A-weighted decibels or dBA).	• Requirement to comply with the *Guideline for Ambient Air Quality Standards in the Northwest Territories*. • The potential for health implications. • Noise levels are likely to increase as a result of program activities.
Benthos	• Includes benthic invertebrates living on the seafloor (epifauna) or within the sediment of the seafloor (infauna) in the LSA, benthic macrophytes (seaweeds) occurring in Tuktoyaktuk Harbour and benthic habitat in the LSA.	• Ecological importance in the RSA. • Potentially affected by proposed program activities.
Coastal landscapes	• Shoreline habitats and seafloor in nearshore areas.	• Shoreline morphologic changes are possible because of program activities. • Erosion of the shoreline might increase risk to existing coastal populations (i.e., Tuktoyaktuk). • Oil spills during storm surges could result in fouling large areas of coastal plain and vegetation.
Community wellness	• Community health and wellness includes determinants that can have an effect on economic, physical, mental and social well-being.	• Importance of community wellness in the ISR.
Human health	• Health of individuals in the ISR harvesting country foods.	• Public concern that program activities could influence the health of the populations in and around Tuktoyaktuk and other local communities.
Marine and anadromous fish	• Includes marine and anadromous fish and fish habitat occurring in the RSA, including broad whitefish, lake whitefish, round whitefish, inconnu, Dolly Varden, Arctic cisco, least cisco, Bering cisco, Arctic char, Pacific herring, Arctic cod, rainbow smelt, fourhorn sculpin, Arctic flounder, starry flounder, blackline prickleback and northern wolffish.	• Identified as important during traditional knowledge studies and during consultation activities. • Ecological, social, cultural and commercial importance in the RSA. • Biological indicators for marine and terrestrial ecosystem health. • Mackenzie River and estuary supports spawning, rearing and feeding areas. • Potentially affected by proposed program activities. • Includes several federal SARA-listed species.

Table 14-1: Selected VECs (cont'd)

VEC	Description	Rational for Selection
Marine avifauna	• Includes: • seabirds • waterfowl • shorebirds • raptors • passerines occurring in the RSA • protected migratory bird areas, important bird areas and other critical habitat areas for marine avifauna	• Identified as important during traditional knowledge studies and during consultation activities. • Ecological, social, cultural and commercial importance in the RSA. • Biological indicators for marine and terrestrial ecosystem health. • Potentially affected by proposed program activities. • Includes several federal SARA-listed species. Migratory and non-migratory species protected by federal and territorial legislation. • Identified as important by regulators and in the Beaufort Sea Petroleum and Environmental Management Tool (PEMT).
Marine mammals	• Includes: • beluga whales • bowhead whales • ringed seals • polar bears • protected marine mammal zones and critical habitat areas (e.g., foraging ground and migratory corridors)	• Identified as important during traditional knowledge studies and during consultation activities. • Ecological, social, cultural and commercial importance in the RSA. • Biological indicators for marine and terrestrial ecosystem health. • Potentially affected by proposed program activities. • Includes federally SARA-listed species. • Program activities would take place in, or adjacent to, recognized beluga management zones. • Identified as important by regulators and in the PEMT (AECOM 2010).
Terrestrial wildlife	• Includes: • barren-ground caribou • Peary caribou • grizzly bear • wolf • Arctic fox	• Importance as Inuvialuit resources (nutrition, clothing, cultural). • Territorial and federally protected species listings (i.e., SARA listing). • Ecological, social, cultural and commercial importance in RSA. • Biological indicators for terrestrial ecosystem health (keystone species). • Potentially effected by program activities. • Identified as important by regulators (i.e., Peary Caribou identified in the PEMT). • Identified as important during traditional knowledge studies.
Traditional land and resource use	• Considers harvesting of marine mammals, marine birds, fish and terrestrial wildlife.	• Program activities might affect traditional harvesting activities. • An EISC requirement.

14.1.4 SPATIAL AND TEMPORAL BOUNDARIES

Boundaries provide a meaningful and manageable focus for an environmental assessment and assist in the determination of the most effective use of available study resources. Temporal boundaries establish the time frame during which program effects are assessed, and spatial boundaries (i.e., study areas) define the geographic range over which the potential effects are likely to occur.

14.1.4.1 Temporal Boundaries

The temporal boundaries are based on the program schedule outlined in Section 6.2.3, Phases of Activity. The drilling program for a single well is expected to take up to four seasons to complete (i.e., during the summer open-water seasons). The duration of drilling activities might vary from year to year based on ice conditions in the Beaufort Sea, day-to-day ice incursions at the drill site and the annual progress of drilling to the planned well depth.

These time frames are intended to be sufficiently flexible to capture the expected environmental effects of the program. The environmental effects assessment will also consider seasonal and annual variations related to VECs for all phases of the program, where appropriate.

14.1.4.2 Spatial Boundaries

Three study areas of increasing size will be used to focus the environmental effects assessment. The study areas have been defined based on:

- the footprint of the program
- the spatial extent of potential effects
- traditional and local knowledge
- current and proposed land use by Aboriginal groups
- ecological, technical, social and cultural considerations

The study areas include the:

- site study area (SSA) – includes the footprint of the program, encompassing all physical works and activities onshore and offshore. In particular, the SSA includes the footprint of the drill site, the shore-based facility, the area that might potentially be dredged in Tuktoyaktuk Harbour and the vessel and air traffic routes to and from the drill site.
- local study area (LSA) – represents the geographic range over which the potential effects could occur from routine activities. It includes the zone of influence of the program that might extend beyond the SSA. The size and geographic extent of the LSA will vary for each VEC, which will provide justification and rationale for the geographic extent of each respective study area. The LSA will include the SSA and surrounding areas where effects are likely to occur, such as the EL area, areas determined by noise attenuation, and safety and security boundaries.
- regional study area (RSA) – encompasses the maximum geographical extent (or zone of influence) in which effects from the program could occur, including socio-economic effects. The RSA represents the largest of the three study areas and is defined by the ISR.

The study areas are not geographically separate. The SSA is located within the LSA, and the LSA is located within the RSA.

14.1.5 IDENTIFICATION OF POTENTIAL PROGRAM ACTIVITY INTERACTIONS

Before predicting and assessing effects that are likely to occur, the potential for program activities to interact with VECs were determined and likely interactions identified (see Table 14-2). These interactions and associated effects have been identified based on a general understanding of the existing environment, and the experience of technical specialists, supported by existing information and data collected from past studies. Both direct and indirect interactions have been identified. A direct interaction occurs when the VEC is affected by a program component or activity. An indirect interaction occurs when one VEC is affected by a change in another VEC (e.g., beluga whales and resource harvesting).

14.1.6 IMPACT DEFINITIONS AND EVALUATION OF IMPACT SIGNIFICANCE

The environmental effects that are expected to occur because of the program have been considered for all physical works and activities during the program's life cycle. Where a VEC is likely to change as a result of the program activities, the effects on the environment and the direction of the effects (i.e., positive, neutral or negative) have been assessed by comparing the future expected conditions against the measured existing environment. Both beneficial and adverse effects have been identified and assessed, taking into consideration applicable design modifications, mitigation and impact management measures, and standard policies and practices.

Applicable mitigation measures have been identified to avoid or minimize any likely environmental effects. Under the CEAA 2012, mitigation is defined as the measures for the elimination, reduction or control of adverse environmental effects of a designated project, and includes restitution for any damage to the environment caused by those effects through replacement, restoration, compensation or any other means. Mitigation of adverse effects has been introduced at the program design stage, and adverse effects will be avoided to the greatest extent practicable. Further steps to eliminate or reduce adverse effects, including an assessment of the effectiveness of proposed technically and economically feasible mitigation measures have been included in the assessment. Traditional and local knowledge have also been used to identify possible mitigation.

The significance assessment focuses on potential residual program effects on VECs, taking into account feasible mitigation measures. The assessment recognizes the widest reasonable range of potential effects without specific regard for their respective probability of occurrence. The level of the effect is assessed using the criteria shown in Table 14-3 and assigned a significance using a decision tree (see Figure 14-1). This is a visual representation of possible combinations of effects criteria leading to an overall significance conclusion of the residual adverse effects for all identified VECs. The residual adverse effects can be either significant or not significant. Effects that are assessed as negligible after mitigation are considered not significant and are not assessed using the decision tree.

Table 14-2: VEC and Program Activity Interaction

Program Activity	Description	Atmospheric environment	Benthos	Coastal Landscapes	Community Wellness *	Human Health	Marine and Anadromous Fish	Marine Avifauna	Marine Mammals	Terrestrial Wildlife	Traditional Land and Resource Use
Routine											
Mobilization/Demobilization/Support or Resupply											
Vessel transit and presence	• Vessel movements to and from the drill site • Vessel movement to the Beaufort Sea • Drilling unit presence	X			X	X		X	X		
Aircraft support	• Aircraft flights to and from the shore-based facility	X			X	X	X		X		
Transfer of supplies and consumables	• Land-to-ship transfers • Ship-to-ship transfers	X			●						
Routine discharges	• Ballast water • Wastewater and greywater • Cooling water		●	●	●	●		●	●		
Drilling Program											
Site preparation and construction	• Drill site preparation	X	X						●		
Icebreaking and management	• Ice management for the drilling program • Ice management for supply transits	X				X	X		X		
Drilling	• Well spud • Well drilling • Cuttings disposal • Well completion • Suspension and abandonment	X	X	X	●	X			X		
Well testing	• Flaring, vertical seismic profiling and surveys	X		X	X	X			X		
Onshore Support											
Shore-based facility preparation and operation	• Shore-based facility upgrades • Ongoing operations • Storage of supplies and materials	●				X	X			●	
Dock construction	• Upgrade of dock infrastructure	X	X	X	X	●			X	●	
Harbour dredging (might not be undertaken)	• Removal and disposal of material	X	X	X	●	●		X	X	●	
Waste disposal	• Disposal of ship-generated waste and shore-based facility waste				●	●	●			●	

Table 14-2: VEC and Program Activity Interaction (cont'd)

Program Activity	Description	Atmospheric environment	Benthos	Coastal Landscapes	Community Wellness [(a)]	Human Health	Marine and Anadromous Fish	Marine Avifauna	Marine Mammals	Terrestrial Wildlife	Traditional Land and Resource Use
Non-Routine											
Tier 3 spills	• Subsea blowouts • Blowout during open water • Blowout during fall	X	X	X	X	X	X	X	X	X	
Tier 1 spills	• Spills during open-water fuelling • Spills from vessel collisions • Onshore spills	X	X	X	X	X			X	X	

Note:
* The program as a whole has the potential to affect community wellness (both positively and negatively). This will be addressed separately in the assessment.
● = interaction is negligible and is not assessed further
X = likely effect to be assessed

Table 14-3: Effects Criteria and Levels for Determining Significance

Effects Criteria	Effects Level Definition		
Magnitude	**Low**	**Medium**	**High**
	For physical VECs: No violations of quality standards and guidelines. **For ecological VECs:** Affects individuals within a year-class or cohort of a population or stock within natural variability. **For socio-economic VECs:** Does not have a measurable effect on traditional land and resource use or human health above baseline variability.	**For physical VECs:** Occasional violations of quality standards and guidelines. **For ecological VECs:** Affects a portion of a year-class or cohort of a population so that it is noticeable above background conditions. **For socio-economic VECs:** Has a detectable effect on traditional land and resource use or human health occasionally above baseline variability.	**For physical VECs:** Persistent violations of quality standards and guidelines. **For ecological VECs:** Loss of a whole year-class or cohort of a population or stock. **For socio-economic VECs:** Has a detectable effect on traditional land and resource use or human health consistently above baseline variability.
Geographic extent	**Localized**	**Within LSA**	**Extensive**
	Effect is within the SSA.	Effect extends into the LSA but not beyond.	Effect extends beyond the LSA.
Duration	**Short Term**	**Medium Term**	**Long Term**
	For physical VECs: During the active drilling season. **For ecological VECs:** Recovery within one year or less. **For socio-economic VECs:** Effects are limited to one drilling season.	**For physical VECs:** Year-long for the duration of the program. **For ecological VECs:** Recovery from one to five years. **For socio-economic VECs:** Effects are observed over the duration of the program.	**For physical VECs:** Extending past the duration of the program. **For ecological VECs:** Recovery in more than five years. **For socio-economic VECs:** Effects extend beyond the duration of the program.
Frequency	**Occasional**	**Regular**	**Continuous**
	Effect occurs infrequently.	Effect to occur at regular, although infrequent intervals.	Effect occurs at regular and frequent intervals.

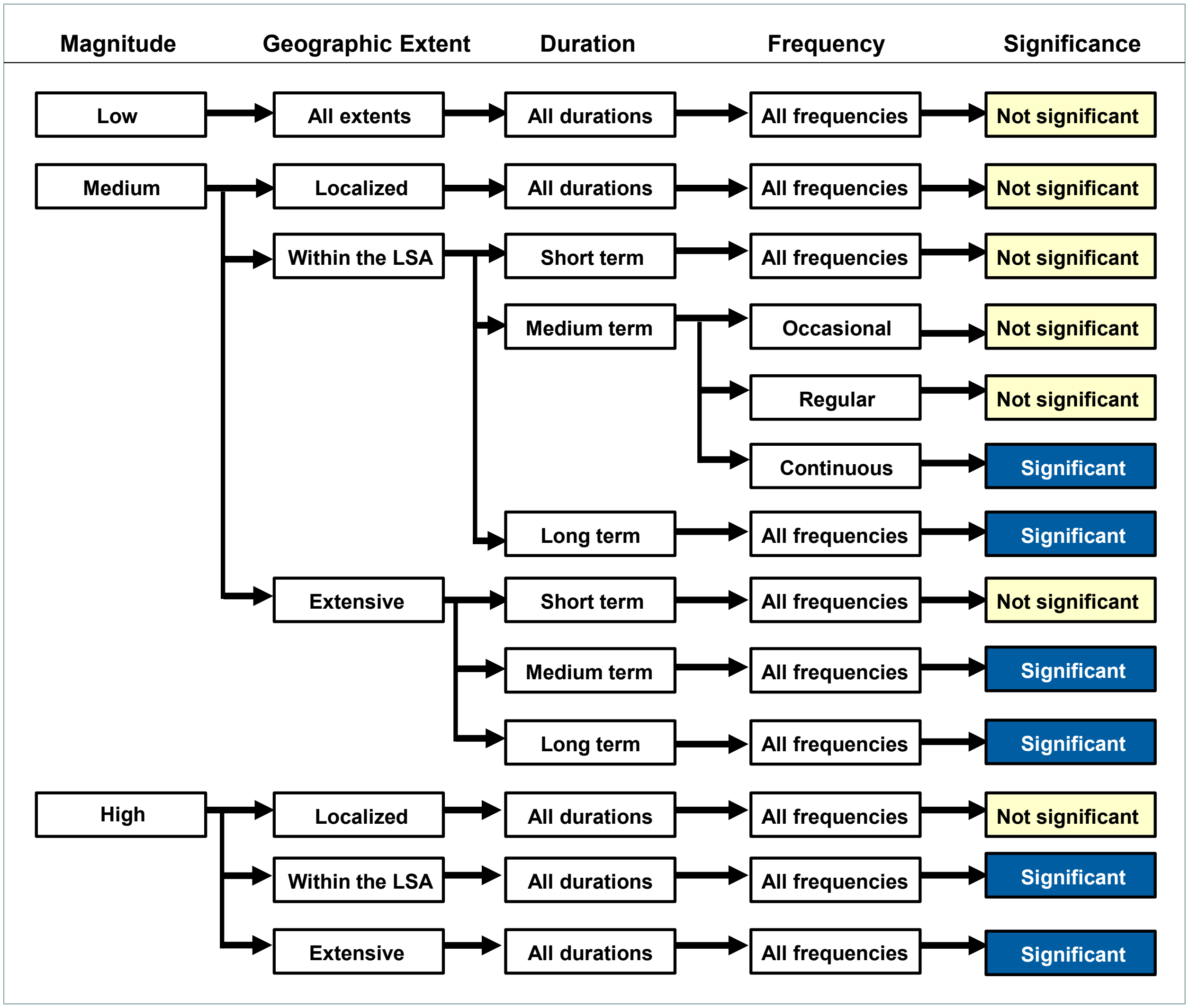


Figure 14-1: Decision Tree for Significance Determination

14.2.1 VESSEL TRANSIT AND PRESENCE

In the spring, at the beginning of each drilling season, ships carrying crew members to the drilling unit or support vessels and vessels carrying supplies are expected to travel to the Beaufort Sea from ports outside the area. Throughout the drilling season, vessels are expected to make regular transits between the drill site and the shore-based facility at Tuktoyaktuk or from an offshore supply warebarge or wareship to replenish supplies. These transits will be on average about once every two to three days.

An initial assessment has indicated that vessel transit and presence activities will likely interact with all the identified VECs, with the exception of benthos, marine and anadromous fish, terrestrial wildlife and human health.

14.2.1.1 Potential Effects and Mitigation

14.2.1.1.1 Atmospheric Environment

Air Quality

Commercial marine vessels use diesel engines for propulsion and to generate auxiliary power. These engines typically use heavy fuel oils with high sulphur content. Diesel exhaust is a complex mixture of oxides of carbon, nitrogen and sulphur, and unburned hydrocarbons, volatile organic compounds (VOCs) and fine particulate matter. Sulphur dioxide (SO_2) is released during fuel combustion. Nitrogen dioxide (NO_2) is formed through the oxidation of nitric oxide (NO), which is also a product of fuel combustion. Both SO_2 and NO_2 are soluble in water and can further oxidize to form sulphates and nitrates, both of which are precursors to Arctic haze.

Fine particulates are emitted directly from the diesel combustion process (e.g., metals and carbon) as well as indirectly produced through the chemical transformation of oxides of sulphur (SO_x), oxides of nitrogen (NO_x) and VOCs into sulphates, nitrates and other organic compounds. The chemical composition and particle size of diesel exhaust emissions vary significantly for different engine types, engine operating conditions (e.g., idling, accelerating, decelerating) and fuel types (e.g., high or low sulphur content). In addition to diesel exhaust, diesel vapours might be emitted from fuel storage systems and during fuel transfer.

In 2010, the US Environmental Protection Agency (US EPA) adopted new standards for Category 3 engines installed on US vessels and to marine

Air Quality (cont'd)

diesel fuels produced and distributed in the US. The new requirement allowed for the implementation of Tier 2 standards in 2011 and Tier 3 standards in 2016. Tier 3 standards for newly built engines are expected to reduce vessel NO_x emissions by 80% compared with 2010 levels. The new requirement also restricts the production and sale of marine fuel oil above 1,000 ppm sulphur, unless the vessel uses other methods to achieve equivalent emission reductions. The strategy for reducing marine air emissions also includes a US-Canada designation of an emission control area to ensure that ships operating within 200 nautical miles of the US coasts meet the new NO_x and fuel sulphur requirements (US EPA 2009).

All marine vessels used for the program will meet the emission standards in effect at the time of mobilization. Residual effects will include increased criteria air contaminant (CAC) and greenhouse gas (GHG) emissions. Because of the transient nature of vessel activity, the increase in air emissions resulting from vessel transit and presence is predicted to be of medium magnitude, localized extent, short-term duration and regular frequency.

Noise

Vessel movement to the Beaufort Sea and movement of supply vessels to and from the drill site have the potential to increase noise levels in the LSA. Above-water noise sources from marine vessels are primarily from their diesel engines (i.e., noise emission through the exhaust stack and air intake vents). Noise emissions vary substantially for different vessel sizes and engine types and for different operating conditions (e.g., idling, accelerating, decelerating).

Marine vessels used for the program will be fitted with standard noise mitigation, such as mufflers and louvers, to limit noise emissions from the exhaust stack and air intake vents. Because marine vessels presently operate in the Beaufort Sea, the presence of program-related vessels does not represent a qualitatively new or different type of sound source for the area.

The residual effect will consist of increased dBA noise levels during those times when vessels are present. The increase in noise levels because of vessel transit and presence are not predicted to exceed guideline values provided by the Alberta Energy Resources Conservation Board (ERCB) (2007), Health Canada (2010) or the International Finance Corporation (IFC) (2007). The residual noise effects are predicted to be of low magnitude, local extent within the LSA, short-term duration and regular frequency.

14.2.1.1.2 Marine Avifauna

The potential effects of vessel transit and presence on marine birds are related to physical injury or mortality because of collisions with vessels and infrastructure. Some marine birds are attracted to lights at night and in low light conditions (Montevecchi et al. 1999). Bird injury or mortality rates could increase as a result of collisions with vessel infrastructure caused by attraction to lighting. Under conditions of poor visibility such as low cloud cover or fog, nocturnal migrating birds have difficulty navigating and might be attracted to bright lights. Birds that have lost their celestial navigation aids might enter these illuminated areas and become confused, potentially resulting in collisions, exhaustion, or both. Birds that are attracted might experience injury or mortality by colliding with a vessel's infrastructure. Birds might also become disoriented by lights, particularly during overcast or foggy conditions, and fly continuously around them consuming energy and delaying foraging or migration (Avery et al. 1978, Bourne 1979, Sage 1979, Wood 1999).

Weather conditions and the magnitude of bird movements are important factors influencing bird injury or mortality from strikes at tower structures (Crawford 1981). Moisture droplets in the air during conditions of drizzle and fog refract the light and greatly increase the illuminated area, thus enhancing the attraction (Montevecchi et al. 1999). Injury or mortality might also be higher during migration periods, when large numbers of birds might be forced down to a lower flight path or to ground level by inclement weather. Some nocturnal predators of marine birds are more successful when hunting in illuminated areas, potentially increasing the risk of bird predation in areas with anthropogenic lighting.

The following mitigation measures will be implemented to minimize the potential for adverse effects on marine avifauna because of vessel presence and movements:

- Where permissible under safety and navigation requirements, outdoor lights will be shielded to minimize light spillage from vessels or angled to minimize direct illumination and reflection of the sea surface.
- Program vessels will maintain a minimum distance of 200 m from nesting locations in accordance with best management practices for raptor conservation (Demarchi et al. 2005).

If high-intensity staging lights are used on the drilling unit or on a support vessel to extend work hours after dusk or before dawn, there is a risk of increasing collisions or adverse behavioural responses by birds, which might become disorientated by the lights. Attraction to lighting has been recorded in pelagic birds such as albatross, petrels, and shearwater, but not the type of marine birds that have been documented in the LSA. Furthermore, there are no IBAs in the immediate vicinity of the LSA.

The potential for injury or mortality of marine birds from site or vessel lighting is predicted to be of low magnitude, site-specific extent and short-term duration. The residual effects on bird populations as a whole resulting from potential injuries, or fatalities of individual birds, are predicted to be reversible through natural recruitment. With proposed mitigation in place (e.g., shielded lights) the probability of a fatality or injury from a collision with vessels because of program lighting is considered unlikely. The long-term viability of marine bird populations is not predicted to be affected.

14.2.1.1.3 Marine Mammals

The potential effects of vessel transit and presence to marine mammals will likely be:

- physical injury or mortality as a result of potential vessel strikes
- behavioural disturbance as a result of underwater vessel noise

Physical Injury or Mortality as a Result of Potential Vessel Strikes

Most marine mammals are fast and manoeuvrable in the water and have sensitive underwater hearing, enabling them to avoid approaching vessels. Odontocetes (toothed whales, such as beluga whales) and pinnipeds (e.g., seals and walrus) are known to be highly manoeuvrable and are rarely struck by vessels (Laist et al. 2001, Jensen and Silber 2003). There are very few documented cases of seal mortality as a result of a vessel strike (Richardson et al. 1995). Mysticetes (baleen whales, such as bowhead whales) are the mammals most commonly struck by vessels (Laist et al. 2001, Jensen and Silber 2003). Baleen whales are relatively large and slow moving and potentially unable to exhibit a rapid avoidance response to approaching vessels.

A vessel strike on a marine mammal might result in either injury or direct mortality. Injuries are typically the result of blunt force trauma from impact with the vessel or from lacerations from contact with the propellers. The severity of the strike and the potential injuries inflicted is the primary determinate for potential recovery for the animal. Most strikes occur between slow-moving whales and vessels travelling at 14 knots or faster, with vessel sizes of 80 m in overall length or longer (Laist et al. 2001).

Recent research shows that vessel speed is positively correlated with the probability of a vessel strike (Kite-Powell et al. 2007, Vanderlaan and Taggart 2007). Mathematical models from current vessel-strike probability research support the reduced probability of a vessel strike with reduced speeds. At a speed of 10 knots, the models predicted a 30% chance of vessel strike when the whale is directly in the vessel's path (Kite-Powell et al. 2007, Vanderlaan and Taggart 2007). Serious or lethal strikes to whales are infrequent at vessel speeds of less than 14 knots and are rare at speeds of less than 10 knots (Laist et al. 2001).

Marine mammals that spend a considerable amount of time at or near the surface are at increased risk of vessel strikes. They are often physically in the path of approaching vessels and research has shown that sound levels are lower near the surface, providing a potential explanation as to why baleen whales are often unresponsive to approaching vessels (Richardson et al. 1995). Acoustic modelling around the hull of a ship further demonstrates that underwater sound levels might be lowest directly off the bow ahead of an oncoming vessel, in comparison to the sides and behind the stern (Terhune and Verboom 1999). Therefore, baleen whales are more susceptible to potential ship strikes when they are in the direct path of a vessel.

After mitigation, physical injury or mortality as a result of potential vessel strikes are predicted to be of low magnitude, extensive, short-term duration and occasional frequency.

Behavioural Disturbance as a Result of Underwater Vessel Noise

Vessel operations at the proposed well sites and along the marine resupply corridor will introduce underwater noise to the marine environment and might cause marine mammals to avoid affected habitat areas. This could potentially include displacement of animals from important foraging and breeding areas, disruptions to the annual migration of marine mammals in the RSA and their availability for harvest. Marine mammals that occur near the program area likely have prior experience with vessel presence and underwater noise from existing traffic and natural acoustic sources (e.g., surface agitation, such as wind and waves). The individual and species-specific reactions to anthropogenic noise might include no reaction, subtle reaction (e.g., change in breathing rate) and obvious reaction (e.g., altering swim direction and avoidance).

Underwater noise has the potential to cause an avoidance response or auditory masking (interference with communication space) in marine mammals. In the extreme case, these effects could lead to a change in migration patterns, reduced foraging efficiency, increased energy expenditure and reduced fecundity and population health. The majority of underwater noise generated by a moving vessel is from propeller cavitation (Mitson 1995). Operational aspects are also important, for example, speed and sudden course alterations. Maintaining constant speed and avoiding rapid changes in speed generates an even level of noise output (Mitson 1995).

Several mitigation measures and program design features will be implemented to reduce the potential for behavioural disturbance and acoustic masking effects, and to minimize the potential for vessel strikes on marine mammals, including:

- limiting vessel speeds
- following established shipping lanes
- maintaining a constant course and speed
- implementing a Marine Mammal Management Plan (MMMP), including the use of marine mammal observers (MMOs)

To the extent practicable, vessel speeds will be kept at a minimum (less than 12 knots) when operating in the marine transit corridor during ingress and egress between the embarkation port and the program area, along the marine resupply corridor between Tuktoyaktuk Harbour and the proposed well sites, and along the route to potential vessel overwintering areas in the vicinity.

Program vessels will follow established shipping lanes and navigational routes typically used for transit in the RSA and adjacent areas. In addition, program vessels will maintain a constant course and speed, to the extent practicable, when operating in the RSA. However, as necessary for safe operations, during ice management operations vessels might require flexibility or freedom to

Behavioural Disturbance as a Result of Underwater Vessel Noise (cont'd)

manoeuvre, including making rapid changes in speed and direction to respond to changing ice conditions.

As part of the EPP, an MMMP will be implemented on the drilling unit and support vessels during the course of the drilling program and will include placing accredited MMOs on board the program vessels to monitor for marine mammals during active drilling operations and while navigating within designated shipping lanes. The MMOs will oversee mitigations set out in the MMMP, including:

- notifying the vessel's Master if there is a concern of the vessel striking a marine mammal (personnel will then make a decision if actions are required to avoid a possible ship strike on a marine mammal, which might include reducing the vessel's speed, if safe to do so, until the animal has travelled clear of the vessel's course)
- only in the case of an emergency will vessels approach within 300 m of a polar bear observed on sea ice or any marine mammal engaged in feeding activities (for all other marine mammal encounters, vessels will not approach within 100 m of a marine mammal)
- if marine mammals approach within 100 m of a vessel, the vessel would reduce its speed and, if possible, cautiously move away from the animal (if it is not possible for a vessel to move away from or detour around a stationary marine mammal or group of marine mammals, the vessel will reduce its speed and wait until the animal moves at least 100 m from the vessel before resuming speed)
- all program vessels will operate in such a way as to prevent the separation of an individual member of a group of marine mammals from other members of the group
- if weather conditions require, such as when visibility decreases, all program vessels would adjust speed accordingly to avoid the likelihood of the vessel striking an animal
- MMOs will maintain a daily log of sightings, sighting locations, recordable incidents and other ancillary marine mammal data throughout the drilling program (MMOs will also prepare an annual field report summarizing marine mammal sighting information collected as part of the program)

After mitigation, behavioural disturbance as a result of underwater vessel noise are predicted to of low magnitude, extensive, short-term duration and occasional frequency.

14.2.1.1.4 Coastal Landscapes

Under certain circumstances, vessel transits in and out of Tuktoyaktuk Harbour have the potential to increase erosion of the adjacent shoreline and seafloor because of vessel-generated waves (wake wash) or currents generated by the propeller (propeller wash). The size of vessel wake wash is dependent on water depth, vessel speed, distance from the vessel sailing line and vessel characteristics (primarily displacement and hull geometry). The erodibility of the shoreline or seafloor is dependent on the nature of the shoreline, seafloor topography (or bathymetry) and seafloor soils (e.g., the grain size and the effects of permafrost). The effects of wake wash and propeller wash can be determined through comparison of the energy of the local natural waves and currents to those generated by vessels. If vessels in the harbour operate at reduced speed and can maintain navigation or heading in response to wind and wave conditions, then wake and wash effects on the shoreline would be minimized.

It is expected that the potential effects from vessels will be mitigated through controlling vessel speed near the shoreline and in shallower water and by using a selected number of sailing routes. The evaluation of potential effects of vessel transits is predicted to be of medium magnitude, local extent within the LSA, short-term duration and regular frequency (every two to three days).

14.2.1.1.5 Traditional Land and Resource Use

Vessel transit and presence will have a limited overlap with traditional harvesting. The program drilling and ice management activities will occur at a significant distance from the shore (about 150 km). Consequently, no potential effects are predicted on nearshore fish harvesting.

Fishing occurs throughout Kugmallit Bay during the spring, summer and fall. Beluga whale harvesting occurs during June, July and August. Program vessel transits are not expected to affect fish harvesting in the larger bay because the vessels will not be close to shore where fish harvesting normally occurs. Vessels will arrive in the Beaufort Sea early in the season, before fishing activities begin, and will leave the Beaufort Sea after the fish harvesting has ended. There will be limited overlap of vessel transits with traditional fish harvesting activities.

Although seals are also harvested along the coastal areas near Tuktoyaktuk, available traditional knowledge information suggests they are harvested further away from the hamlet. Therefore, program-related activities are not predicted to have any overlap with seal harvesting.

Vessel transit and presence has the potential to indirectly affect the traditional harvesting of marine mammals (i.e., whales, seals and polar bears), marine birds and fish. Vessel transit in and out of Tuktoyaktuk Harbour will likely occur in areas that are traditional harvest locations and, therefore, this activity has the potential to directly affect harvesting activities. For example, to avoid collisions, program vessels would need to alter their courses, where practicable, or harvesters might need to move their boats or fishing nets.

Indirect effects would result from changes to populations of harvest species (birds and mammals) previously assessed in Sections 14.2.1.1.2, Marine Avifauna and 14.2.1.1.3, Marine Mammals. The effects of underwater noise on marine mammals are predicted to be of low magnitude and short-term duration. Potential mortality and injury to marine birds and marine mammals as a result of vehicle strikes (i.e., terrestrial impacts associated with shore-based facilities) are also predicted to be of low magnitude and short-term duration. There will likely

14.2.1.1.5 Traditional Land and Resource Use (cont'd)

be no effects on fish, marine birds or terrestrial mammals from vessel transit and presence. Although there might be a small effect on the availability of marine mammals and marine birds, the effect is expected to fall within the normal variation of wildlife availability. The effect on traditional resource harvesting is predicted to be of low magnitude, local extent within the LSA, medium-term duration and regular frequency.

Mitigation measures for direct effects include reducing vessel speed, adjusting direction of travel to avoid harvesting boats and timing vessel excursions to avoid transits during community hunts (e.g., beluga whales). Implementation of mitigation measures is expected to reduce the predicted direct effects of vessel transit on harvesting (i.e., low magnitude, localized extent, medium-term duration and occasional frequency).

Imperial will implement a process to provide compensation related to potential effects on traditional harvesting for those circumstances where, despite mitigation, there is an effect on current or future harvesting activities. The objective of the wildlife compensation program would be to compensate Inuvialuit harvesters for actual subsistence or commercial losses resulting from activities associated with the program. Compensation could cover the following:

- damage or loss of harvesting equipment
- loss or reduction of income
- loss or reduction in wildlife harvest
- adverse changes to the quality of the harvest

The types of compensation could include:

- relocation costs for equipment
- replacement of equipment
- provision of wildlife products
- cash settlements

14.2.1.2 Significance of Residual Effects

A summary of the effects of vessel transit and presence, mitigation and the significance of residual effects is provided in Table 14-4.

14.2.2 AIRCRAFT SUPPORT

The existing airstrip in Tuktoyaktuk is expected to be used for air transportation. For drilling workforce rotations, two or more helicopters are expected to be chartered to make regularly scheduled transits between the Tuktoyaktuk airstrip and the drilling unit and icebreakers, averaging about one flight per day. Helicopters and fixed-wing aircraft might also be used for ice reconnaissance.

An initial assessment indicated that aircraft support activities will likely interact with all the identified VECs, with the exception of benthos, marine and anadromous fish, coastal landscapes and human health.

Table 14-4: Effects, Mitigation and Significance – Vessel Transit and Presence

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Increase in CAC and GHG.	• All marine vessels used for the program will meet the emission standards in effect at the time of mobilization.	Medium	Localized	Short term	Regular	Not significant
	Increase in dBA noise levels.	• Marine vessels used for the program will be fitted with standard mitigations, such as mufflers and louvers, to limit noise emissions from the exhaust stack and air intake vents.	Low	Within LSA	Short term	Regular	Not significant
Marine avifauna	Physical injury or mortality from collisions with vessels and associated infrastructure.	• Shield outdoor lights to minimize light spillage. • Keep activities limited to daylight hours as much as possible (summer season during extended daylight). • Avoid nesting locations and sensitive bird habitat areas.	Low	Site-specific/ localized	Short term	Occasional	Not significant
Marine mammals	Physical injury or mortality as a result of potential vessel strikes.	• All marine vessels will be subject to vessel speed restrictions and will follow established shipping routes in the RSA. • All marine vessels will adhere to mitigation set out in the program-specific MMMP.	Low	Extensive	Short term	Occasional	Not significant
	Behavioural disturbance as a result of underwater vessel noise.	• All marine vessels will be subject to vessel speed restrictions and will follow established shipping routes in the RSA. All marine vessels will adhere to mitigation set out in program-specific MMMP.	Low	Extensive	Short term	Occasional	Not significant
Coastal landscapes	Waves or currents generated by vessel transit resulting in morphologic change of the shoreline or seafloor.	• Minimize vessel speed in shallow coastal waters. • Constraints on navigation on selected waterway routing.	Medium	Within LSA	Short term	Regular	Not significant
Traditional land and resource use	Vessel transit affecting harvested populations.	• See mitigation for marine avifauna and marine mammals.	Low	LSA	Short term	Regular	Not significant
	Vessel transit affecting harvesting activities.	• Reduce vessel speed and adjust direction of travel to avoid harvesting activities. • Schedule vessel excursions to avoid transits during community hunts (e.g., beluga whales).	Low	Localized	Medium term	Regular	Not significant

14.2.2.1 Potential Effects and Mitigation

14.2.2.1.1 Atmospheric Environment

Air Quality

The high-temperature combustion of jet fuel by aircraft engines produces water vapour, CO_2, NO_x, SO_x, hydrocarbons, VOCs, CO and particulate matter. As with marine vessel emissions, the SO_2 and NO_2 are soluble in water and can further oxidize to form sulphates and nitrates, both of which are precursors to Arctic haze.

Fine particulates are emitted directly from fuel combustion and are also produced through the transformation of SO_x, NO_x and VOCs in the atmosphere. These fine particulates might include sulphates, nitrates, organic compounds, elemental carbon and metal compounds. The chemical composition and particle size of jet fuel emissions vary significantly for different engine types, engine operating conditions (e.g., idle, takeoff, landing, cruising) and fuel types (e.g., JP-4, JP-8).

Transport Canada regulates aircraft exhaust emissions in accordance with standards established by the International Civil Aviation Organization. All aircraft used for the program will meet emission standards in effect at the time of mobilization. Residual effects will include increased CAC and GHG emissions. Because of the transient nature of aircraft activity, the increase in air emissions caused by aircraft support is predicted to be of low magnitude, local extent, short-term duration and regular frequency.

Noise

Program-related helicopter flights have the potential to increase noise levels in the RSA. Noise from helicopters is related to the interaction of the spinning rotor with the air and with the engine. To mitigate potential noise effects from aircraft support, consultation with local communities and stakeholders will be undertaken to identify preferred aircraft flight times, corridors and altitudes. In addition, the existing Tuktoyaktuk airstrip will be used for air transportation and, therefore, program-related helicopter flights do not represent a qualitatively new or different type of sound source for the area.

The residual effect will consist of increased dBA noise levels during those times when helicopters are operating. During times when helicopters are operating, the noise levels might exceed the guideline or criteria values provided by the ERCB (2007), Health Canada (2010) or IFC (2007). The residual noise effects are predicted to be of medium magnitude, extensive, short-term duration and regular frequency.

14.2.2.1.2 Marine Avifauna

Noise from program aircraft support could result in behavioural disturbance of marine avifauna. Passing aircraft noise is expected to result in low, short-term disturbances of marine birds over a localized area. Marine birds generally respond to low-altitude (less than 600 m) passing aircraft with a flush or dive response and, in some cases, with a flight response (Manci et al. 1988). Nesting seabirds are a primary concern as the effects of noise might cause them to panic and temporarily abandon their nest leaving it unprotected from predators and potentially causing eggs to break (Burger 1981). However, several studies have reported little to no response by nesting seabirds to aircraft noise as long as noise levels remain below 85-95 dB (Burger 1981, Brown 1990).

Mitigation measures will be implemented to prevent behavioural effects from noise on marine avifauna, including:

- adherence to the EISC *Flight Altitude Guidelines* (these consider different aircraft, wildlife species and situations applicable in the ISR [see Table 14-5], and in the case of birds, program aircraft operations will maintain travel at altitudes greater than 650 m, whenever possible)
- program aircraft operators will be made aware of the location of sensitive bird areas along the flight path, including nearby seabird colonies, and will maintain altitudes above 1,100 m
- pilots will be instructed to travel in a direct path to and from their destination avoiding sensitive bird areas, including local seabird colonies (as safe travel allows)
- if aircraft are required to detour into the path of seabird colonies, pilots will be instructed to avoid repeatedly flying over the same colony

After mitigation, the effects of aircraft support on marine birds are predicted to be of low magnitude, local extent within the LSA, short-term duration and occasional frequency.

14.2.2.1.3 Marine Mammals

Noise from program aircraft support might result in behavioural disturbance of marine mammals. Sound produced in air does not efficiently transmit underwater. Effects of noise produced by program aircraft will only affect marine mammals near the surface, or in the case of seals, resting on the surface of the sea ice directly underneath a passing aircraft. Information is limited on how aircraft noise might elicit adverse reactions in marine mammals. Seals have been shown to exhibit a startled reaction to noise from low-altitude aircraft, although animals returned to their normal activities after several minutes (Manci et al. 1988). Effects of aircraft noise on marine mammals in the water are described as being minimal when aircraft maintain an altitude greater than 600 m (LGL 2005). Effects are expected to be of low to negligible magnitude, short-term duration and occasional in frequency.

The following mitigation measures will be implemented to minimize behavioural effects from aircraft noise on marine mammals:

- flights will adhere to the EISC *Flight Altitude Guidelines* (these guidelines take into account the type of aircraft, the type of wildlife receptor and variable logistical situations applicable in the ISR)

14.2.2.1.3 Marine Mammals (cont'd)

- aircraft will travel at flight altitudes greater than 600 m, as safe navigation allows
- program aircraft operators and pilots will be made aware of the location of sensitive marine mammal areas along the flight path
- aircraft operators and pilots will be instructed to travel in a direct path to and from their destination avoiding sensitive marine mammal areas (as safe travel allows)

With mitigation in place, the effects of aircraft support on marine mammals are predicted to be of low magnitude, local extent within the LSA, short-term duration and occasional frequency.

Table 14-5: Environmentally Acceptable Minimum Flight Altitudes

Aircraft Type	Species or Situation	Recommended Altitude	Source
Not specified	Over areas likely to have birds.	> 650 m (2,100 ft)	CWS (WMAC NWT)
Not specified	Over areas where birds are known to concentrate (sanctuaries, colonies, moulting areas).	> 1,100 m (3,500 ft)	CWS (WMAC NWT)
Subsonic aircraft	Over large mammals during ferry flights.	> 300 m (975 ft)	GNWT-ENR (WMAC NWT)
Subsonic aircraft	During wildlife surveys.	> 100 m (325 ft)	GNWT-ENR (WMAC NWT)
Subsonic aircraft	Aeromagnetic surveys in areas with large mammals.	Timing should be restricted rather than altitude.	GNWT-ENR (WMAC NWT)
Not specified	When flying point to point in vicinity of caribou and other wildlife species.	> 610 m (2,000 ft)	TC (WMAC NS)
Not specified	Over parks, reserves and refuges.	> 610 m (2,000 ft)	TC
Not specified	Over areas where there are beluga and bowhead whales.	> 300 m (975 ft)	FJMC
Not specified	Beluga Management Zone 1.	> 760 m (2,500 ft)	Tourism Guidelines Beluga Management Plan (FJMC)
Not specified	Beluga Management Zone 2.	> 610 m (2,000 ft)	Tourism Guidelines Beluga Management Plan (FJMC)

14.2.2.1.4 Terrestrial Wildlife

Aircraft support has potential to interact with terrestrial wildlife species (i.e., barren-ground caribou, Peary caribou and grizzly bear) occurring in the LSA and adjacent areas.

Barren-Ground Caribou

The effects of fixed-wing aircraft and helicopters on barren-round caribou are reasonably well understood. Numerous studies have been completed in the northern Yukon and Alaska to test effects of aircraft altitude, type of aircraft, season and terrain on caribou activity and group size (Calef et al. 1976). When aircraft flew at altitudes of less than 60 m, panic and escape behaviour reactions were observed in a high percentage of caribou groups with several animals reported to have sustained injuries during their flight response. The caribou also spent a large amount of energy as a response to the panic and escape behaviour.

The Bluenose West and the Cape Bathurst caribou herds overwinter on the southern portion of the Tuktoyaktuk Peninsula and the Tuktoyaktuk Peninsula herd is present year-round. Flying at minimum aircraft altitudes as specified by the EISC *Flight Altitude Guidelines* will minimize disturbance, energy loss and the potential of injuries to the animals (Calef et al. 1976).

Peary Caribou

Studies have shown that Peary caribou cows and calves are the most affected by helicopter overflights (Reimers and Colman 2003). The effects of helicopter activity on caribou appeared to be temporary. However, the energy use during aircraft activity and the long-term effects on the animals are unknown (Reimers and Colman 2003).

Peary caribou are not expected to be in the area of the flight corridors for aircraft support and, therefore, no interaction is predicted.

Grizzly Bear

Grizzly bears appear to be more susceptible to helicopter disturbance than to fixed-wing aircraft. It has been reported that bear responses vary depending on the time of year and might range from:

- loss of habitat because of avoidance or displacement
- disturbance of bears during denning, causing abandonment of dens
- physiological or behavioural stress (Feldhamer et al. 2003)

Grizzly bears are known to occur and den on the Tuktoyaktuk Peninsula (Community of Tuktoyaktuk et al. 2008). Flying at minimum aircraft altitudes, as specified by the EISC *Flight Altitude Guidelines*, is predicted to minimize disturbance at all times of the year and is predicted to mitigate the negative consequences of aircraft disturbance (i.e., avoidance of habitat, den abandonment and physiological stress).

Based on the implementation of the proposed mitigation measures, the effects of aircraft support activities and terrestrial wildlife is predicted to be negligible.

14.2.2.1.5 Traditional Land and Resource Use

Aircraft support has the potential to indirectly affect the traditional harvesting of marine mammals (i.e., whales, seals and polar bears), marine birds and terrestrial

14.2.2.1.5 Traditional Land and Resource Use (cont'd)

mammals. Indirect effects would result from changes to populations of harvest species (e.g., birds, marine mammals and caribou) previously assessed in Sections 14.2.1.1.2 to 14.2.1.1.4. After mitigation, the effects of noise from support aircraft are predicted to be low for marine birds and marine mammals, and negligible for marine and anadromous fish and terrestrial mammals. Consequently, the effects of noise from support aircraft are considered not significant.

As a result of noise from aircraft support, the program might cause some behavioural disturbance to harvested species. However, traditional harvesters are not likely to notice the additional effects on the availability of species for harvesting, as the effects are predicted to fall within the range of normal variation. Therefore, the program effects on traditional harvesting of marine birds, marine mammals and terrestrial mammals are predicted to be of low magnitude, local extent within the LSA, medium-term duration and occasional frequency.

As previously described in Section 14.2.1.1.5, Imperial will implement a wildlife compensation program that will provide compensation (where appropriate) to traditional harvesters, if the program interferes with these activities.

14.2.2.2 Significance of Residual Effects

A summary of the effects of air support, mitigation and the significance of residual effects is provided in Table 14-6.

14.2.3 TRANSFER OF SUPPLIES AND CONSUMABLES

Drilling operations at the drill site will require large quantities of supplies, including pipe, drilling fluids, cement and other materials, fuel, parts and equipment. Food, medical supplies and other consumables will be required for the crews on the drilling unit and support vessels. Options for resupply of consumables could include:

- use of a supply warebarge or wareship to transport all of the supplies expected to be required for a single season (the vessel would be positioned at the drill site and consumables transferred to the drilling unit, as required)
- use of a shore-based facility, transferring consumables to the drilling unit via supply vessels

Interactions related to these requirements are likely to be related to the ship-to-ship and shore-to-ship transfer of supplies and consumables.

An initial assessment indicated that resupply activities will likely have a negligible interaction with marine avifauna and the potential to interact with air quality.

Table 14-6: Effects, Mitigation and Significance – Aircraft Support

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Increase in CAC and GHG emissions.	• All aircraft used for the program will meet the emission standards in effect at the time of mobilization.	Low	Localized	Short term	Regular	Not significant
	Increase in dBA noise levels.	• Consultation with community stakeholders will be undertaken to identify preferred aircraft flight times, corridors and altitudes.	Medium	Extensive	Short term	Regular	Not significant
Marine avifauna	Behavioural disturbance as a result of noise.	• Implement the EISC *Flight Altitude Guidelines*. • Aircraft operators will be made aware of the location of sensitive bird areas along the flight path, including nearby seabird colonies. • Aircraft operators will be instructed to travel in a direct path to and from their destination avoiding sensitive bird areas, including local seabird colonies (as safe travel allows). • If required to detour into the path of seabird colonies, aircraft operators will be instructed to avoid repeatedly flying over the same colony.	Low	Within LSA	Short term	Occasional	Not Significant
Marine mammals	Behavioural disturbance as a result of noise.	• Implement the EISC *Flight Altitude Guidelines*. • Aircraft operators will be made aware of the location of sensitive marine mammal areas along the flight path. • Aircraft operators will be instructed to travel in a direct path to and from their destination avoiding sensitive marine mammal areas (as safe travel allows).	Low	Within LSA	Short term	Occasional	Not Significant
Terrestrial wildlife	Behavioural disturbance to barren-ground caribou and grizzly bears as a result of noise.	• Implement the EISC *Flight Altitude Guidelines*.	Negligible	-	-	-	Not significant
Traditional land and resource use	Indirect effects of aircraft support activities on harvest species.	• See mitigation for marine avifauna and marine mammals.	Low	Within LSA	Medium term	Occasional	Not significant

14.2.3.1 Potential Effects and Mitigation

14.2.3.1.1 Atmospheric Environment

Air Quality

The use of heavy equipment during the transfer of supplies from shore-to-ship or ship-to-ship will result in CAC and GHG emissions. It is expected that all heavy equipment will use diesel fuel, and that air emissions will have a composition similar to the emissions described for vessel transit and presence in Section 14.2.1.

Changes to air quality resulting from resupply activities will be reduced through the use of standard mitigation and management practices, such as the use of equipment with current emission control technologies, reducing unnecessary idling of equipment and regular maintenance of equipment. Residual effects are predicted to be of low magnitude, localized extent, short-term duration and regular frequency.

Noise

The use of heavy equipment during the transfer of supplies from shore-to-ship or ship-to-ship has the potential to increase background noise levels in the LSA. Sound sources from heavy equipment include diesel engines, electric motors, electrical generators and backup alarms. Sound emissions from specific heavy equipment vary substantially.

Noise mitigation implemented during resupply activities is expected to include:

- advising nearby residents of particularly noisy activities and scheduling these events to reduce community disruption
- ensuring that all internal combustion engines are fitted with appropriate muffler systems
- taking advantage of acoustical screening from existing on-site buildings to shield nearby dwellings from equipment noise

Furthermore, heavy equipment currently operates in Tuktoyaktuk and so the presence of program-related heavy equipment for resupply activities does not represent a qualitatively new or different type of sound source for the area.

The residual effect will consist of increased dBA noise levels during resupply activities. The increase in noise levels because of resupply activities are not expected to exceed guideline or criteria values provided by the ERCB (2007), Health Canada (2010) or the IFC (2007). The residual noise effects are predicted to be of low magnitude, local extent within the LSA, short-term duration and regular frequency.

14.2.3.2 Significance of Residual Effects

A summary of the effects related to resupply activities, mitigation and the significance of residual effects is provided in Table 14-7.

Table 14-7: Effects, Mitigation and Significance – Transfer of Supplies and Consumables

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects: Magnitude	Extent	Duration	Frequency	Significance of Residual Effect
Atmospheric environment	Increase in CAC and GHG emissions.	• Use equipment with current emission control technologies • Reduce unnecessary idling. • Perform regular equipment maintenance.	Low	Localized	Short term	Regular	Not significant
	Increase in dBA noise levels.	• For shore-to-ship transfer, advise nearby residents of particularly noisy activities and scheduling events to reduce community disruption. • Ensure all internal combustion engines are fitted with appropriate muffler systems. • Take advantage of acoustical screening from existing on-site buildings to shield nearby dwellings from equipment noise.	Low	Within LSA	Short term	Regular	Not significant

14.2.4 ROUTINE DISCHARGES

Routine discharges from maritime operations could include domestic wastewater (greywater), sewage (blackwater), washdown and drainage from decks and exposed structures, cooling water, ballast water and bilge water. All ships in the fleet are subject to international maritime law, including the MARPOL 73/78 International Convention for the Prevention of Pollution from Ships and the provisions of the *Arctic Shipping Pollution Prevention Regulations* and *Arctic Waters Pollution Prevention Regulations*. All potential discharges will follow a program-specific WMP. The plan will be developed in accordance with the NEB's *Offshore Waste Treatment Guideline* and will meet the applicable regulations, such as *Canada Oil and Gas Drilling and Production Regulations* and *Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals*.

Some capacity might exist on some of the larger vessels to collect and hold drainage water in limited amounts, but drainage from the ship's structure (above the waterline) into the sea cannot be avoided. Decks will be kept clean to prevent draining water from mixing with oil stains, chemical stains, granular or finer material, or other residue on the surface of any deck. Bilge water and any collected drainage water will be processed through oil-water separators on each ship and will be monitored for oil concentration before release. Discharge of oily mixtures is prohibited in Canadian Arctic waters.

Greywater will be discharged directly to the sea, as treatment of greywater is not required before release under MARPOL 73/78. It is possible that greywater discharges will contain residual chlorine in very low amounts. This chlorine will react with organic matter in the surface mixed layer and become inactive. Sewage and domestic waste will be processed through treatment plants on each ship before discharge to the sea. Discharge of treated blackwater and macerated food waste might increase biological oxygen demand in the surface mixed layer, but it is unlikely it will have any appreciable (or detectable) effect on the dissolved oxygen content of waters in the program area, including those adjacent to any vessels involved in program activities.

Cooling water is generally part of a closed loop system. Seawater pumped or taken onboard for this purpose will not be contaminated or mixed with water from other sources before it is returned to the sea during normal operations.

If ballast water discharge were required, it would be governed by a Ballast Water Management Plan, including onboard treatment. All mitigation described in the IMO *Convention for the Control and Management of Ship's Ballast Water and Sediments* (2004), including federal guidance specific to Canadian waters, would be implemented. The Ballast Water Management Plan would be compliant with:

- *Ballast Management Control and Management Regulations*
- IMO Resolution A.868(20), *Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens*, in particular Section 7.1

- the Model Ballast Water Management Plan developed by the International Chamber of Shipping and the International Association of Independent Tanker Owners
- Regulation B-1 of the IMO's International Convention for the Control and Management of Ships' Ballast Water and Sediments
- Part B of Annex 5 to Resolution MEPC.127(53), *Guidelines for Ballast Water Management and Development of Ballast Water Management Plans*

Water column chemistry in the RSA is low in pollutants and other contaminants. It is unlikely that any unintended discharges to the sea during program activities (or any discharges allowed under Canadian regulations or in accordance with international conventions) will affect water quality. Short-term effects offshore or nearshore during vessel transits (if any) would be negligible compared to other maritime activity in the region.

If potential effects from all types of routine discharges are mitigated properly and standard industry good practices at sea are followed, including compliance with all applicable regulations and conventions, the significance of residual effects on VECs will be negligible and are not considered further.

14.2.5 DRILL SITE PREPARATION

The proposed drilling plan calls for completion of one or more exploration wells over the course of up to four drilling seasons. Site preparation activities include the annual positioning and mooring of the drilling unit, well spudding during the 2020 open-water season and plugging and abandoning the well at the end of the program.

Site preparation and construction is only predicted to interact with the atmospheric environment and benthos.

14.2.5.1 Potential Effects and Mitigation

14.2.5.1.1 Atmospheric Environment

Air Quality

The use of ship-board equipment for drill site preparation and construction will result in CAC and GHG emissions. It is expected that all equipment will use diesel fuel, and that air emissions will have a composition similar to the vessel emissions described for vessel transit and presence in Section 14.2.1.

Changes to air quality resulting from drill site preparation and construction will be reduced through the use of standard mitigation and management practices, such as the use of equipment with current emission control technologies, reducing unnecessary idling of equipment and regular maintenance of equipment. Residual effects are predicted to be of medium magnitude, localized extent, and short-term duration and continuous during drill site preparation.

Noise

The use of ship-board equipment for drill site preparation and construction has the potential to increase noise levels in the LSA. Above-water sound sources from drill site preparation and construction are expected to be similar to those from vessel transit and presence (see Section 14.2.1.1.1, Atmospheric Environment), but with a greater quantity of ship-board equipment in operation.

Marine vessels used for the program will be fitted with standard mitigation, such as mufflers and louvers, to limit sound emissions from the exhaust stack and air intake vents. Noise mitigation for other equipment for drill site preparation and construction will be identified and implemented as appropriate – in particular, all internal combustion engines will be fitted with appropriate muffler systems.

The residual effect will consist of increased dBA noise levels. The increase in noise levels because of drill site preparation and construction are not predicted to exceed guideline values provided by the ERCB (2007), Health Canada (2010) or the IFC (2007). The residual noise effects are predicted to be of low magnitude, local extent within the LSA, short-term duration and regular frequency.

14.2.5.1.2 Benthos

The drilling unit anchoring and well spud installation might result in a loss or alteration of benthic habitat in the immediate vicinity of the spud and anchor locations from the breakage and fragmentation of hard substrate in these areas. These activities might also result in direct mortality of benthic organisms via direct physical effects on the seafloor, such as smother by sediment (Lissner et al. 1991). There is limited information available on the recolonizing capacity of hard-substrate benthic species in the program area. However, the predicted effects on benthos will be of low magnitude and localized over a short distance. It is expected that after the drilling unit anchoring and well spud installation are complete that recolonization of benthic invertebrates will be sufficient to mitigate temporary effects on the local benthic invertebrate community. Effects are not expected at the population level, as benthic organisms are generally widely distributed, and recovery, in terms of both diversity and abundance, occurs rapidly in response to localized effects. No further mitigation is proposed for the effects of drilling unit anchoring and well spud installation on benthos.

14.2.5.2 Significance of Residual Effects

A summary of the effects related to drill site preparation, mitigation and the significance of residual effects is provided in Table 14-8.

14.2.6 ICEBREAKING AND ICE MANAGEMENT

It is expected that icebreaking will be required to clear a path for the drilling unit, tankers and wareships into and out of the Beaufort Sea at the beginning and end of each season. It might also be required as part of the ice management around the drill site throughout the drilling season. It is unlikely that ice conditions in and around Tuktoyaktuk Harbour will require icebreaking, although some might be required in the vessel transit path from Tuktoyaktuk to the offshore drill site.

Table 14-8: Effects, Mitigation and Significance – Drill Site Preparation and Drilling

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Increase in CAC and GHG emissions.	• Use equipment with current emission control technologies. • Reduce unnecessary idling. • Perform regular equipment maintenance.	Medium	Localized	Short term	Continuous	Not significant
	Increase in dBA noise levels.	• Marine vessels used for the program will be fitted with standard mitigation, such as mufflers and louvers to limit noise emissions from the exhaust stack and air intake vents. • All internal combustion engines will be fitted with appropriate muffler systems.	Low	Within LSA	Short term	Regular	Not significant
Benthos	Loss or alteration of benthic habitat or direct mortality from physical impacts on the seafloor related to drilling unit anchoring and well spud installation.	• None required.	Low	Within LSA	Short term	Occasional	Not significant

14.2.6 ICEBREAKING AND ICE MANAGEMENT (cont'd)

An initial assessment indicated that icebreaking and ice management activities will likely interact with all the identified VECs, with the exception of benthos, marine and anadromous fish, coastal landscapes and human health.

14.2.6.1 Potential Effects and Mitigation

14.2.6.1.1 Atmospheric Environment

Air Quality

The effects of icebreaking and ice management on the atmospheric environment will be the same as those described for vessel transit and presence in Section 14.2.1.

Noise

The effects of icebreaking and ice management on the above-water noise levels will be the same as those described for vessel transit and presence in Section 14.2.1.

14.2.6.1.2 Marine Mammals

The potential effects of icebreaking activities on marine mammals include:

- behavioural disturbance as a result of underwater icebreaker noise
- physical injury or mortality as a result of physical interaction with icebreakers
- disruption of existing ice habitat and potential entrapment effects

Behavioural Disturbance as a Result of Underwater Icebreaker Noise

The type of ice present in the program area will strongly influence the types of marine mammals frequenting the area and the nature of the icebreaker operations required. In loose pack ice, ship speed and underwater noise might be similar to that observed in open water (Richardson et al. 1995). In heavier pack ice or landfast ice, ship speed will be reduced, power levels higher and propeller cavitation greater, resulting in much higher levels of underwater noise (Richardson et al. 1995). Hall et al. (1994) took field measurements of three icebreaking vessels breaking ice at a drill site in the Beaufort Sea with broadband (10 to 10,000 Hz) source levels estimated at between 174 and 184 dB re 1 μPa-m.

There is limited information on the effects of icebreaking on most species of marine mammals. Ringed seal and polar bear are the only two species that occupy landfast ice. Ringed seals maintain breathing holes in the ice through the late fall, winter and spring. During this time, their mobility is severely limited by access to breathing holes (Richardson et al. 1995). Alliston (1980) found no evidence of reduced seal abundance during the spring in areas of the Beaufort

Sea where icebreaking had occurred the previous winter. It is possible that seals preferentially established breathing holes in areas of weakened ice created by ship tracks. Polar bears show either no reaction or very limited reaction to icebreakers and icebreaking support ships (Fay et al. 1984). Some polar bears have demonstrated short-range avoidance behaviour, but these reactions were brief and local, other polar bears have shown no reaction and some approached the vessel (Brueggeman et al. 1991, Rowlett et al. 1993).

Whales are not present in areas of landfast ice, but icebreaking during spring in the Canadian High Arctic has been shown to disturb beluga whales located near ice edges many kilometres away, including an observed flight/alarm response (LGL and Greeneridge 1986, Finley et al. 1990, Richardson et al. 1995). Evidence of habituation has also been observed. Beluga whales initially displaced in response to relatively low levels of icebreaking noise (94-105 dB re 1 μPa in the 20 to 1000 Hz band) returned several days later when icebreaker noise levels were still as high as 120 dB re 1 μPa (Finley et al. 1990). Reactions of bowhead whales to icebreaking are largely unknown. Migrating bowhead whales in the Beaufort Sea have been shown to avoid an icebreaker-supported drill site by more than 25 km when intense icebreaking occurred on a daily basis in the fall (Brewer et al. 1993). Migrating bowhead whales have also been shown to avoid drill sites during the fall when minimal icebreaking was occurring (LGL and Greeneridge 1987). It is uncertain what role icebreaking noise, drilling noise and overall ice conditions actually play in potential divergence of bowhead whales from drill sites (Richardson et al. 1995).

The proposed mitigation measures for eliminating or reducing the risk of potential marine mammal behavioural disturbance from icebreaking activities is the same as those described in Section 14.2.1.1.3. Based on the results from the literature, marine mammals are expected to habituate to underwater icebreaker noise generated and remain in the program area or leave the vicinity temporarily and return once the icebreaking activities are completed. No effects at the population level are predicted. After mitigation, behavioural disturbance as a result of underwater noise from icebreakers is predicted to be of low magnitude, extensive, short-term duration and occasional frequency.

Physical Injury or Mortality as a Result of Physical Interaction with Icebreakers

The potential for icebreaker strikes on marine mammals will be largely the same as those for potential ship strikes described in Section 14.2.1.1.3. Proposed mitigation measures for eliminating or reducing the risk for potential icebreaker strikes on marine mammals is the same as those described in Section 14.2.1.1.3. After mitigation, physical injury or mortality as a result of icebreaking activities are predicted to be of low magnitude, extensive, short-term duration and occasional frequency.

Disruption of Existing Ice Habitat and Potential Entrapment Effects

Marine mammals might follow icebreakers into ice-covered areas and become trapped by refreezing ice, although no evidence of this is shown in the literature with respect to marine mammal VECs identified for the Beaufort Sea region

Disruption of Existing Ice Habitat and Potential Entrapment Effects (cont'd)

(LGL and Greeneridge 1986, Richardson et al. 1995). Thomas et al. (1981) reported this type of behaviour in killer whales accompanying icebreakers in the Antarctic ice. Given that all icebreaking activities proposed for the program will be limited to the summer operating season (late spring to early fall or May 1 to October 31) when extensive or heavy sea-ice conditions are not prevalent, the potential for entrapment of marine mammals is predicted to be negligible. Proposed mitigation measures for eliminating or reducing the risk of this effect include the implementation of an MMMP involving the placement of trained MMOs on all program icebreaking vessels to monitor for marine mammals during active icebreaking and to implement mitigation measures described in Section 14.2.1.1.3. After mitigation, potential entrapment as a result of icebreaking activities is predicted to be of low magnitude, extensive, short-term duration and occasional frequency.

14.2.6.1.3 Terrestrial Wildlife

Icebreaking vessels are expected to potentially interact with terrestrial wildlife species (barren-ground caribou, Peary caribou and Arctic fox) which occur in the LSA and adjacent areas. Potential impacts could include:

- noise that would deter wildlife in the area
- direct encounters between icebreaking vessels and wildlife using the sea ice
- destruction of travel corridors, which could lead to either avoidance of the area or drowning of individual animals

Barren-Ground Caribou

Icebreakers creating leads in nearshore areas might interact with barren-ground caribou from three herds. The Bluenose West and the Cape Bathurst caribou herds overwinter on the southern portion of the Tuktoyaktuk Peninsula and the Tuktoyaktuk Peninsula herd is present year-round. These caribou might occasionally use the nearshore ice for their travel. However, unlike other herds (e.g., the Dolphin Union herd in the eastern NWT and western Nunavut, which regularly loses animals due to drowning [Nishi and Gunn 2004]), none of these herds are known to use the sea ice for their annual migrations (GNWT-ENR 2013). Any potential interaction would include individual animals that use the sea ice occasionally to travel near the coast. Because the MMOs on board the icebreaking vessels would be able to spot the caribou, the interaction is assessed as being negligible.

Peary Caribou

Peary caribou are known to travel long distances over the sea ice during their annual migrations. The Banks Island population travels between Banks Island and northwestern Victoria Island (AANDC 2012). The High Arctic population travels seasonally between the High Arctic islands. Over the past decades, the sea ice extent in the Arctic has declined, which is believed to interfere with Peary caribou inter-island movements (AANDC 2012). Interactions between icebreaking vessels and Peary caribou would depend on the route the icebreaker is taking to reach the LSA. However, because Peary caribou are not expected to be in the LSA, no interaction is predicted.

Arctic Fox

Arctic foxes use the sea ice in nearshore areas and have been reported to travel long distances across the ice. Any potential interaction with icebreaking vessels would include individual animals that use the sea ice occasionally to travel near the coast. Because the MMOs on board icebreaking vessels would be able to spot these foxes, the interaction is assessed as being negligible.

14.2.6.1.4 Traditional Land and Resource Use

Icebreaking and ice management have the potential to indirectly affect the traditional harvesting of marine mammals, marine birds and terrestrial mammals. Indirect effects would result from changes to populations of harvest species previously assessed. Icebreaking is not expected to have an effect on fish and effects of icebreaking on terrestrial wildlife are negligible (see Section 14.2.6.1.3). The effects of icebreaking and related ice management on marine mammals as a result of underwater noise and potential vessel strikes have been assessed as low in magnitude and limited to the LSA (see Section 14.2.6.1.2). The effects of altered habitat use on marine birds and marine mammals because of changes in natural sea-ice conditions have been assessed as low in magnitude and localized in extent (see Sections 14.2.6.1.1 and 14.2.6.1.2). Indirect effects on traditional land and resource use are predicted to be of low magnitude, local extent within the LSA, short-term duration and occasional frequency.

Although the ELs are located in an area where no traditional harvesting occurs (because of the distance offshore), icebreaking is expected to occur along the transit corridors closer to shore where marine mammals, marine birds and terrestrial mammals (e.g., caribou) are traditionally harvested. If harvesting occurs at the same time that icebreaking is taking place, traditional harvesters might notice a change in the distribution of marine mammals, marine birds and terrestrial mammals. As a result, icebreaking and ice management is expected to have a medium magnitude effect on traditional harvesting that is localized in extent. As the effect is expected to last throughout each drilling season, it is predicted to be of medium-term duration and occasional frequency.

14.2.6.2 Significance of Residual Effects

A summary of the effects related to icebreaking and ice management, mitigation and the significance of residual effects is provided in Table 14-9.

14.2.7 DRILLING

Drilling will be conducted over up to four open-water seasons from 2020 to 2023. Prospective drilling locations could be in water depths ranging from 80 to 850 m.

Table 14-9: Effects, Mitigation and Significance – Icebreaking and Ice Management

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Increase in CAC and GHG emissions.	• Marine vessels used for the program will meet the emission standards in effect at the time of mobilization.	Medium	Localized	Short term	Regular	Not significant
	Increase in dBA noise levels.	• Marine vessels used for the program will be fitted with standard mitigation, such as mufflers and louvers, to limit noise emissions from the exhaust stack and air intake vents.	Low	Within LSA	Short term	Regular	Not significant
Marine mammals	Behavioural disturbance as a result of underwater icebreaker noise.	• Marine mammal monitoring will be performed on all program icebreaking vessels by trained MMOs. • The MMOs will notify the vessel operator if there is an imminent risk of striking a marine mammal. Ship officers will make a decision if actions are required to avoid deceleration or avoidance manoeuvres.	Low	Extensive	Short term	Occasional	Not significant
	Physical injury or mortality as a result of physical interaction with icebreaker.		Low	Extensive	Short term	Occasional	Not significant
	Disruption of existing ice habitat and potential entrapment effects.		Low	Extensive	Short term	Occasional	Not significant
Terrestrial wildlife	Noise could deter wildlife in the area. Direct encounters between icebreaking vessels and wildlife using the sea ice, leading to injury or mortality of individuals. Destruction of travel corridors, which can lead to either avoidance of the area or drowning of individual animals.	• Place MMOs on board icebreakers.	Negligible	-	-	-	Not significant
Traditional land and resource use	Indirect effects of icebreaking activities on harvest species.	• See mitigation for marine avifauna and marine mammals.	Low	Within LSA	Short term	Occasional	Not significant
	Effects of icebreaking on harvesting activities.	• Communication with communities with regard to icebreaking activities.	Medium	Localized	Medium term	Occasional	Not significant

14.2.7 DRILLING (cont'd)

Top holes will be drilled with water-based drilling fluids and cuttings will be discharged to the seafloor. A BOP will be installed. Casing will be drilled and set, and drilling will continue until the well reaches the required target depth. A drilling fluid formulation will be developed for the well, with a fluid weight sufficient to maintain hydrostatic overbalance. Water-based fluids will be used for the first and shallow depth sections of the well. Nonaqueous drilling fluids will be used for subsequent and deeper sections of the well.

An initial assessment has indicated that drilling activities will likely interact with the atmospheric environment, benthos, marine and anadromous fish, marine mammals and traditional land use and resources. The interaction with marine avifauna is expected to be negligible.

14.2.7.1 Potential Effects and Mitigation

14.2.7.1.1 Atmospheric Environment

Air Quality

The use of ship-board drilling equipment will result in CAC and GHG emissions. It is expected that all drilling equipment will use diesel fuel, and that air emissions will have a composition similar to the vessel emissions for vessel transit and presence described in Section 14.2.1.

Changes to air quality resulting from drilling will be reduced through the use of standard mitigation and management practices, such as the use of equipment with current emission control technologies and regular maintenance of equipment. Residual effects are predicted to be of medium magnitude, localized extent, short-term duration and continuous during drilling operations.

Noise

The effects of drilling on the above-water noise levels will be the same as those described in Section 14.2.5, for drill site preparation and construction. Some of the specific ship-board equipment in operation during drilling activities will likely be slightly different than during drill site preparation and construction, but the overall noise effects are predicted to be the same.

14.2.7.1.2 Benthos

The potential effects of drilling on benthos include loss or alteration of benthic habitat and direct mortality from discharge of cuttings on the seafloor.

All phases of oil field operations generate waste. The composition and proportion of waste will vary from phase to phase. At the exploration and appraisal phase, drilling waste would consist mostly of used drilling fluids and drilling cuttings. Additional waste produced during this phase could be discharges from installation and operation of subsea systems, such as BOP fluids. Other drilling

14.2.7.1.2 Benthos (cont'd)

waste can include small amounts of produced water and sand, cement residues, desalination brine and other materials.

During the installation and use of subsea systems, there might be discharges to the environment that include ethylene glycol, methanol, water, brine, residual petroleum and other residues. These discharges are typically limited in volume and occur when submerged systems are opened to the environment subsea. Water-based drilling fluid will be used for the first and shallow sections of the well since it is less toxic. However, at subsequent intervals, the use of NADF is necessary. Because there is no dissolution of clay and salts, NADF can be separated from associated materials and reused. As part of the EPP, a program-specific WMP will address issues related to potential effects from the discharge of drilling waste. The plan will be developed in accordance with the NEB's *Offshore Waste Treatment Guidelines* and will meet the *Canada Oil and Gas Drilling and Production Regulations*.

Before selecting the drilling fluids to be used, all components that constitute the drilling fluids will be screened through the chemical management system developed in consideration of the *Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands*. The NADF selected for the program drilling will have lower toxicity levels as compared to traditional oil-based fluids.

Water-based fluid and associated drilling cuttings will be discharged to the marine environment without treatment. Other types of drilling fluid and associated drilling cuttings will be continuously monitored to meet specific standards specified in NEB's *Offshore Waste Treatment Guidelines*. They would be discharged to the sea only if these cuttings met the required legislated standards. Drilling fluid or drilling cuttings do not meet the standards will be transported onshore for disposal under approved conditions. Subsea system chemicals to be discharged will be screened through the operator's chemical management system and checked against the *Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands*. Planned batch discharges from subsea systems will be described in the operator's EPP. Other potential drilling discharges, such as produced (associated) water, produced sand and cement residues will be screened against the standards of NEB's *Offshore Waste Treatment Guidelines* and treated, if necessary, before being discharged into the sea. Desalination brine recovered from the production of potable water will be discharged without treatment.

Benthic invertebrates in the drill cuttings discharge area might be destroyed and local benthic habitat will be lost or altered causing a temporary disturbance to benthic invertebrates. Effects on marine benthos and benthic habitat during drilling are predicted to of low magnitude, site specific (confined to a much localized area near the well site) and short-term duration. Effects are not predicted at the population level, as benthic organisms are generally widely distributed, and recovery, in terms of both diversity and abundance, occurs rapidly in response to localized effects.

14.2.7.1.3 Marine and Anadromous Fish

Pelagic marine fish, predominantly Arctic cod, play a key role in the Beaufort Sea ecosystem as a food source for marine mammals and birds. Research by BREA has indicated that adult cod spend the summer on the slope at water depths greater than 400 m, near where drilling will likely take place. As a benthic fish species, they are most likely to be affected by drilling activity.

Potential effects of drilling activities on marine fish include behavioural disturbance from underwater drilling noise, potentially resulting in avoidance of the program area or displacement from sensitive habitat areas (e.g., foraging and spawning areas or migratory routes). Effects will be similar to those described in Section 14.2.11.1.3, for behavioural disturbance in fish from underwater dredging noise. Residual effects for changes in fish behaviour because of underwater drilling noise are not expected. Although noise will be detectable to fish in the immediate vicinity of the drilling unit and will occur at regular intervals throughout the open-water season, adverse effects are predicted to be of low magnitude, site specific (local) and short-term duration and reversible. Effects are likely to be limited to short-term behavioural responses (e.g., startle, displacement and schooling behaviour) that will vary by species and hearing group, and will be dependent on the properties of the received sound. No mitigation is proposed for effects of drilling noise on marine fish.

Marine fish species in the drill cuttings discharge area, including Arctic cod, might be negatively affected. Fish habitat will be lost or altered causing a temporary disturbance to fish. Effects on marine fish and fish habitat during drilling are predicted to be of low magnitude, site specific (i.e., confined to a localized area near the well site) and short-term duration. Effects are not predicted at the population level, as the affected fish species are generally widely distributed, and recovery, in terms of both diversity and abundance, can occur rapidly in response to localized effects.

14.2.7.1.4 Marine Mammals

Potential effects of drilling activities on marine mammals include behavioural disturbance from underwater drilling noise or from acoustic pingers that will be used to assist in reconnecting subsea moorings after a disconnect, potentially resulting in avoidance of the program area or displacement from sensitive habitat areas (e.g., foraging and breeding areas or migratory corridors).

Underwater sound from a fixed, ongoing source, such as an operating drilling unit, is considered continuous, unlike the transient or intermittent sounds typically produced by a ship underway (Richardson et al. 1995). Drilling operations generally produce underwater noise that includes strong tonal components at low frequencies that can overlap with the sensitive hearing range of bowhead whales, but not likely beluga whales, ringed seals or polar bears (Richardson et al. 1995). Brewer et al. (1993) and Hall et al. (1994) measured underwater sounds from the ice-strengthened conical drilling unit (the *Kulluk*), a specialized floating platform designed for drilling in Arctic waters. Broadband source levels (10 to 10,000 Hz) were estimated to be 179 dB re 1 µPa-m during drilling and to be 191 dB re 1 µPa-m during tripping (i.e., pulling the drill string

14.2.7.1.4 Marine Mammals (cont'd)

from the hole and replacing it), based on measurements taken at a depth of 20 m in waters about 30 m deep (with received levels at depth 10 m notably less than those at 20 m) (Hall et al. 1994).

Bowhead whales have been shown to react to drilling noise within 4 to 8 km of a drillship when received levels were about 118 dB re 1 µPa (about 20 dB above ambient levels) (Greene 1985 and 1987). Richardson et al. (1990) reported avoidance behaviour by migrating bowhead whales in the Beaufort Sea at distances of up to 10 km from the drilling unit, corresponding with an underwater received level of 115 dB re 1 µPa. Evidence of habituation has been observed, with bowheads later approaching to within 4 km of the same drilling unit (Richardson et al. 1990). Kapel (1979) reported numerous sightings of baleen whales within visual range of active drilling units off the west coast of Greenland. Beluga whales are often observed near drilling sites (Richardson et al. 1995), with reports of this species within 100 m of an active drilling operation (artificial island) off the coast of Alaska (Fraker and Fraker 1979).

Beluga whales transiting along an ice lead during spring were shown to change course when they came within 1 km of a stationary drillship, and exhibited more active avoidance when support vessels were moving near the drillship (Fraker and Fraker 1982).

Ringed seals have been reported near drilling operations in the Arctic during summer and fall, with many studies demonstrating considerable tolerance by seals for drilling noise (Brewer et al. 1993, Hall et al. 1994, Richardson et al. 1995, Moulton and Lawson 2002). Polar bears often approach stationary drillships and drilling sites when ice is present nearby (Stirling 1988).

In summary, behavioural reactions of marine mammals to underwater noise generated by drilling operations have been demonstrated at broadband levels as low as about 115 dB re 1 µPa-1m (Richardson et al. 1995). Assuming spherical spreading, underwater noise generated by an active drilling unit equivalent to the Kulluk would likely attenuate to below 115 dB re 1µPa at a distance of several kilometres from the source. Behavioural reactions would be limited to a small area around the proposed drill site location. Dependent on the properties of the received sound, effects are likely to be limited to short-term behavioural responses (avoidance or displacement) that will vary by species and hearing group. Based on results from the literature, marine mammals are predicted to habituate to underwater drilling noise generated during the program and remain in the program area, or leave the vicinity temporarily and return once drilling is completed.

Proposed mitigation measures for minimizing this potential effect include implementation of an MMMP and placement of trained MMOs on the drilling unit and support vessels to monitor for marine mammals during active drilling and to implement the mitigation measures described in Section 14.2.1.1.3. Although noise will be detectable to animals in the immediate vicinity of the drilling unit and noise will occur at regular intervals throughout the open-water season, with the proposed mitigation in place, adverse effects are predicted to be of low magnitude, site specific (local), short-term duration and reversible. No effects at the population level are predicted, and no residual effects for changes in marine mammal behaviour are expected.

14.2.7.1.5 Traditional Land and Resource Use

Drilling activities in the offshore have the potential to indirectly affect the traditional harvesting of fish, marine birds and marine mammals. Indirect effects would result from changes to populations of harvest species previously assessed. It is likely that underwater noise from drilling activities will have a localized, low-magnitude effect on marine mammals (see Section 14.2.7.1.3) and no effect on marine birds, fish or terrestrial mammals. Therefore, indirect effects on traditional land and resource use are predicted to be of low magnitude, local extent within the LSA, medium-term duration and occasional frequency.

Program-related drilling activities will occur in an area that is not used for traditional harvesting, because of its distance offshore and distance from traditional harvesting areas along the coastline. Therefore, the direct effects of routine drilling activities offshore in traditional land and resource use are predicted to be negligible.

14.2.7.2 Significance of Residual Effects

A summary of the effects related to drilling, mitigation and the significance of residual effects is provided in Table 14-10.

14.2.8 WELL TESTING

During drilling and following completion of the exploration well, well logging will be conducted to measure the formation properties, which includes the porosity and permeability of the rock. Sampling could be conducted to determine the fluid properties if oil or gas is encountered.

After completion of the well, a VSP could be conducted using geophones inside the wellbore to obtain real depth information for comparison with the original seismic data.

Well testing could also be carried out on any specific zone of interest. This could involve the carefully controlled release of reservoir fluids through the test pipe, which might be allowed to flow to the surface for a period of time. The produced oil or gas would typically be flared at the surface from the drilling unit.

An initial assessment indicated that well testing activities will likely interact with the atmospheric environment, marine and anadromous fish, marine avifauna, marine mammals and traditional land use and resources. The interaction with marine avifauna is predicted to be negligible.

Table 14-10: Effects, Mitigation and Significance – Drilling

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Increase in CAC and GHG emissions.	• Use equipment that complies with applicable emission standards. • Perform regular equipment maintenance.	Medium	Localized	Short term	Continuous	Not significant
	Increase in dBA noise levels.	• Marine vessels used for the program will be fitted with standard mitigation measures, such as mufflers and louvers, to limit noise emissions from the exhaust stack and air intake vents. • Internal combustion engines will be fitted with appropriate muffler systems.	Low	Within LSA	Short term	Regular	Not significant
Benthos	Loss or alteration of benthic habitat and direct mortality from discharge of muds and cuttings on the seafloor.	• Adhere to the program-specific WMP developed in accordance with the NEB's *Offshore Waste Treatment Guidelines* and in accordance with *Canada Oil and Gas Drilling and Production Regulations*.	Low	Localized	Short term	Regular	Not significant
Marine and anadromous fish	Behavioural disturbance from underwater drilling noise.	• None.	Low	Localized	Short term	Regular	Not significant
Marine mammals	Behavioural disturbance from underwater drilling noise.	• Adhere to mitigation measures set out in the MMMP (see Section 14.2.1.1.3).	Low	Localized	Short term	Regular	Not significant
Traditional land and resource use	Indirect effects of drilling on harvest species.	• See mitigation for marine avifauna and marine mammals.	Low	Within LSA	Medium term	Occasional	Not significant
	Effects of drilling on harvesting activities.	• No mitigation required.	Negligible	-	-	-	Not significant

14.2.8.1 Potential Effects and Mitigation

14.2.8.1.1 Atmospheric Environment

Air Quality

Flare operation will result in the emission of CACs and GHGs, if well testing requires bringing formation fluids to the surface. Flare emissions will depend on the flare equipment used and the flare gas composition, but are expected to include SO_2, NO_x, fine particulates, VOCs and GHGs (i.e., CO_2, methane and nitrous oxide). Flare emissions might also include such compounds as benzene, PAHs, naphthalene, acetaldehyde, acrolein, ethyl benzene, hexane, toluene, xylene and hydrogen sulphide.

A screening-level dispersion model (e.g., AERSCREEN) will be used to assess the effects of flare stack emissions on ambient air quality. The model results will be compared with regional baseline levels and the *Guidelines for Ambient Air Quality Standards in the Northwest Territories*.

Flaring activities will comply with industry standards in effect at the time of the program. The effects of flaring on the atmospheric environment are predicted to be of medium magnitude, localized extent, short-term duration and regular frequency.

Noise

Well testing has the potential to increase noise levels in the LSA. The only important above-water noise source from well testing is predicted to be flaring. Noise emissions from flaring will vary substantially depending on the rate at which material is burned. To mitigate potential noise effects, flaring will be conducted only when required for well testing.

The residual effect will consist of increased dBA noise levels during flaring events. The increase in noise levels because of well testing are not predicted to exceed guideline or criteria values provided by the ERCB (2007), Health Canada (2010) or the IFC (2007). The residual noise effects are predicted to be of low magnitude, local extent within the LSA, short-term duration and occasional frequency.

14.2.8.1.2 Marine and Anadromous Fish

The potential effects of well testing on marine and anadromous fish are limited to behavioural disturbance effects as a result of underwater noise from the proposed VSP survey. Following completion of drilling, a VSP might be conducted using geophones inside the wellbore to obtain real depth information for comparison to the original seismic data. This would result in a series of detailed seismic images. VSP is the geophysical technique of taking seismic measurements in a borehole to assist with further refinement of a potential hydrocarbon resource.

Source levels of underwater VSP sound are generally less than those from seismic acquisition surveys. Given that the effects of underwater noise on marine and anadromous fish from seismic surveys conducted in the EL areas were

14.2.8.1.2 Marine and Anadromous Fish (cont'd)

assessed as being not significant (Kavik-AXYS 2008 and 2009), the effects of VSP noise exposure on marine and anadromous fish will likely be not significant. A 30-minute ramp-up procedure will be undertaken for each VSP, where possible. After mitigation, the effects of well testing on marine and anadromous fish are predicted to be of low magnitude, local extent within the LSA, short-term duration and occasional frequency.

14.2.8.1.3 Marine Avifauna

The potential effects of well testing on marine avifauna are limited to physical injury or mortality as a result of proposed flaring activities. Species of marine birds that migrate or are active at night are drawn towards sources of artificial light (Gauthreaux and Belser 2006). Birds that migrate at night over the open ocean are especially vulnerable to artificial lighting as the open ocean at night is usually dark, with few or no other sources of light (Montevecchi 2006). Gas flaring on the drilling unit will produce light that might attract birds. Flaring also produces heat, which has the potential to cause mortality for birds that come in direct contact with it. The light might also attract birds to come close enough to the drilling rig that they come in contact with the structure causing injury or death (Wiese et al. 2006). The noise or heat emitted during flaring might deter birds from entering the area or from coming close enough to the flaring location to be potentially injured.

The overall effect of flaring on marine bird populations is predicted to be of low magnitude and limited to within a short radius of the drilling unit. Efforts will be undertaken to mitigate the potential mortality or injury effects on marine avifauna, including:

- conducting flaring only when necessary for well testing
- making program personnel aware of the potential for birds to be attracted to light sources
- making reasonable efforts to allow birds that become stranded on the drilling unit to recover and move away from the source of light during the night

After mitigation, the effects of well testing on marine birds are predicted to be of low magnitude, localized extent, short-term duration and occasional frequency.

14.2.8.1.4 Marine Mammals

The potential effects of well testing on marine mammals are limited to behavioural disturbance effects as a result of underwater noise from the proposed VSP survey. Source levels of underwater VSP sound are generally less than those from marine seismic acquisition surveys.

Given that the effects of underwater noise on marine mammals from seismic surveys conducted in the EL areas were assessed as being not significant (Kavik-AXYS 2008 and 2009), the effects of VSP noise exposure on marine mammals is also predicted to be not significant. A 30-minute ramp-up procedure will be undertaken for each VSP where possible. After mitigation, the effects of well testing on marine mammals are predicted to be of low magnitude, local extent within the LSA, short-term duration and occasional frequency.

14.2.8.1.5 Traditional Land and Resource Use

Well testing might indirectly affect traditional harvesting as a result of the effects of underwater VSP noise on marine mammals, and as a result of mortality or injury from exposure to flaring activities. The wildlife assessments determined that behavioural disturbance to marine mammals as a result of underwater VSP noise are predicted to be low in magnitude and localized in geographic extent (see Section 14.2.8.1.4). There is no predicted effect to marine birds, fish or terrestrial mammals as a result of underwater VSP noise. Mortality or injury to marine birds from flaring activities has been assessed as low in magnitude and localized (see Section 14.2.8.1.3). There will be no predicted effect on fish, marine mammals or terrestrial mammals from flaring activities. Traditional harvesters are not predicted to notice any change in availability of marine mammals or marine birds beyond natural variation. Therefore, the indirect effects of well testing activities on traditional harvesting are predicted to be of low magnitude, local extent within the LSA, medium-term duration and regular frequency.

Well testing will be limited to within the offshore EL areas and will not occur in areas used for traditional harvesting. Harvesting of marine birds and marine mammals, such as whales, seals and polar bears occurs closer to the shoreline or along the ice floe edge. Therefore, well testing is not predicted to have direct effects on traditional land and resource use.

14.2.8.2 Significance of Residual Effects

A summary of the effects related to well testing, mitigation and the significance of residual effects is provided in Table 14-11.

14.2.9 SHORE-BASED FACILITY PREPARATION AND OPERATION

A shore-based facility might be required to support the offshore drilling program, including providing:

- accommodation for personnel, to be determined at a future date
- staging sites and storage areas
- offices and communication services
- storage of emergency equipment
- access to a potable water supply
- a docking area
- land and air transportation services
- waste management services

The most likely location for the shore-based facility will be in Tuktoyaktuk. There is existing infrastructure and services in place in Tuktoyaktuk that would require only minor upgrades to establish the shore-based facility.

The only interaction that the shore-based facility preparation and operation might have will be with marine mammals and terrestrial wildlife.

Table 14-11: Effects, Mitigation and Significance – Well Testing

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Increase CAC and GHG emissions.	• Use equipment with current emission control technologies. • Reduce unnecessary idling. • Perform regular equipment maintenance.	Medium	Localized	Short term	Regular	Not significant
	Increase in dBA noise levels.	• Conduct flaring only as required for well testing.	Low	Within LSA	Short term	Occasional	Not significant
Marine and anadromous fish	Behavioural disturbance as a result of underwater VSP noise.	• None.	Low	Within LSA	Short term	Occasional	Not significant
Marine avifauna	Mortality or injury from exposure to flaring activities.	• Conduct flaring only as required for well testing. • Make program personnel aware of the potential for birds to be attracted to light sources • Make reasonable efforts to allow birds that become stranded on the drilling unit to recover and move away from the source of light during the night.	Low	Within LSA	Short term	Occasional	Not significant
Marine mammals	Behavioural disturbance as a result of underwater VSP noise.	• None.	Low	Within LSA	Short term	Occasional	Not significant
Traditional land and resource use	Indirect effects of well testing on harvest species.	• See mitigation for marine mammals.	Low	LSA	Medium term	Regular	Not significant

14.2.9.1 Potential Effects and Mitigation

14.2.9.1.1 Marine Mammals

Polar bears are known to be attracted to the smells and sounds from human developments, such as camp sites (Schliebe et al. 2006). This attraction can result in an increase in the number of bears killed in defence of human life. In areas where polar bears might be responding to changing sea ice conditions and might be in poorer health, their attraction to alternative food sources (e.g., shore-based facility waste) might increase, and human–bear contacts (possibly resulting in injuries or fatalities) will increase as a result (Derocher et al. 2004). Polar bears might approach the shore-based facility attracted by activity and smells. Polar bears use the coastline of the Tuktoyaktuk Peninsula when the ice melts during the summer (Ferguson et al. 1997). There are also several areas of known maternity denning habitat along the coast in the Tuktoyaktuk area.

Although the shore-based facility that might be used for this program is an established facility, it is assumed that management and layout of the facility will follow standard guidelines and best practices to minimize wildlife attraction and encounters. A Wildlife Interaction Plan will be developed as a component of the EPP, and program staff and contractors will be trained in attractants management, wildlife avoidance and encounter procedures, and bear encounter responses. After mitigation, the effects of the preparation and operation of the shore-based facility on marine mammals are predicted to be negligible.

14.2.9.1.2 Terrestrial Wildlife

Similar to polar bears, grizzly bears, wolves and foxes are also attracted by human activities, such as camp sites. This attraction can result in an increase in the number of grizzly bears and wolves killed in defence of human life. Grizzly bears occur in low numbers on the Tuktoyaktuk Peninsula and are known to den on neighbouring Richards Island (Section 10.14.3). It is possible that grizzly bears, wolves and foxes might approach the shore-based facility attracted by human activity and smells. Habituated wildlife might increase the number of human-wildlife encounters, which could result in injuries or fatalities.

Efficient mitigation measures to detect and deter wildlife will be in place at the shore-based facility. Program personnel will receive bear safety and awareness training and a Wildlife Interaction Plan will outline all processes and procedures to ensure human and bear safety and well-being. After mitigation, the effects of the preparation and operation of the shore-based facility on terrestrial wildlife are predicted to be negligible.

14.2.9.2 Significance of Residual Effects

A summary of the effects related to the shore-based facility preparation and operation, mitigation and the significance of residual effects is provided in Table 14-12.

Table 14-12: Effects, Mitigation and Significance – Shore-Based Facility Preparation and Operation

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Marine mammals	Attraction of polar bears to the shore-based facility leading to increased human–bear encounters.	• Implement standard shore-based facility procedures to deter wildlife. • Implement a Wildlife Interaction Plan.	Negligible	-	-	-	Not significant
Terrestrial wildlife	Attraction of grizzly bears, wolves and foxes to the shore-based facility leading to increased human–wildlife encounters.	• Implement standard shore-based facility procedures to deter wildlife. • Implement a Wildlife Interaction Plan.	Negligible	-	-	-	Not significant

14.2.10 DOCK CONSTRUCTION

Some dock construction and upgrading might be required in the Tuktoyaktuk Harbour for loading and unloading of supplies and equipment. The dock area might require additional equipment to handle all types of bulk materials, including the potential installation of larger cranes.

Likely interactions related to the upgrading of the dock will be with the atmospheric environment, benthos, marine and anadromous fish, marine avifauna and traditional land and resource use.

14.2.10.1 Potential Effects and Mitigation

14.2.10.1.1 Atmospheric Environment

Air Quality

The use of heavy equipment for upgrading the dock will result in CAC and GHG emissions. It is expected that all heavy equipment will use diesel fuel, and that air emissions will have a composition similar to the vessel emissions described for vessel transit and presence in Section 14.2.1. In addition to diesel exhaust, diesel vapours might be emitted from fuel storage systems and during fuel transfer processes. The vehicle and equipment travel on unpaved surfaces and earth moving activities could also result in fugitive dust emissions.

Changes to air quality from upgrading the dock will be reduced through the use of standard mitigation and management practices, such as the use of equipment with current emission control technologies, reducing unnecessary idling of equipment and regular maintenance of equipment. Residual effects are predicted to be of low magnitude, localized extent, short-term duration and regular frequency.

Noise

Equipment used for construction of the dock will be largely consistent with the heavy equipment used during resupply activities (see Section 14.2.3). Noise sources from heavy equipment include diesel engines, electric motors, electrical generators and backup alarms. Noise emissions from specific heavy equipment will vary. Driving new dock support pilings might be necessary during the program-related dock construction. Pile driving is a loud and highly impulsive noise source. The pile driver is the only piece of equipment used for dock construction that is qualitatively different than the equipment used for resupply activities.

Noise mitigation implemented during dock construction is expected to include:

- advising nearby residents of particularly noisy activities (e.g., pile driving) and scheduling these events so as to reduce community disruption, where possible
- ensuring that all internal combustion engines are fitted with appropriate muffler systems

Noise (cont'd)

- taking advantage of acoustical screening from existing on-site buildings to shield nearby dwellings from equipment noise

With the exception of pile driving equipment, heavy equipment currently operates in Tuktoyaktuk and so the presence of program-related heavy equipment for dock construction does not represent a qualitatively new or different type of sound source for the area.

The residual effect will consist of increased dBA noise levels. The increase in noise levels because of dock construction are not expected to exceed guideline or criteria values provided by the ERCB (2007), Health Canada (2010) or the IFC (2007), except during pile driving activities when there might be temporary exceedances. The residual effects are predicted to be of medium magnitude, extensive, short-term duration and occasional frequency.

14.2.10.1.2 Benthos

The potential effects of dock construction or modification on marine benthos include habitat loss or alteration. Benthic habitat will be altered during piling removal and installation causing a temporary disturbance to benthic invertebrates. Mobile invertebrates might be confined underneath new structures, while attached invertebrates and macro-vegetation (seaweeds) would be shaded. The removal of existing pilings will also remove organisms that have colonized the pilings (i.e., removal of established subtidal habitat). This will cause a temporary loss of invertebrates and habitat until new pilings are installed and recolonized.

The following measures will be implemented to mitigate effects on benthos and benthic habitat:

- a qualified environmental monitor will be on site during all construction activities to implement mitigation measures prescribed in the EPP
- manoeuvring vessels (e.g., a construction barge) within the intertidal and shallow subtidal waters will be kept to a minimum and caution would be exercised during barge operations in shallow waters to avoid grounding of vessels and potentially affecting benthic habitat and associated species
- where possible, hard substrates that are removed (e.g., boulders and cobbles) will be replaced with similar substrate types to support recolonization by marine biota
- compensation for the disturbance to fish habitat will be implemented in accordance with DFO requirements, Section 35(2) authorization pursuant to the *Fisheries Act*

Dock construction is not predicted to have a significant effect on benthos and benthic habitat, as the existing benthic habitat in Tuktoyaktuk Harbour is naturally disturbed each year by winter sea-ice scour. With mitigation in place, any effects on marine benthos and benthic habitat during pile installation are predicted to be of low magnitude (less severe than those effects naturally occurring from winter ice-scour events), site specific (confined to a localized area in Tuktoyaktuk Harbour) and short-term duration. Effects are not predicted at the population level, as benthic organisms are generally widely distributed, and recovery, in terms of both diversity and abundance, occurs rapidly in response to localized effects.

14.2.10.1.3 Marine and Anadromous Fish

Underwater noise produced during construction activities has the potential to alter fish behaviour. Systematic studies regarding the effects of underwater noise and vibrations from pile driving on fish are limited, and in some cases contradictory. Popper and Hastings (2009) reviewed the available studies, which addressed the following potential effects mechanisms:

- behavioural responses
- stress and other physiological responses
- hearing loss and damage to auditory tissues
- structural and cellular damage on non-auditory tissues
- mortality

Depending on the species of fish and the nature of the noise exposure (e.g., duration, peak pressure, rise times, accumulation of energy with time), underwater noise might result in the following effects:

- startle responses or migration out of areas exposed to underwater noise
- increased levels of corticosteroid levels, which is an indicator of stress (stress might impair a fish’s ability to avoid predation)
- hearing loss (the inability to hear might affect a fish’s ability to respond to other noise cues and be more susceptible to predation or less able to find food items)
- tears or rupture of the swim bladder or other tissues, which might affect buoyancy or cause internal bleeding and ultimately mortality

The following measures will be implemented to mitigate effects on fish and fish habitat related to impact pile driving noise:

- adherence to DFO Best Management Practices for Pile Driving and Related Operations
- where possible, vibrational pile driving will be used instead of impact pile driving as this method generates considerably lower underwater noise levels
- if aggregations of fish (e.g., schooling fish) are observed within the work area during impact pile driving, work activities will cease and DFO will be contacted
- concurrent multiple underwater noise-generating activities will be minimized, when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise-generating activities are planned they will be sequenced when possible to minimize construction duration.

14.2.10.1.3 Marine and Anadromous Fish (cont'd)

- underwater noise will be monitored in accordance with the following:
  - underwater noise from impact pile driving will not exceed 30 kPa at 1 m from the source (30 kPa is the value typically specified in authorizations issued by DFO and is equivalent to a sound pressure level of 210 dB re 1 μPa [Urick 1975, Richardson et al. 1995])
  - if the sound level exceeds 30 kPa at 1 m, efforts will be made to modify pile installation methods to reduce the intensity of the sound generated
- compensation for the disturbance to fish habitat will be implemented in accordance with DFO requirements, Section 35(2) authorization pursuant to the *Fisheries Act*

After mitigation, the effects of dock construction activities on marine and anadromous fish are predicted to be of low magnitude, local extent, short-term duration and occasional frequency.

14.2.10.1.4 Marine Avifauna

Marine bird behaviour near Tuktoyaktuk Harbour will be temporarily disturbed by noise from dock construction or modification. Pile driving and associated construction noise might result in sensory disturbance to marine birds, including avoidance and displacement behaviour. This could include disruptions to the annual migration of marine birds in the RSA and, consequently, their availability for harvest. Sensory disturbance might cause birds to abandon or make less use of preferred or traditional habitats leading to a reduction in abundance. This might affect reproduction and nesting success resulting in reduced recruitment and population size, and might limit the ability of staging birds during migration to survive and successfully migrate.

Mitigation measures to be implemented to minimize the potential for behavioural disturbance of marine birds near construction works include avoidance of known bird nesting areas and implementation of reduced travel speeds for vessels operating in Tuktoyaktuk Harbour (i.e., construction barges, tugs, small fuel tankers) to minimize the amount of noise generated by these vessels.

The potential for behavioural changes in marine avifauna because of noise from construction activities is considered low as this part of the LSA is already exposed to regular acoustic disturbance from human activities. Although normal bird behavioural patterns in the LSA might be initially disrupted, any deterrence from the area is likely to be temporary as effects will be limited in temporal and spatial scale. Birds are likely to habituate to noise provided that the disturbances are not associated with other negative experiences (Ward and Stehn 1989, Steidl and Anthony 2000, Goudie and Jones 2004).

There is extensive suitable habitat in the region for birds, and birds that are present in the LSA will likely move to areas at least 100 m from where the point of disturbance is occurring (Larsen et al. 2004). Marine birds might temporarily alter foraging and loafing patterns and distribution to avoid certain noise sources.

However, no substantial behavioural and physiological effects are predicted. The shorelines present along the support vessel transit route do not have steep cliff faces typically favoured by nesting birds. Therefore, no disturbance to nesting birds is predicted. With best management practices and proposed mitigation measures in place, incremental effects are predicted to be of low magnitude, site specific and short-term duration. Effects might be measurable in other parts of the home range of certain migratory birds and might represent a transboundary effect if outside of the ISR. Any changes in behaviour because of noise are predicted to be temporary and are not expected to result in population-level effects to a point where natural recruitment will not re-establish the population to its original level within one generation.

14.2.10.1.5 Traditional Land and Resource Use

Activities related to upgrading the dock have the potential to affect traditional land and resource use through:

- behavioural disturbance to birds as a result of in-air piling noise
- behavioural disturbance to fish from underwater piling noise
- fish habitat loss or alteration from new and modified dock structures

The effects of noise from pile driving on marine birds are predicted to be of low magnitude and localized extent (see Section 14.2.10.1.4). The effects of underwater noise from pile driving on marine fish behavior are predicted to be of low magnitude and localized extent. The effects on fish as a result of habitat loss and alteration because of any new or modified dock structures are predicted to be of low magnitude and localized extent (see Section 14.2.10.1.3). No effect on marine mammals or terrestrial mammals is predicted as a result of activities related to modifying dock facilities or building new ones.

Dock facilities are expected to be in Tuktoyaktuk Harbour, which is part of a larger area used for fish and bird harvesting. Fishing occurs throughout Kugmallit Bay, and geese and eggs are harvested along the coastline in the general area of Tuktoyaktuk. As a result, harvesters might notice a change in the availability of birds during pile-driving activities for dock construction. Traditional harvesters might also notice a change in fish distribution because of underwater noise during pile driving and the temporary loss or alteration of habitat during dock modification or construction. As a result, the effects of program-related activities for dock construction on traditional fishing and bird harvesting are predicted to be of medium magnitude, localized extent, short-term duration (effects are not predicted to last beyond a single drilling season) and occasional frequency.

14.2.10.2 Significance of Residual Effects

A summary of the effects related to dock construction, mitigation and the significance of residual effects is provided in Table 14-13.

Table 14-13: Effects, Mitigation and Significance – Dock Construction

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Increase in CAC and GHG emissions.	• Use equipment with current emission control technologies. • Reduce unnecessary idling. • Perform regular equipment maintenance.	Low	Localized	Short term	Regular	Not significant
	Increase in dBA noise levels.	• Advise nearby residents of particularly noisy activities and schedule these events so as to reduce community disruption. • Ensure that all internal combustion engines are fitted with appropriate muffler systems. • Take advantage of acoustical screening from existing on-site buildings to shield nearby dwellings from equipment noise.	Medium	Extensive	Short term	Occasional	Not significant
Benthos	Habitat loss or alteration from new and modified dock structures.	• Ensure that a qualified environmental monitor will be on site during all construction activities to implement EPP mitigation measures. • Manoeuvre vessels (e.g., construction barge) within the intertidal and shallow subtidal zone to a minimum. • Use caution during barge operations in shallow waters to avoid grounding of vessels. • Where possible, ensure that hard substrates removed (e.g., boulders and cobbles) will be replaced with similar substrate types to support recolonization by marine biota. • Provide compensation in accordance with Section 35(2) authorization of the *Fisheries Act*.	Low	Local	Short term	Occasional	Not significant
Marine and anadromous fish	Behavioural disturbance from underwater noise from piling.	• Adhere to DFO Best Management Practices for Pile Driving and Related Operations (DFO 2012). • Where possible, use vibrational pile driving in place of impact pile driving. • Cease work activities and contact the DFO, if aggregations of fish (e.g., schooling fish) are observed within the work area during impact pile driving activities.	Low	Local	Short term	Occasional	Not significant

Table 14-13: Effects, Mitigation and Significance – Dock Construction (cont'd)

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Marine and anadromous fish (cont'd)		• Minimize concurrent multiple underwater noise-generating activities when practicable (e.g., avoiding multiple pile driving activities at the same time). Where multiple underwater noise-generating activities are planned they will be sequenced, when possible, to minimize construction duration. • Ensure that underwater noise from impact pile driving will not exceed 30 kPa at a distance of 1 m from the source. • Ensure that if the sound level exceeds 30 kPa at 1 m, then efforts will be made to modify the pile installation methods to reduce the intensity of the sound generated. • Provide compensation for the disturbance to fish habitat in accordance with Section 35(2) authorization of the *Fisheries Act*.					
Marine avifauna	Behavioural disturbance from construction noise.	• Ensure that all program vessels operating in Tuktoyaktuk Harbour (e.g., cargo barges, tugs, small fuel tankers) will travel at reduced speeds to minimize the amount of noise generated. Bird nesting areas will be avoided.	Low	Local	Short term	Occasional	Not significant
Traditional land and resource use	Impact on harvesting of fish and marine birds.	• Imperial will meet with harvesters and discuss placement of docking modifications or new structures to avoid important harvesting sites	Medium	Localized	Short term	Occasional	Not significant

14.2.11 HARBOUR DREDGING

To allow vessels with deeper drafts to enter and exit Tuktoyaktuk Harbour, dredging might be required near the dock and at some locations within the harbour. The extent of the dredging required is currently unknown, as this has not been identified as a program requirement at this time.

If dredging is required, there would potential for interactions with all VECs except marine mammals and terrestrial wildlife. The interaction between dredging and marine avifauna would likely be insignificant.

Possibly, some community members might perceive that dredging contaminates country foods and could present a health issue. Because dredging of the harbour would be contained, chemical contamination of the water and subsequent accumulation in marine life would not be expected. As a result, effects on human health from consuming contaminated country foods would not be expected and are not considered further.

14.2.11.1 Potential Effects and Mitigation

14.2.11.1.1 Atmospheric Environment

Air Quality

The effects of harbour dredging on the atmospheric environment would include CAC and GHG emissions from dredging equipment. The effects would be similar to those described for vessel transit and presence in Section 14.2.1.

Noise

The effects of harbour dredging on above-water noise levels would be largely the same as those described for vessel transit and presence in Section 14.2.1.

14.2.11.1.2 Benthos

The potential effects of dredging on benthos include:

- direct mortality from physical dredging activities
- loss or alteration of benthic habitat from sediment removal and resuspension

Mortality of benthic organisms might occur from direct removal of benthic organisms from their existing habitat because of dredgeate removal, crushing of marine organisms during physical contact of the dredge bucket with the seafloor, and burial of organisms as a result of sediment removal, resuspension and lateral deposition events. Loss or alteration of benthic habitat because of dredging might occur as a result of sediment resuspension effects, siltation effects, contaminant release and uptake, release of oxygen consuming substances, and alterations to hydrodynamic regimes and physical habitat. Dredging might also modify current patterns and water circulation, which might affect vegetation and larval settlement. Suspended solids might reduce light penetration, potentially affecting the amount of solar radiation reaching benthic vegetation.

If dredging is required, the following mitigation measures would be implemented for the protection of benthic habitat:

- a qualified environmental monitor will be on site during all construction activities to implement mitigation measures prescribed in the EPP
- before dredging, the perimeter of the area to be dredged will be identified to confine the work within the program area. Tools such as real-time kinematic positioning controls (e.g., differential GPS) might be used to assist in positioning.
- a silt curtain will be installed to help contain resuspended sediments
- sediment containment and water filtering devices will be employed on the barge. This might require containment and treatment of barge dewatering effluent that exceeds limits for acute toxicity.
- the contract specifications will include operational controls to minimize disturbance of substrates (e.g., making additional dredge passes rather than dragging a bucket or beam to level the dredge surface, not stockpiling material underwater and controlling the rate of ascent and descent of the bucket)
- the dredged material barge will not be overloaded beyond the top of the side rails to minimize loss of dredged material from the barge and to prevent barge listing or instability
- manoeuvring vessels (e.g., construction barge) within the intertidal and shallow subtidal waters will be kept to an absolute minimum and caution will be exercised during barge operations in shallow waters to avoid grounding of vessels and effects on benthic habitat and associated species

Dredging is not predicted to have a significant effect on benthos and benthic habitat, given that the existing benthic habitat in Tuktoyaktuk Harbour is already naturally disturbed each year by winter sea-ice scour. After mitigation, any effects on marine benthos and benthic habitat during dredging are predicted to be of low magnitude (less severe than those effects naturally occurring from winter ice-scour events), site specific (confined to a localized area in Tuktoyaktuk Harbour) and short-term duration. Effects are not expected at the population level, as benthic organisms are generally widely distributed, and recovery, in terms of both diversity and abundance, occurs rapidly in response to localized impacts.

14.2.11.1.3 Marine and Anadromous Fish

The potential effects of dredging of marine and anadromous fish are likely behavioural disturbance from underwater dredging noise and loss or alteration of fish habitat from sediment removal and resuspension during dredging.

Underwater noise generated by dredging in Tuktoyaktuk Harbour might result in behavioural changes in marine fish because of sensory disturbance. Noise disturbance might cause fish to temporarily school in larger groups, move away

14.2.11.1.3 Marine and Anadromous Fish (cont'd)

from suitable habitat (displacement) or alter their natural movements (avoidance or diversion from a foraging area or migratory path). This could reduce foraging efficiency and fecundity and increase energy expenditure. Behavioral changes resulting in disrupted migration patterns or spawning events, or resulting in movement away from valuable food sources, have the potential to cause a change in fish populations or communities, particularly if these changes occur over a critical period of time when fish have a short window of opportunity to complete an activity.

Fish can detect noise at long distances when the ambient noise level is low but are unlikely to move away until the noise level is relatively high (i.e., when the distance is a few hundred metres) (Mitson 1995). The ability of fish to detect sound varies with species and is dependent on a number of factors, including the:

- presence of an air bladder
- structure of the internal hearing system
- size of the otoliths (i.e., a sensory detector)
- distance from the sound source and depth of water

Fish do not hear as mammals hear. Sound is interpreted by the otoliths of the inner ear, which respond to the kinetic components of the sound wave rather than the sound pressure (Mitson 1995). For fish species with a swim bladder, the organ sends the sound waves to the otolith. Because the bladder increases with the size of the fish, it has been suggested that sensitivity to sound might increase in proportion to the size of the fish (Mitson 1995).

Existing ambient noise has not been measured in Tuktoyaktuk and no published data or publicly available information exists on ambient underwater noise levels. Currently, the dominant sources of underwater ambient noise within the harbour include residential boating, community resupply vessels and delivery barges, surface agitation from wind, waves, rainfall and existing biological noise. Few studies have quantified sound levels associated with dredging activities though some studies have recorded in-water sound pressure levels between 150 and 162 dB re to 1 μPa (Richardson et al. 1995). More recent studies report suction dredging sound levels to be about 30 dB lower than pile driving sound levels in general, and hydraulic and mechanical dredging sound levels to be even lower (Robinson et al. 2011).

Hearing thresholds for Arctic species of fish are largely unknown and knowledge on the behavioural responses of fish to underwater sound are poorly understood (Popper and Hastings 2009). The intensity of the response of a fish to vessel noise depends on the species, its physiological conditions and its environment. Pelagic fish might dive deeper, while benthic fish might move laterally away from the noise source. Arctic char, which are benthopelagic, have a greater flexibility for movement in a 3-D space and might move deeper and laterally. Most research has investigated the responses of captive fish to high intensity sounds from seismic air guns and pile driving (Popper et al. 2005 and 2006).

Research has shown that the intensity of a fish's response was reduced with increased swimming depth of the fish and decreased speed of the vessel (Mitson 1995).

Residual effects for changes in fish behaviour because of underwater dredging noise are not predicted. Although noise will be detectable to fish in the immediate vicinity of dredging activities in the LSA and will occur at regular intervals throughout the open-water season, underwater noise disturbance on fish is predicted to be of low magnitude and within the range of existing noise levels (given existing vessel traffic in the harbour), site specific (local), short-term duration and reversible. Effects are likely to be limited to short-term behavioural responses (e.g., startle, displacement and schooling behaviour) that will vary by species and hearing group, and will depend on the properties of the received sound.

Mitigation measures to be implemented to minimize behavioural effects on fish from underwater noise include avoiding simultaneous operation of multiple underwater noise generating activities (e.g., dredging and pile driving), when practicable. Where multiple underwater noise-generating activities are planned, they will be sequenced, when possible.

Loss or alteration of fish habitat from sediment removal and resuspension during dredging will be similar to that described for benthos and benthic habitat in Section 14.2.10.1.2 for dock construction. Mitigation measures for protection of fish habitat during dredging activities will be the same as those described in Section 14.2.10.1.3.

After mitigation, the effects of dredging on marine and anadromous fish are predicted to be of low magnitude, localized extent, short-term duration and occasional frequency.

14.2.11.1.4 Coastal Landscapes

Harbour and channel dredging has the potential to affect the morphology of the shoreline and seafloor in the nearshore area by altering the distribution of sediments with resulting implications for wave, current and sediment transport patterns. This could result in shoreline and seafloor morphology changes (erosion or accretion) depending on the proximity of the dredging or disposal areas to the shoreline and the sediment transport climate near the dredged areas. It is expected that dredging might need to be ongoing throughout the program to maintain adequate water depths for navigation purposes. Dredging could occur alongside the existing dock facilities or similar facility in the harbour itself (where the sediment could be contaminated with petroleum products from past activity), at the entrance to the harbour or along the fairway to deeper water off the coast.

Mitigation of the effects of dredging can be incorporated into the design of dredged channels and harbour areas by determining the potential effects using hydrodynamic, sediment transport, and coastal morphologic models and sediment budget considerations. A comprehensive Dredging Management Plan, or

14.2.11.1.4 Coastal Landscapes (cont'd)

equivalent, including monitoring on areas where spoil would be placed, would be developed and implemented. Fine sediment dispersion and migration from the dredging and sediment placement areas might be controlled by the application of silt curtains and the use of low turbidity dredging equipment. The potential effects are predicted to be of medium magnitude, local extent within the LSA, continuous over the life of the project and at regular intervals.

14.2.11.1.5 Traditional Land and Resource Use

The effects of harbour dredging have the potential to affect traditional harvesting as a result of effects on fish populations, such as behavioural disturbance from underwater dredging noise, and adverse effects from potential resuspension of sediments from dredging (see Section 4.2.11.1.3). The effects on fish because of underwater noise are predicted to be of low magnitude and localized extent. The effects on fish as a result of resuspension of sediments during dredging are also predicted to be of low magnitude and localized extent. The wildlife assessments determined that there will be no effects on marine birds or terrestrial wildlife as a result of activities related to harbour dredging.

Harbour dredging occurs within a larger area that is used for harvesting marine mammals and fish. Beluga whales are harvested in the larger area around Tuktoyaktuk during July and August. Seals are harvested in the spring and early fall, but harvesting areas are located along the coastline, further away from Tuktoyaktuk Harbour. Fishing occurs throughout Kugmallit Bay during the spring, summer and fall. Because of the close proximity of dredging activity to harvesting activities, there is the potential for harvesters to notice a change in the availability of marine mammals and fish during dredging activities. As a result, the effect of dredging activities on traditional harvesting is considered medium and localized in geographic extent. Because the effect is expected to last for the duration of a single drilling season, the effects of dredging on traditional land and resource use are predicted to be of short-term duration and occasional frequency.

Imperial will implement a process to provide compensation related to potential effects on traditional harvesting for those circumstances where, despite mitigation, there is an effect on current or future harvesting activities.

14.2.11.2 Significance of Residual Effects

A summary of the effects related to dredging of the harbour, mitigation and the significance of residual effects is provided in Table 14-14.

14.2.12 WASTE DISPOSAL

It is assumed that any existing shore-based facility would be permitted to either incinerate waste or dispose of it at the Tuktoyaktuk landfill site. These processes are in place and are regulated by the appropriate agencies. The use of existing facilities by the program will increase the amount of domestic waste for the duration of shore-based activities, but it can be assumed that the processes in place will facilitate appropriate waste handling, transfer and disposal.

Table 14-14: Effects, Mitigation and Significance – Dredging

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects: Magnitude	Extent	Duration	Frequency	Significance of Residual Effect
Atmospheric environment	Increase in CAC and GHG emissions.	• All marine vessels used for the program will meet the emission standards in effect at the time of mobilization.	Medium	Localized	Short term	Regular	Not significant
	Increase in dBA noise levels.	• Marine vessels used for the program will be fitted with standard mitigations, such as mufflers and louvers, to limit noise emissions from the exhaust stack and air intake vents.	Low	Within LSA	Short term	Regular	Not significant
Benthos	Direct mortality from physical dredging activities. Loss or alteration of benthic habitat from sediment removal and resuspension.	• A qualified environmental monitor will be on site during program activities. • Before the start of dredging, the perimeter of the dredge area will be identified so that work occurs within the confines of the site. • A silt curtain will be installed to help contain resuspended sediments. • Sediment containment and water filtering devices will be used on the barge. This might require containment and treatment of barge dewatering effluent that exceeds limits for acute toxicity. • The contract specifications will include operational controls to minimize disturbance of substrates. • The dredged material barge will not be loaded beyond the top of the side rails. This will minimize loss of dredged material from the barge and prevent barge listing or instability. • The barge will not come to rest on the seafloor.	Low	Local	Short term	Occasional	Not significant
Marine and anadromous fish	Behavioural disturbance from underwater dredging noise.	• Concurrent multiple underwater noise-generating activities will be minimized, when practicable. Where multiple underwater noise-generating activities are planned they will be sequenced to minimize construction duration, where possible.	Low	Localized	Short term	Occasional	Not significant
	Loss or alteration of fish habitat from sediment removal and resuspension during dredging.	• See mitigation for Benthos.	Low	Localized	Short term	Occasional	Not significant

Table 14-14: Effects, Mitigation and Significance – Dredging (cont'd)

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Coastal landscapes	Effects of dredging on shoreline and nearshore morphology.	• A Dredging Management Plan will be developed and will cover application of controls on silt dispersion. • Prediction of effects using numerical hydrodynamic and sediment transport models to allow design for minimum effects.	Medium	Within LSA	Medium term	Regular	Not significant
Traditional land and resource use	Effects of dredging on fish harvesting within Tuktoyaktuk Harbour.	• See mitigation for marine and anadromous fish. • A Dredging Management Plan will be developed and discussed with the community.	Medium	Localized	Short term	Occasional	Not significant

14.2.12 WASTE DISPOSAL (cont'd)

Waste from offshore activities, including kitchen waste, medical waste, potentially hazardous industrial waste and miscellaneous dry and wet ship's garbage will be transported by supply vessel back to the shore-based facility. A qualified contractor will arrange for disposal onshore or for storage preparation for shipping out of the Beaufort Sea region.

A program-specific WMP will be developed to outline the processes involved in generation, handling, transfer, disposal and documentation of waste streams produced during the different program activities over the lifetime of this program. The objective of the plan is to ensure program compliance with all applicable regulations, standards and best practices to minimize effects on environment and human health. Program personnel and contractors will be provided with a copy of the program-specific WMP and will be made aware of the shore-based facility's waste management procedures (posted at locations around the facility). Interactions of waste disposal with the environment are likely to be negligible and are not considered further.

14.2.13 EFFECTS OF THE PROGRAM ON COMMUNITY WELLNESS

Program effects on community wellness are largely expected to be positive. The program will provide economic opportunities (e.g., jobs, opportunities to supply goods or services to the program) during construction and drilling, and has potential to benefit individuals (and their families) who pursue these opportunities. Increased incomes provide individuals and their families with better access to resources for harvesting country foods, better nutrition and the ability to save money. However, these positive effects are expected to be modest, given the small number of jobs that will be created by the program.

Individuals who do access economic opportunities associated with the program are subject to the choices they make concerning their new incomes. This can have a negative effect on individual and family wellness, if these choices are poor. Increased substance abuse can negatively affect individual health, family cohesion and function, and has the potential to increase family violence. Given the small number of jobs (and the small number of individuals who will experience increased incomes), it is unlikely that a negative effect would manifest at the level of the community (i.e., an increase in the local crime rate). Existing health and social services in the region will be able to support individuals with substance abuse and other issues related to increased incomes. Furthermore, Imperial will provide drug and alcohol awareness training to all employees and employee assistance programs for employees and their families, to help mitigate potential issues within the community associated with substance abuse and subsequent negative effects on quality of life.

The small number of jobs created by the program will limit potential negative effects on community-level quality of life that are typically associated with the development of larger projects in the Arctic. Effects on inequalities and social disparity are not expected at the community level. Inflation as a result of higher incomes in the community is not likely to occur. Those who would be vulnerable

14.2.13 EFFECTS OF THE PROGRAM ON COMMUNITY WELLNESS (cont'd)

to inflation and social disparity are subsequently not likely to be negatively affected by the program. Changes to public health and safety, crime rates and the number of traffic accidents are also not expected.

Potential program effects on human health are linked to the dredging of the harbour and the associated potential for water contamination. Other program activities are not predicted to result in human health effects. Any dredging of the harbour would be contained and, therefore, chemical contamination of the water and subsequent accumulation in marine life is not predicted. Effects on human health as a result of the consumption of contaminated country foods are not expected. Despite this, public perceptions of harm may persist. Imperial will communicate strategies to community to mitigate the potential for environmental contamination. This is typically accomplished through environmental awareness training and involvement of communities in environmental monitoring. Such an approach is expected to reduce some of the public perception of harm.

14.2.14 HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

Program elements that have the potential to affect human health (not including occupational exposures, which are addressed separately) are:

- increased air emissions related to supply vessel traffic
- potential for uptake in country foods of:
  - vessel-related contaminants (e.g., hydrocarbons, metals associated with antifouling paints)
  - sediment-related contaminants from navigational dredging in Tuktoyaktuk Harbour or other nearshore areas to facilitate operation of supply ships
  - leaked oil

Program elements that have the potential to affect the environment in relation to contaminants of potential concern are:

- potential for exposure of biota directly or through diet to:
  - sediment-related contaminants during drilling and side-casting of drill cuttings
  - residual drilling fluids in drill cuttings
  - sediment-related contaminants from navigational dredging in Tuktoyaktuk Harbour or other nearshore areas
  - vessel-related contaminants (e.g., hydrocarbons, metals associated with antifouling paints)
  - leaked oil
  - ballast water discharges

The potential for effects from these conceptual exposure pathways cannot be quantified at this time. For some exposure pathways, mitigation will be applied at the start of the program to meet the provisions of laws such as the *Arctic Waters Pollution Prevention Act*, which prohibits the discharge of waste in Arctic waters. As a result, quantitative assessment might not be necessary.

14.3.1 INTRODUCTION

In evaluating the effects of non-routine events, with a focus on accidental spills, Imperial will consider the following:

- the type and location of oil spills that could occur
- the likelihood of these oil spills happening during the proposed drilling program
- precautionary measures that will be incorporated into the design and execution of the drilling program to minimize the likelihood of oil spills
- the oil spill response structure, contingency plans and organization
- opportunities for Inuvialuit to play a role in preventing and responding to oil spills
- the oil spill response capability that will be in place to respond to the types of spills that could occur
- the significance of potential immediate and residual environmental effects of these oil spills on important biophysical resources, wildlife and wildlife habitat and resource harvesting activities before and after spill cleanup operations in the ISR
- unique surface and subsurface features that would be particularly sensitive to an oil spill
- socio-economic effects resulting from the environmental effects of an oil spill
- how ongoing research or information will be incorporated into OSRPs

Offshore drilling requires development of a credible, risk-based OSRP based on potential spill scenarios for the specific operation.

14.3.2 TYPE AND LOCATION OF POTENTIAL OIL SPILLS

There are two main types of petroleum oils that might be spilled during the proposed drilling program:

- Arctic P-50 diesel fuel
- crude oil

14.3.2 TYPE AND LOCATION OF POTENTIAL OIL SPILLS (cont'd)

Other oil products that might be spilled include lubricating oils, oil-based drilling fluid and gasoline (at the shore-based facility only). However, spills of these products are not specifically addressed here because they would make up only a small fraction of the inventory of fuel for the proposed program.

Arctic P-50 diesel fuel might accidentally be released:

- during bulk fuel transfer operations (ship-to-ship, shore-to-ship, fuel barge-to-ship)
- during offshore or shore-based fuelling operations
- from a storage tank on land or from a vessel as a result of an accident

These types of spills are usually small in size. Arctic P-50 diesel fuel is non-persistent oil that does not form stable water-in-oil emulsions and would be expected to evaporate and naturally disperse quickly in offshore open-water conditions. All diesel fuel spills would be responded to immediately using various surveillance or tracking methods, and containment and recovery equipment and techniques. Removal of diesel fuel spills in ice conditions might also involve controlled in situ burning or chemical dispersant application augmented with agitation of the water from a ship's propeller wash, or both.

Crude oil might accidentally be released as a result of malfunctions during drilling or testing of a well, or as a result of a major accident involving the drilling unit. These spills would be located at the offshore drill site. The response to small crude oil spills would involve using surveillance and tracking methods and a variety of on-site containment and recovery equipment and techniques. Removal of small crude oil spills in ice conditions might also involve controlled in situ burning or chemical dispersant application augmented with agitation of the water from a ship's propeller wash, or both.

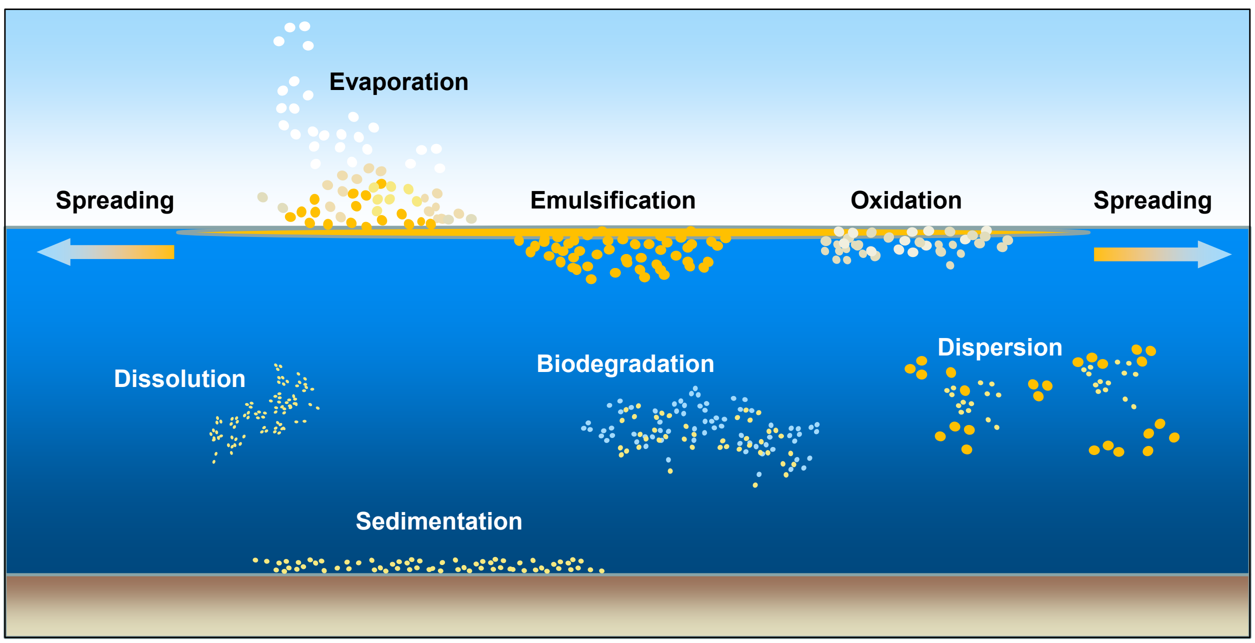
14.3.3 SUBSEA BLOWOUTS

A large crude oil spill might involve a subsea blowout, with oil and gas from the reservoir being released into the water at the seafloor. The behaviour of the jet of oil droplets and gas bubbles released from the well depends on the water depth at the site. At water depths greater than 450 m, natural gas will react with the deep, cold water to form gas hydrates. The combination of hydrate formation and dissolution into the water will result in the gas being removed from the plume and only oil droplets surfacing. At water depths less than 450 m, the gas bubbles will not form hydrates and both oil droplets and gas bubbles will rise quickly to the surface caused by the buoyancy of the rising gas bubbles. Whether the gas bubbles survive their rise through the water column will affect the thickness of the slick that forms on the surface from the oil droplets and how far from the blowout site the oil droplets will surface.

The water depths for hydrate formation are highly variable depending on the composition of the associated natural gas. With the addition of ethane, propane and heavier gases can significantly raise the depth at which hydrates will form, as high as 150 m below the surface.

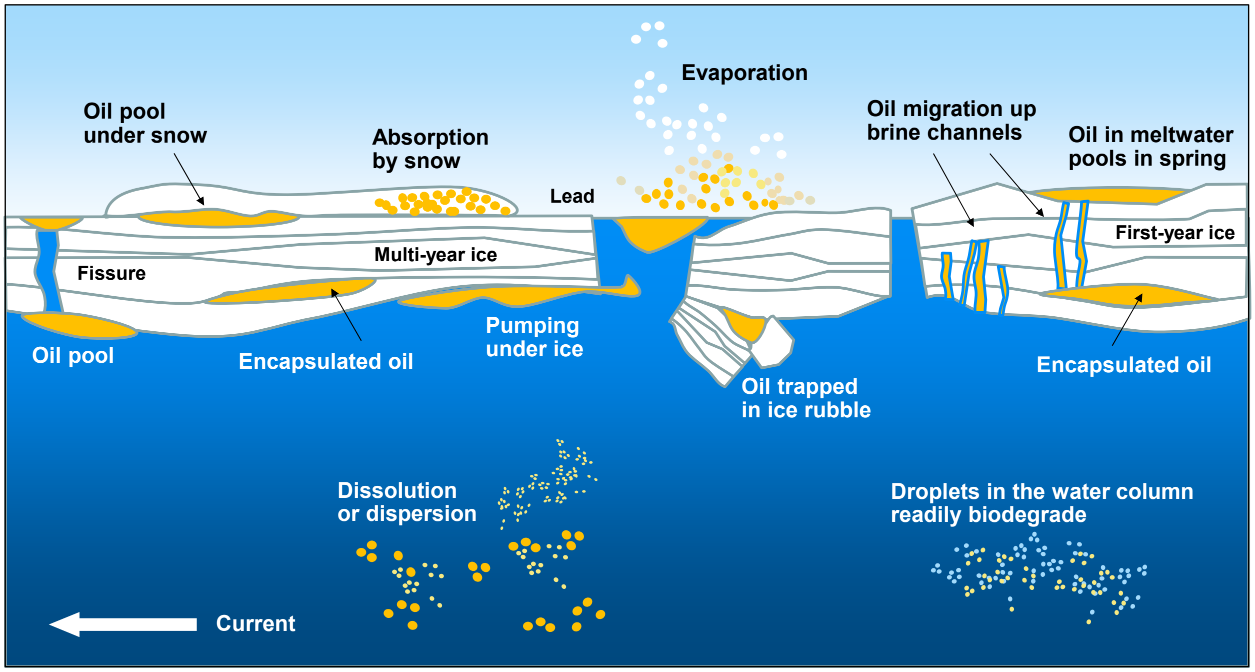
If the oil surfaces, it will begin to spread and evaporate, naturally disperse and perhaps emulsify (depending on the characteristics of the particular crude oil). Over the long term, some components of the surface oil could be oxidized by sunlight and dissolve in the seawater. The dispersed oil droplets will dilute to very low concentrations and biodegrade. Recent studies in Alaska have confirmed that dispersed oil does biodegrade with the help of indigenous microbes in the open Arctic waters under both summer and winter conditions (McFarlin et al. 2011). Figure 14-2 illustrates these processes. Figure 14-3 is a schematic of the possible fate and behavior of oil spilled on ice, under ice, between ice and within ice.

The response to a large crude oil spill would involve using a variety of offshore response techniques, including surveillance and tracking, chemical dispersants and controlled in situ burning. Different techniques would be used as the primary response method in different sea conditions. For example, controlled in situ burning could be the preferred option in calm open-water conditions and extensive ice cover, whereas application of aerial dispersants could be preferable in open water and light ice conditions where waves are present.



Adapted from ITOPF (www.itopf.com)

Figure 14-2: Oil Spill Fate and Behaviour in Open Water



Adapted from ABSORB Training Manual, 1981

Figure 14-3: Possible Fate and Behaviour of Oil Spilled on and in Ice

14.3.4 LIKELIHOOD OF OIL SPILLS

For the purposes of this PD, the likelihood of two types of accidental events during drilling operations were assessed, blowouts and batch spills. Blowouts are continuous spills that can last hours, days or weeks, if uncontrolled, and involve the discharge of large volumes of associated gas into the atmosphere and discharge of crude oil into surrounding waters. Batch spills are instantaneous or short-duration discharges of hydrocarbons (in this case, fuels) that could occur from an accident on the drilling unit, support vessels or at the shore-based facility.

Blowouts are rare events. There have been no large offshore blowouts in Canada, with close to 400 wells drilled (149 exploratory) in Newfoundland waters since 1966 and 83 drilled in the Beaufort Sea, mostly in the 1970s and 1980s. Spill frequencies are estimated using the historical worldwide record, as a large data source. In exploratory drilling, there have been about 50,000 wells drilled offshore worldwide with two large blowout spills, the Ixtoc incident in Mexican waters of the Gulf of Mexico in 1979 and the *Deepwater Horizon* accident in 2010. The frequency of a spill is on the order of one incident per 25,000 wells drilled. This spill frequency is based on worldwide data, including countries that do not generally have regulatory standards as stringent as those in Canada. Therefore, the likelihood of an extremely large spill in Canadian waters could be expected to be even lower.

Other oil spills could occur during drilling activities. However, most of these spills are very small and include spills:

- of diesel fuel on the drilling unit
- of diesel fuel from transfer operations
- from similar incidents involving the handling of oil needed to run operations

As there have been very few large spills related to exploration and development drilling in Canadian waters, US and worldwide statistics are used. There is a reasonably sized database on small spill incidents in Newfoundland and Labrador waters. Spill statistics are maintained and reported by the Canada-Newfoundland and Labrador Offshore Petroleum Board.

Based on the Canadian offshore data, spills in the size range of 8 m^3 to 159 m^3 (50 to 1,000 bbl, where 1 bbl = 159 L, 1 m^3 = 6.3 bbl) occur with a frequency of one every 540 wells, and one every 37 wells for spills less than 8 m^3 (50 bbl).

The likelihood of a large, uncontrolled blowout occurring when drilling only one or two exploration wells for the proposed program is extremely remote. Even smaller spills less than 8 m^3 (50 bbl) are unlikely for the proposed drilling program.

Very small spills of 1 to 2 L occasionally occur on drilling units and support vessels and are cleaned up quickly with sorbent materials kept on hand.

14.3.5 OIL SPILL RESPONSE

14.3.5.1 Oil Spill Response Principles

The specific oil spill response principles that Imperial would apply to an Arctic drilling program include:

- ensuring, through disciplined risk assessment and management processes, that the top priority is the prevention of incidents that could result in a spill
- operating in the Arctic in a sustainable manner that involves consulting and working with Inuvialuit in a way that is compatible with the natural environment and people’s traditional way of life
- taking immediate responsibility in the unlikely event of a spill resulting from its operations and responding quickly and effectively to all incidents
- ensuring that a scalable, fit-for-purpose response system (plans, people and equipment) is available and that the local infrastructure is in place to support a major spill response
- recognizing that credible response options are available to respond to all types of spills in the Arctic offshore in both open water and ice conditions
- meeting applicable regulatory requirements and commitments made by the Imperial to Inuvialuit
- focusing on protecting the shoreline and harvested wildlife

14.3.5.1 Oil Spill Response Principles (cont'd)

- having a compensation process in place if the spill or the response operations affect wildlife harvesters in the Beaufort Sea region

14.3.5.2 Oil Spill Response Strategies

Oil spill response strategies that are available and would be applied to an Arctic drilling program include:

- ensuring the health and safety of response personnel
- having the operational capability to use all existing response options
- continuing to advance and enhance existing capabilities through ongoing research and development, and field studies and exercises
- ensuring that no option is arbitrarily ruled out or constrained in advance of taking response action
- developing a level of response that is fit for purpose (i.e., based on risk, probability, consequence and effectiveness and scalable to respond to any size incident)
- understanding and possibly using to advantage the various environmental conditions that could be experienced in the field to develop and improve the ability to respond to an incident
- having a good understanding of the fate of an oil spill, including where the spill might go, what might happen to it, and how the oil will behave under Arctic conditions, particularly, oil trapped in ice
- having a good understanding of the most vulnerable species and sensitive areas in the Beaufort Sea region
- using local knowledge and expertise to understand the environment, particularly different ice conditions
- recognizing that sometimes the best response might be to monitor the situation and develop a plan for future response actions
- applying a net environmental benefit analysis (NEBA) to help determine the best response options that will lead to the:
    - lowest overall effects on the environment and harvesters
    - most rapid recovery of oil and the environment
- focusing assessments on the advantages and limitations of each response option under the existing conditions at the time of the spill. These assessments also lead to decisions on prioritizing the deployment and use of monitoring, mechanical recovery, controlled in situ burning and dispersants.

14.3.5.3 Oil Spill Response Technology

Since open-water offshore drilling ceased in the Beaufort Sea in the early 1990s, significant advances have been made in oil spill response capabilities for an oil spill in the Arctic, particularly an offshore spill of crude oil where oil could come in contact with ice. These advances in oil spill response capabilities resulted from extensive research and development in laboratories, wave basins, and meso-scale and full-scale field trials that have been conducted by industry, governments and oil spill response equipment manufacturers. Many of the advancements were initiated and financed by the companies operating in the Beaufort Sea at the time, as well as by EC, the US Minerals Management Service (now the Bureau of Safety and Environmental Enforcement [BSEE]) and international studies conducted in Norway and other circumpolar countries.

The advances in oil spill response capabilities in Arctic conditions include improvements in:

- oil spill behaviour and modelling
- surveillance and monitoring
- dispersant use on the sea surface
- subsea dispersant injection
- controlled in situ burning
- mechanical containment and recovery
- shoreline response techniques

Today, the number of viable options available to oil spill responders increases the rate of success in reducing oil spill effects on the natural environment and traditional use by wildlife harvesters.

14.3.5.3.1 Oil Spill Behaviour and Modelling

In the 1970s and 1980s, oil spill behaviour and modelling were focused primarily on spills in open water or under landfast ice, with the primary interest being shoreline contact. Routine analysis of the physical and chemical properties of crude oils to determine their spill-related properties was not common at the time. Since then, several Beaufort Sea crude oils have been extensively analyzed, primarily by EC, and can now be used as an analog for modelling oil spills in deeper waters.

Oil spill modelling has also progressed for predicting spill behaviours, such as spread rate and weathering on open water and in ice conditions. Algorithms have now been developed and field tested that can predict with a higher degree of accuracy the movement of an oil spill under varying environmental conditions, including in ice.

14.3.5.3.2 Surveillance and Monitoring

Much of the research on surveillance and monitoring technologies took place over an intensive period beginning in the late 1970s and 1980s, largely in response to offshore drilling in the Canadian sector of the Beaufort Sea.

14.3.5.3.2 Surveillance and Monitoring (cont'd)

Researchers carried out analytical bench tests, basin tests and field trials with a wide variety of sensor types in an effort to solve the challenges of detecting oil in ice. Much of this work was conducted in Canada under the direction of Imperial, EC and the Centre for Cold Oceans Resources Engineering. The technologies tested included:

- acoustics
- radar
- ultraviolet fluorescence
- infrared
- gamma ray
- microwave radiometers
- resonance scattering theory
- gas sniffers
- impulse radar

A series of recent projects sponsored by BSEE and industry in Canada, the US and Norway have evaluated a new generation of ground-penetrating radar, acoustic and ethane gas detectors. ExxonMobil is investigating the use of nuclear magnetic resonance as a basis for future airborne detection systems.

The greatest advances in Arctic ice surveillance have been made in all-weather radar satellite systems, with platforms launched over the past two years that can detect surface features down to 1 m in size. These systems provide highly detailed images of ice conditions near an oil spill to assist with planning marine operations on a tactical scale and in tracking the movement of oiled ice.

Using current technologies, the most effective surveillance tools use a combination of remote sensing devices supplemented with visual observations from personnel and equipment on site. Surveillance equipment that provides coverage under all types of weather and ice conditions is available through governments and contractors.

To monitor oil movement, both in open water and under ice conditions, Imperial will consider using a combination of:

- ultraviolet and infrared scanners
- forward-looking infrared radar
- microwave radiometers
- laser fluorosensors
- synthetic aperture radar and side-looking airborne radar
- ground-penetrating radar
- satellite systems, such as IRS, SPOT and RADARSAT
- ice drift buoys
- other technologies

The monitoring will have a level of accuracy not previously available and will greatly increase Arctic spill response capabilities. Selection of the equipment actually deployed will reflect the results of ongoing research and industry and government consensus on the best practicable approaches.

14.3.5.3.3 Dispersant Use on the Sea Surface

Basin testing has shown that dispersants can be used effectively in ice-covered and cold water environments (Brown and Goodman 1988 and 1996, Owens and Belore 2004). Field tests conducted in the Barents Sea in 2009, as part of a joint industry program on oil spill response for Arctic and ice-covered waters by SINTEF in Norway, also showed that dispersants work in cold, ice-covered water (SINTEF JIP 2010).

Cold temperatures do not inhibit dispersant effectiveness, but colder temperatures do increase the viscosity of the spilled oil. Dispersants have been shown to be effective as long as the pour point of the oil (i.e., the lowest temperature at which the oil will flow) is not more than 5 to 10°C below the ambient water temperature, as is the case for most crude oils and petroleum products (Daling et al. 1990, Brandvik et al. 1995, Nedwed et al. 2006).

Conventional dispersants (e.g., Corexit 9500 and Corexit 9527) have been formulated to be relatively non-viscous and can be successfully applied to heavy or viscous oils in cold temperature.

The presence of ice might affect dispersant use, primarily through its influence on the mixing energy available to generate and then diffuse small oil droplets once the dispersant has been applied. Research has shown that ice floes in waves can generate localized energy through their mechanical grinding and pumping action as they rise and fall. Energy generated at these ice edges and in broken ice and slush fields exposed to wave action is sufficient to disperse chemically treated oil. Figure 14-4 shows the icebreaker MSV *Fennica* generating the mixing turbulence needed for effective dispersant use in an ice-covered environment.

In a complete ice cover situation, the mechanical energy provided by a ship's propeller can be used to both expose trapped oil for dispersant application and to shear dispersant-treated oil into a fine oil droplet cloud that will diffuse into the water column. The use of azimuth stern drive systems has been shown to be a promising option to apply the necessary mixing energy for dispersant use in a completely ice-covered environment. This concept was successfully tested on a large scale in the Barents Sea in 2009 as part of a joint industry program on oil spill response for Arctic and ice-covered waters by SINTEF in Norway. Figure 14-5 shows a crude oil slick in pack ice being sprayed with dispersant.

An appropriate dispersant delivery system capability will be established for the Beaufort Sea, similar to that currently used in Alaska. This system will include access to a dispersant stockpile, dispersant spraying systems using both vessels and aircraft, and continuous manufacturing and replenishing of dispersant supplies, as needed. The infrastructure to ensure a continuous supply of dispersants will also be put in place. The largest stockpile of dispersants in North America is located in Anchorage, Alaska. Figure 14-6 shows airborne dispersant application during a field study using a C-130 Hercules transport aircraft.

Photo courtesy of Aker Arctic Technology

Figure 14-4: Icebreaker MSV *Fennica* Generating Mixing Turbulence for Dispersant Use

Photo courtesy of SINTEF

Figure 14-5: Dispersant Applied from an Articulated Sprayer on Crude Oil in Pack Ice (Barents Sea in 2009)

Photo courtesy of Charles Huber and Marine Spill Response Corporation

Figure 14-6: C-130 Hercules Transport Aircraft Applying Dispersant

14.3.5.3.4 Subsea Dispersant Injection

Subsea dispersant injection is a technique that was used effectively during the response to the *Deepwater Horizon* accident (R/V *Brooks McCall* Cruise Report - *Deepwater Horizon* - May 7 – 12, 2010, USCG 2011) and the offshore petroleum industry has incorporated this tool in OSRPs for deepwater wells. It involves pumping dispersant into the oil and gas as it exits the wellhead. Subsea dispersant injection is intended to promote natural dispersion of the oil by increasing the formation of extremely small oil droplets at the wellhead by the force of the escaping reservoir fluids. Once the gas bubbles disappear from the plume, these extremely small droplets do not rise to the surface and form a slick, but remain in the sea at some depth, drift with the currents, dilute and are biodegraded by naturally occurring oil-consuming bacteria. One of the important benefits of subsea dispersant injection during the *Deepwater Horizon* accident response was the reduction in surface oil slicks and VOC concentrations in the air around the well site. This protected the health and safety of the responders in the immediate vicinity of the spill.

Imperial will continue to monitor and participate in ongoing worldwide research on subsea dispersant injection and consider its use as a Tier 3 response option in consultation with regulatory agencies and Inuvialuit.

14.3.5.3.5 Controlled In Situ Burning

Controlled in situ burning was developed in the Beaufort Sea in the 1970s and 1980s as a response to two types of spill situations:

- a large spill in ice conditions
- a large spill in open-water conditions

Recent advances developed for open water have included improved fire-resistant containment booms that are more easily deployed and last longer. The strategy for oil in landfast and close pack ice is to track the oiled ice and start a burning

14.3.5.3.5 Controlled In Situ Burning (cont'd)

operation where oil surfaces in melt pools or collects in open leads over the winter and into spring. The oil is ignited by heli-torches deployed from the air. Controlled in situ burning technology improvements have increased the burn efficiencies by removing up to 90% or more of the oil in the full range of ice conditions.

Environment Canada's Emergencies Science and Technology Section and the US National Institute for Science and Technology lead programs on assessing data on smoke emissions from controlled in situ burning and the resultant burn residue. Several field trials were carried out, including the Newfoundland Offshore Burn Experiment in 1994. Studies found that burn residue showed little or no acute toxicity to marine life and that the more toxic components, polycyclic aromatic hydrocarbons, are largely consumed during combustion. People can be kept safe and unaffected by the smoke by maintaining adequate separation distances of a few kilometres between them and burn operations.

Ignition technology development has focused on improving ignition of oil by adding emulsion-breaking chemicals to the igniter fuel to help ignite oil emulsions with water content greater than 25% and by using better designed and safer hand-held igniters. Advancements have also been made in developing better, more durable fire-resistant booms. Low-toxicity surfactants (herding agents) that thicken oil in both pack ice and open water, to allow it to be ignited and burned efficiently, have been approved for use in the US and commercialized.

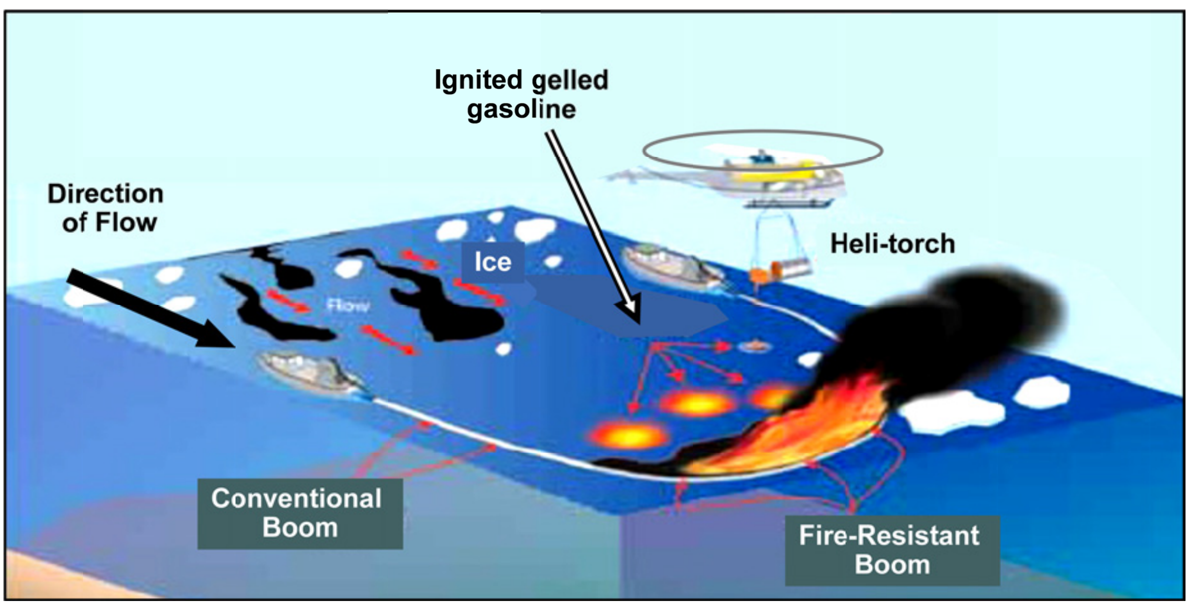
As a result of the significant advancements, and recognizing that controlled in situ burning is a viable oil spill response option, the American Society for Testing and Materials (ASTM) adopted the Standard Guide for In-Situ Burning of Spilled Oil: Fire-Resistant Boom (ASTM F2152). Environment Canada has issued a report titled *In-situ Burning: A Cleanup Technique for Oil Spills.* The Alaska Regional Response Team has incorporated controlled in situ burning into its Unified Response Plan (2008) and the International Association of Oil and Gas Producers has prepared a state-of-knowledge report on in situ burning in ice-affected waters. The US Coast Guard now considers controlled in situ burning to be an operational response tool for open water and ice conditions, and the US National Oceanic and Atmospheric Administration Office of Response and Restoration has developed monitoring guidelines for measuring smoke plumes and residue.

Controlled in situ burning is a countermeasure that has rarely been used on marine oil spills, but its successful use during the *Deepwater Horizon* accident response in the Gulf of Mexico has increased interest. According to US government estimates, deliberate controlled burning of spilled oil with fire booms eliminated between 220,000 and 310,000 bbl of oil that could have otherwise reached shorelines and other sensitive resources in the Gulf of Mexico. Between April 28 and July 19, 2010, a total of 411 oil collection and ignition attempts were conducted. These efforts resulted in 376 burns of a significant enough size and duration to merit inclusion in burn volume estimates. Burns continued throughout this period in daily-approved in situ burning burn areas, typically within 3 to 15 miles of the *Deepwater Horizon* site (Mabile 2012). Extensive monitoring of air quality by various US government agencies during the burning operations did not detect any burn emissions of concern along the coast of the Gulf of Mexico.

Controlled in situ burning of oil in both open water and under ice conditions is now acknowledged as one of the most effective spill response options available. As the key response option for all ice conditions, Imperial plans to have an operational capability for in situ burning in the Beaufort Sea. Figure 14-7 shows a conceptual controlled in situ burning response involving fire booms. Figure 14-8 illustrates how herding agents would be used to thicken oil for burning without the need for fire booms.

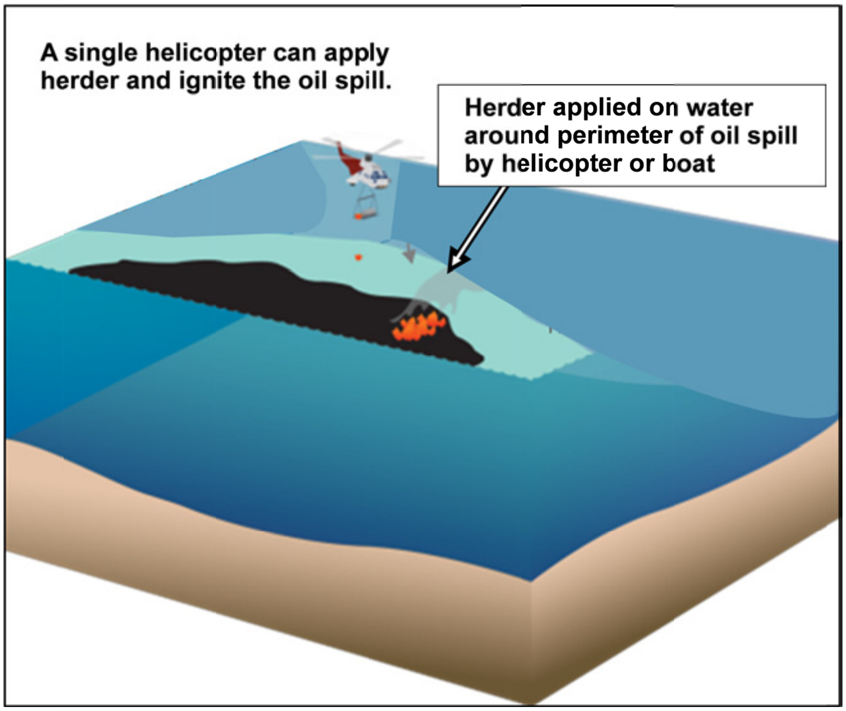
Herding agents sprayed on the water around the perimeter of an oil spill change the surface properties of the water to prevent the oil from spreading. For oil that has already spread, surfactants herd the spreading oil back into a smaller, thicker slick. Herding agents do not require a boundary to push against and work even in unbounded open water. For application in drift and pack ice and open water, the intention is to herd freely drifting oil slicks to a burnable thickness, then ignite them. A molecule-thick surfactant layer is all that is necessary to provide containment in the open ocean during low-energy conditions. Therefore, large amounts of oil can be herded with very small amounts of surfactant.

Figure 14-9 shows burning herded crude oil in an ice lead and Figure 14-10 shows burning crude oil in a fire boom in drift ice being tested during field experiments in the Barents Sea in 2008 and 2009 (Buist et al. 2013).



Adapted from graphic, courtesy of SL Ross Environmental Research

Figure 14-7: Conceptual Controlled In Situ Burn Response



Adapted from graphic, courtesy of SL Ross Environmental Research

Figure 14-8: Use of Herding Agents with Controlled In Situ Burning

Photo courtesy of SL Ross Environmental Research and SINTEF

Figure 14-9: Burning Herded Crude Oil in an Ice Lead (Barents Sea in 2008)

Photo courtesy of SL Ross Environmental Research and SINTEF

Figure 14-10: Burning Crude Oil in a Fire Boom in Drift Ice (Barents Sea in 2009)

14.3.5.3.6 Mechanical Containment and Recovery

In the 1970s and 1980s, the primary spill response in the Beaufort Sea was mechanical containment and recovery of oil in open water using equipment from the Beaufort Sea Oil Spill Co-operative. Improvements in equipment, most notably air-inflatable booms, have enabled containment equipment to be easily and rapidly deployed using reel-mounted systems on board vessels. In recent years, several innovative designs, such as the Vikoma Fasflo and the NOFI Current Buster, are capable of containing oil at speeds greater than 1 knot, the normal upper limit of existing equipment. The US Coast Guard has conducted research on booms capable of handling current speeds in excess of 3 knots.

Figure 14-11 shows a modern high-speed boom deployed by a single vessel with a boom vane to hold one end.

Today's skimmers are an improvement over earlier models. The most commonly used skimmers for offshore application are high-rate weir types, such as the Transec and Desmi models. In recent studies sponsored by the Mineral Management Service and industry, research and testing was performed to optimize the use of oleophilic skimmers in the presence of ice that would recover much less water than weir-type skimmers (see Figure 14-12). These new designs can greatly increase the overall operating efficiency of oil recovery efforts.

Photo from ORC AB web site www.orc.se

Figure 14-11: Boom Deployed from a Single Vessel Using a Boom Vane

Photo courtesy of SL Ross Environmental Research and SINTEF

Figure 14-12: Oleophilic Brush Skimmer Tests in Ice

14.3.5.3.7 Shoreline Response

A shoreline response program would consider both nearshore protection of sensitive coastal areas and shoreline cleanup for any oil that might be stranded on the coast. The development of a response strategy would be a part of the assessment process that evaluates oil transport pathways, traditional harvesting resources at risk, and seasonal sensitivities and vulnerabilities of habitats and resources. Oil transport pathways are strongly affected by surface currents and the outflow from the Mackenzie River Delta. Oil approaching the Mackenzie Delta would be kept away from the coastal zone by the year-round river outflow. As a result, some coastal locations would be more at risk than others. The most current version of the Beaufort Sea Environmental Sensitivity Atlas will be used to take into account changing coastal geomorphology, traditional use areas, areas of environmental importance and resources at risk. Shoreline protection priorities will be developed based on pre-spill strategies for specific areas of importance (Geographic Response Plans or Geographic Response Strategies [GRPs/GRSs]). The GRS and GRP activity will involve community engagement to ensure that traditional knowledge and current resource harvesting practices are considered.

If oil reaches the coast and is stranded, a NEBA will be used to determine the best overall options and the target treatment end points to apply to shoreline response. This analysis would be based on a shoreline oiling assessment survey to determine the location and character of any stranded oil. All treatment recommendations, including operational priorities, generated by this survey would be reviewed with regulators and Inuvialuit.

A typical shoreline response strategy would involve the initial removal of bulk or heavy oiling that could be remobilized and affect adjacent areas. Further treatment phases would be based on the NEBA, and the development of treatment end points would be based on EC guidelines to avoid causing unnecessary additional impacts. The shoreline treatment options would vary depending on shore zone types (e.g., sand beaches, mixed sediment gravel beaches, wetlands) and the degree of oiling. The treatment options are described in EC's *A Field Guide to Oil Spill Response on Marine Shorelines*, and their applicability to and implementation for different Arctic shoreline types would follow those recommendations. The treatment options that would be considered include:

- natural recovery
- flushing and recovering bulk oil
- sediment mixing
- sediment relocation
- burning oiled sediments
- bioremediation

Guidelines and strategies are available for oil spill waste generated during a shoreline cleanup. The use of portable burners and incinerators for waste management or in situ shoreline treatment techniques are the preferred options, particularly in remote areas. Shoreline equipment caches will be available that can be readily transported by helicopter. This equipment will be used to protect shoreline areas that are determined to be the most vulnerable or to treat those with the highest initial priority for onshore oil recovery.

14.3.5.3.8 Tuktoyaktuk Harbour and Approaches Spill Response

In the event of a spill, the response to a spill in Tuktoyaktuk Harbour or its approaches would be focused, rapid and effective to restrict the spill from

14.3.5.3.8 Tuktoyaktuk Harbour and Approaches Spill Response (cont'd)

spreading using containment booms and oleophilic skimmers to recover oil. Shoreline protection boom, small skimmers and temporary storage and transfer equipment would also be available on site. Small spill response boats to quickly deploy and operate it this equipment would be based in Tuktoyaktuk Harbour. A dedicated Tier 1 spill response organization will be located in Tuktoyaktuk. Figure 14-13 illustrates the type of vessels and equipment that could be maintained at Tuktoyaktuk Harbour to respond to nearby spills.

Photo courtesy of the Canadian Coast Guard

Figure 14-13: Typical Tier 1 Spill Response Vessel and Equipment for Protected Waters

14.3.5.4 The Tiered Response Model

In the 1980s, the oil and gas industry developed the concept of three tiers (i.e., Tier 1, Tier 2 and Tier 3) to describe the magnitude of spill response capability. The tiered levels of preparedness and response describe how appropriate resources can be mobilized rapidly and the response escalated to provide an effective response to a spill of varying size.

A Tier 1 spill involves amounts up to 16 m^3 (100 bbl) and is operational in nature, occurring at or near an operator's facilities. The operator is expected to respond with their own resources to clean up the spill.

A Tier 2 spill usually extends outside the zone of the Tier 1 response area and is larger in geographic extent and volume. Additional resources would be needed from a variety of sources, and a broader range of stakeholders could be involved in the response. A Tier 2 response capability would involve regionally available resources (e.g., other operators or a regional spill response cooperative, such as was developed by a number of companies operating in the Beaufort Sea in the 1970s and 1980s). This type of cooperative could provide equipment, vessels, storage, and most importantly, locally trained response teams. Equipment, such as booms (fire and shoreline protection), skimmers, controlled in situ burning equipment and dispersants could be stockpiled and strategically located at various sites, offshore and onshore. As in the Tier 1 response, resources and equipment from operators working nearby would likely be called on through a mutual aid agreement.

A Tier 3 spill is a large-scale spill, likely to have major environmental or socio-economic effects and require substantial resources to achieve cleanup. These resources could originate from a range of national and international oil spill response organizations, equipment manufacturers and suppliers, and other third-party providers, such as logistics and aviation companies. The OSRP developed for the program would include details of where the oil spill response organizations are located, their response time and what equipment and resources they could provide.

14.3.5.4.1 Tier 1 Capability

Most spill response protocols require a robust and dedicated capability to be in place for small spills that can be managed immediately with local resources. Vessels with IMO compliant protocols will have a Shipboard Oil Pollution Emergency Plan and associated equipment on board that can be used for Tier 1 spills.

For drilling in the Arctic, the following vessels could be outfitted with a 20-foot ISO shipping container of oil spill response equipment:

- the supply vessels at the drill site
- the designated supply vessels operating out of the shore-based facility
- each icebreaker

The 20-foot ISO shipping container would allow these vessels to help with Tier 1 spills of Arctic P-50 diesel fuel, crude, base oil, hydraulic fluid or lube oil. Among other items, the container could carry:

- a single-vessel, high-speed sweep system consisting of a fast water boom and either an outrigger or a boom vane
- an oleophilic-type skimmer (ideally convertible to a brush-type skimmer for use in light brash or frazil ice conditions) suitable for deployment into the sweep system pocket from the aft deck of the vessel
- a temporary storage bladder for recovered fluids with a capacity of about 8 to 32 m^3 (100 to 200 bbl)
- a portable, diesel-powered positive displacement transfer pump
- various sorbent pads, sweeps and booms

Controlled in situ burning would be considered for a range of ice conditions, including:

- when using a fire boom in open water, trace ice and possibly up to 3/10ths ice concentration
- where the oil is uncontained and thick
- where the oil is contained by ice or by herding agents

14.3.5.4.1 Tier 1 Capability (cont'd)

In open water and light drift ice conditions, dispersant use could also be considered. Dispersants could be applied by ship-based or aircraft-based application systems (e.g., helicopters).

Other vessels, such as the fuel barge, tanker or the warebarge, would also be outfitted with spill response equipment, focused on containing and recovering fuel transfer spills.

14.3.5.4.2 Tier 2 Capability

In most situations, a Tier 2 capability would be developed using pooled resources from other organizations, drawn from a regional or national source. Additional mechanical containment and recovery equipment (e.g., booms and skimmers) is not considered an effective option for Tier 2 capability. Additional offshore vessels to deploy and operate the equipment would likely be scarce or unsuitable (e.g., not ice-strengthened), and storing and handling large amounts of recovered fluid would require large storage vessels or containers that cannot be readily transported to the spill scene. In the Arctic, and particularly the Beaufort Sea region, the infrastructure for transporting large oil spill response equipment is limited. Skimmers are available for oil spilled in ice. However, based on the limited encounter rate and recovery rate, these skimmers are best suited to working among relatively small ice pieces and for spills that cover a small area.

Equipment and materials for controlled in situ burning or dispersant use are much more easily transported and deployed than mechanical recovery equipment in the Beaufort Sea. This equipment requires far less logistical support and could be used to supplement existing Tier 1 resources offshore in response to a Tier 2 incident. These two response methods (i.e., in situ burning or dispersants) are fit for purpose and can be easily scaled up to meet ongoing needs.

Resources for Tier 2 nearshore operations and shoreline cleanup could be sourced from a number of existing cooperatives and agencies within Canada and worldwide. A locally owned and staffed spill response organization capable of providing Tier 2 on-water and shoreline response resources would also beneficial. Imperial is committed to making this possible. Imperial is considering pre-staging shoreline protection and cleanup equipment and resources at key locations along the coastline of the Beaufort Sea to facilitate quick and effective response to spills that could potentially threaten shorelines.

14.3.5.4.3 Tier 3 Capability

A mechanical containment and recovery response strategy would not be the primary response approach for a Tier 3 spill in the Beaufort Sea. The logistics of delivering adequate deployment, storage and handling equipment for a large-volume spill response would not be feasible or effective.

Use of dispersants and controlled in situ burning would be the primary Tier 3 response options and the focus of Imperial's intentions regarding spill response equipment.

Equipment for a Tier 3 Response – Controlled In Situ Burning

To mount a Tier 3 response using controlled in situ burning, several independent fire-boom systems would likely be required, each of which would include the following primary equipment:

- a 150-m fire boom
- one towing paravane
- one work boat (500 hp minimum)

To be able to provide a timely response, this equipment might be stockpiled at a marine base in the Beaufort Sea region, to be rigged and sent to the scene within one day of a spill occurring. Depending on the extent of the burn operations, it might be necessary to resupply the boom to replace portions used in the operation. If a replacement boom was required, it could be flown to Tuktoyaktuk by cargo aircraft. As was done in the *Deepwater Horizon* accident response, the potential sources of equipment that could be used include:

- Alaska Clean Seas (Prudhoe Bay, Alaska)
- Oil Spill Response Limited (Southampton, United Kingdom)
- Marine Spills Response Corporation (various US locations)
- fire-boom manufacturer inventories
- international government and industry stockpiles

Hand-held igniters would be used to periodically ignite collected oil. Materials to prepare such igniters could be stockpiled at a marine base in the Beaufort Sea region. In drift ice conditions, herding agents might also be used to thicken oil for burning without the need for fire booms. Heli-torches, herding agents and application systems for helicopters would also be stockpiled at a marine base.

If a spill continued into freeze-up, a burning operation could be mounted in the spring. This operation could involve using a fleet of helicopters equipped with heli-torches to fly from remote shore bases or from icebreakers. The period between freeze-up and the appearance of oil in melt pools would be about six months or more, which would allow time to plan a spring operation and stage the equipment.

Equipment for a Tier 3 Response – Dispersant Application

To mount a Tier 3 response using dispersant application, independent dispersant application systems would likely be required, each of which could include the following primary equipment:

- aircraft, such as helicopters or a C-130 transport
- aerial dispersant delivery system packs
- a dispersant supply of about 159 m^3/d (1,000 bbl/d)

Adequate dispersant supply could be stockpiled at an air base in the region (i.e., at Tuktoyaktuk or Inuvik) to supply the first few days of operation, after which, more dispersant could be brought in by air. Imperial will ensure that the infrastructure to support a long-term dispersant operation is in place before the

Equipment for a Tier 3 Response – Dispersant Application (cont'd)

start of drilling. Additional aircraft for dispersant application, including their aerial dispersant delivery system pack application gear, could be prearranged with one or more of the following organizations:

- Oil Spill Response Limited (Southampton, United Kingdom)
- Alaska Clean Seas (Anchorage, Alaska)
- International Air Response (Coolidge, Arizona)

Initial dispersant resupply would come from these sources. If a spill were to continue for a longer time, additional dispersant would be resupplied from the manufacturer, as was done during the *Deepwater Horizon* accident response.

Dispersant application in open water is quite effective at dispersing oil, even in relatively calm conditions and response activities can be extended into the fall freeze-up or in pack ice by using icebreakers to mix the oil with dispersant.

14.3.5.4.4 Response Sequence and Duration

Response to a spill during the open-water season would begin immediately with the deployment of controlled in situ burning or dispersant operations, depending on the specific circumstances of the spill. Spill response operations would continue:

- during the release of hydrocarbons, subject to environmental conditions
- for as long as response techniques could be safely and effectively applied
- after the release of hydrocarbons had ceased or after any oil remaining was too widespread, thin or emulsified to effectively burn or disperse

For a burning operation in the spring, oil ignition would begin with the onset of the melt season (late May and June) when the oil would begin to surface in melt pools. The initiation and duration of the ignition operation would depend on the season in which the oil was released. Oil released during freeze-up would be encapsulated in the ice relatively near the ice surface and would surface relatively early in the melt season, maximizing the time available for spill response. If the spill were to continue, oil deposited on the underside of ice floes passing over the spill site would later appear in melt pools. This oil would begin to evaporate on the surface of the melt pools and be available for burning.

All shorelines affected by oil would be surveyed, assessed and prioritized for cleanup. All oiled shorelines would be cleaned in order of priority, using a NEBA and consultations with the incident command team and local Inuvialuit representatives, to determine the best overall options. The shoreline treatment options would vary depending on shore zone types (e.g., sand beaches, mixed sediment gravel beaches, wetlands) and the degree of oiling. All treatment recommendations, including operational priorities, would be submitted to the incident command team for review.

As part of the NEBA process, and in collaboration and agreement with the regulatory authorities and Inuvialuit representatives, end-point criteria for spill response would be determined, after which, the effort could be downsized or demobilized and a post-spill phase would begin. The treatment end points will follow the EC guidelines to avoid causing unnecessary additional impacts. If a NEBA indicates that residual oil on shorelines should be removed, or if active restoration were appropriate, Imperial would take these actions. During the post-spill phase, a long-term effects monitoring program would be established.

14.3.5.4.5 Response Effectiveness in the Beaufort Sea

Recently, a study of weather and sea conditions in the Beaufort Sea that could reduce the effectiveness of open-water offshore spill response operations was undertaken for the NEB (SL Ross 2011). The objective of the study was to provide estimates about when and how long primary recovery and clean-up techniques of mechanical recovery, dispersants, and controlled in situ burning would be unavailable because of environmental factors, such as adverse ice conditions, fog, darkness and higher sea states.

Weather and sea state statistics were collected and compared to operating limits for each of the various spill countermeasures. Three sets of operating limits were defined for each countermeasure:

- favourable
- marginal
- not possible

The possibility of deferring a response was also assessed, for example:

- oil spilled under ice that is not immediately accessible for cleanup, but could be effectively cleaned up the following spring when the oil reappears on the ice surface

- oil that could not be treated with dispersants from aircraft because of darkness and could be treated the next day

The effectiveness of the deferred dispersant treatment option could be reduced by the weathering of the oil in the interim.

The frequency of open water in the Beaufort Sea is highly variable throughout the summer (i.e., July to October), with the frequency of open water ranging from 46 to 79% in the far offshore location. This range of open-water frequencies is the result of several years with very little open water throughout the season combined with most years that have predominantly open water – it does not reflect a year-by-year frequency with an average amount of ice. These differing occurrences of ice in the summer season would not necessarily represent an impediment to spill response, but rather they would necessitate a change in tactics to using in situ burning in dense ice, or a combination of containment and recovery, burning, or dispersant use in moderate or light ice conditions. As such, the subsequent analysis did not incorporate percent open water.

14.3.5.4.5 Response Effectiveness in the Beaufort Sea (cont'd)

Table 14-15 shows the study results for a far offshore location in the Beaufort Sea using weather and sea state data from 1989 to 2008 during open-water conditions. The study only described when conditions would allow the use of these options and did not describe the efficiency of each option during these periods.

Since each response technique has a different operating limit, further analysis was undertaken to determine the percentage of time that at least one of the three countermeasures is possible in open water (see Table 14-16).

Table 14-15: Percentage of Time for Open-Water Countermeasures

Month	Controlled In Situ Burning			Containment and Recovery			Aerial Dispersant Application		
	Favour-able	Marginal	Not Possible	Favour-able	Marginal	Not Possible	Favour-able	Marginal	Not Possible
June	67	10	23	67	13	20	57	0	43
July	64	11	26	63	13	23	56	0	44
August	43	10	47	43	14	43	48	0	51
September	19	11	70	21	16	63	41	2	57
October	4	7	89	4	9	87	31	3	65

Table 14-16: Percentage of Time at Least One Countermeasure is Possible

Month	At Least One Favourable Countermeasure Option	At Least One Favourable or Marginal Countermeasure Option	No Countermeasure Option Possible
June	80	80	20
July	78	78	22
August	59	59	41
September	42	44	56
October	31	35	65
The response is deferred to the spring melt season for periods of freeze-up and winter (mid-October through June).			

The report concludes that, based on the historical frequency of these conditions, spill response with at least one of the three countermeasures options would be possible for the period when open water is usually present (July through October) from 31 to 78% of the time for the far offshore location in the Beaufort Sea. In comparison to the Grand Banks area off the east coast of Newfoundland, these statistics are quite favourable for effective spill response. Off the east coast of Newfoundland, similar weather and sea state statistics indicate that containment with booms would be possible less than 5% of the time in winter, to a maximum of 25 to 30% of the time in summer (Turner et al. 2011).

Winter conditions were not analyzed in the NEB study. During the winter, oil would remain encapsulated in the ice until being released into melt pools the following spring. For a burning operation in the spring, aerial ignition of melt pools would be possible when:

- acceptable visual flight rule conditions exist
- winds are less than 15 knots
- there is daylight

For the May and June period, these conditions exist for substantial percentages of time (Dickins 1987, Beaufort Sea Steering Committee 1991):

- daylight – 100% of the time
- visual flight rule conditions – 70% of the time
- winds less than 15 knots – 70% of the time

Combined, these factors suggest that springtime burning operations would be possible for about 50% of the time. If operations are not possible on a given day, the oil would still be available for burning on subsequent days. The 50% figure would be used in estimating the number of days available for operations, and based on the extent of the oiled ice area, the number of ignition systems required for maximum effectiveness.

14.3.5.4.6 Community-Based Spill Response Organization

A consistent message from community consultations in the Beaufort Sea region has been a strong community interest in being involved in an oil spill response organization of some sort. Some community members recall the Beaufort Sea Oil Spill Cooperative that employed as many as 20 Inuvialuit in the early 1980s. The Beaufort Sea Oil Spill Cooperative was jointly funded by three operators in the 1970s to the 1990s, with the goal of maintaining an inventory of equipment and a core group of trained personnel for spills beyond Tier 1 capability. Each of the three companies maintained a base level of Tier 1 equipment at Tuktoyaktuk and at various drilling locations and other operating areas such as McKinley Bay. In addition to stockpiling a range of equipment for offshore spills, the cooperative developed a group of trained and committed workers to provide for routine spill responses, field experiments and provide support for other environmental projects. The cooperative provided a visible presence for spill response and attention to clean operations at Canmar’s base in Tuktoyaktuk.

An organization similar to the previous oil spill response cooperative was also emphasized as a preferred model by community members in the recently completed study on training requirements commissioned by AANDC (Kavik-Stantec and SL Ross 2013). In the workshop that was part of that study, Imperial stated that their preferred model was to use a private-sector spill response service provider, and encouraged attendees to consider establishing such a company to provide:

- day-to-day response to small operational spills
- a base group as a focus for training and drills
- a pool of workers that could be used in a large-scale response
- a pool of workers that could be used in demonstrations and experiments

14.3.5.4.6 Community-Based Spill Response Organization (cont'd)

Imperial will investigate and encourage the potential development of a service provider, including potential contractual arrangements. This could take the form of some sort of retainer arrangement to pay for initial and ongoing training, drills and field exercises and linkages with other spill response organizations.

14.3.6 OIL SPILL RESPONSE PLAN

14.3.6.1 Emergency Response Plan

One of the management plans that an operator must have in place is an ERP that outlines the preparations for unexpected events and contingencies, including spill response. An OSRP could be an integral part of an ERP or it could be a stand-alone OSRP. There are current regulatory requirements and various guidelines that describe what documentation should be prepared and filed by an operator to support an offshore exploration program. Imperial would take these into consideration when developing overall contingency plans.

While a large number of agencies and organizations have an interest in emergency response, particularly in the event of a significant incident, the NEB and the CCG have primary responsibilities for emergency response to oil and gas spills in the Beaufort Sea. Environment Canada also has a key role in managing the Arctic Regional Environmental Emergencies Team Contingency Plan. Aboriginal Affairs and Northern Development Canada is responsible for spills on federal land that affect waters and shares with the CCG responsibility for spills of unknown origin that occur north of 60° latitude.

Imperial respects the purpose and intent of the Arctic Council's Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic.

This international instrument will help Arctic nation-states to establish and maintain compatible emergency preparedness, prevention and response policies and eliminate international bilateral legal barriers to effective response. Imperial will work with the Canadian authorities of the parties to this agreement (i.e., the CCG, TC and the NEB), as well as the bilateral Canada–US Joint Marine Pollution Contingency Plan, to ensure consistency and cooperation in the event of an incident resulting from its drilling operations in the Canadian sector of the Beaufort Sea.

The ERP developed by an operator is intended to address the regulatory requirements and provide a foundation for a risk hazard-based response approach. Regardless of the type and cause of the incident, the same response structure would be used to prepare for and respond to any emergency, including oil spills. The primary objectives of the ERP and planning process are to protect the environment and ensure the safety of program personnel and the public.

The ERP will:

- provide emergency response command and control functions for onshore and offshore emergency situations
- cover foreseeable emergencies during all phases of a drilling program
- take into account hazard identification and assessment, environmental considerations, consultation with government and Inuvialuit agencies
- incorporate industry best practice and use of external support resources

The initial approach to developing an ERP would be to develop a framework plan based on the NEB's requirements, CSA standards and company-specific standards and guidelines and other applicable examples and templates, and then develop a detailed plan. The ERP should not replace or conflict with the drilling contractor's emergency procedures, but should integrate the contractor's ERPs into the operator's ERP. The operator's ERP would act as the umbrella document to ensure a consistent, effective and coordinated response to any incident in the Beaufort Sea region.

The OSRP could be a separate detailed document or part of the overall ERP. The oil spill response strategy, tactics and plans would be coordinated with and aligned with the ERP. Integration and consistency with contractor emergency response plans is also an important feature. This would include:

- the drilling contractor's emergency response plan
- vessel emergency plans
- a vessel Shipboard Oil Pollution Emergency Plan
- aircraft emergency procedures
- support base emergency procedures
- geographic response plans or strategies for shoreline response
- waste management plans

14.3.6.2 Oil Spill Response Plan Draft Contents

The following is an example of the contents of an OSRP, including the type of information that would be in each section.

1. Introduction:
   - Purpose of plan – responsibilities of Imperial as operator, policy and intent of plan.
   - Response priorities – health and safety of the workforce and public, protection and restoration of the environment, preservation of the Inuvialuit culture and lifestyle.
   - Ability of the plan to be scaled up or down according to requirements, size of the spill and duration.
2. Response organization charts (by functional role, without specific names and contact information), including:
   - command and control guiding principles (i.e., chain of command)

14.3.6.2 Oil Spill Response Plan Draft Contents (cont'd)

- the incident command system
- the Imperial corporate response organization and headquarters command post, including the:
    - business unit support team
    - crisis management support team
- the Beaufort Sea incident command team and field command posts
- the ExxonMobil North American and global response teams

3. Initial response guides, including:
    - first-on-scene checklist for responders
    - safety checklist, evacuation, if required
    - the process for identifying the initial type, level and severity of an incident and the response required
    - the internal reporting process
    - external notification process and contacts
    - establishment of head office and field command offices
    - the initial steps to stop and control the incident, if possible
4. Responder duties and checklists (based on the incident command system), including those for:
    - the incident command staff, including the:
        - incident commander
        - deputy incident commander
        - safety officer
        - regulatory liaison officer
        - Inuvialuit liaison officer
        - public and media liaison officer
        - Alaska liaison officer
    - the on-site operations staff, including the:
        - on-site operations chief
        - site safety supervisors
        - staging area managers
        - on-site supervisors for:
            - source control, if required
            - search and rescue, if required
            - hazardous materials management
            - mechanical containment (e.g., boom deployment)
            - recovery (e.g., skimmer deployment)
            - oil storage and transport
            - disposal of recovered oil or contaminated materials

   - controlled in situ burning operations
   - dispersant applications (aerial and vessel based)
   - subsea dispersant injection at the wellhead

- the planning section chief, who is responsible for:
  - real-time situation monitoring and reporting
  - weather and oceanographic forecasting
  - fate and trajectory modelling
  - resources assignments
  - documentation
  - environmental resources, including technical specialists
  - wildlife management
  - waste management
  - long-term monitoring of effectiveness of response and residual effects
  - demobilization
- the logistics section chief, who is responsible for the:
  - support unit (i.e., facilities, ground, vessel and air requirements)
  - services unit (i.e., food, medical and communications services)
- the finance and administration chief, who is responsible for:
  - cost control
  - procurement services
  - claims and compensation

5. Contact call-out process (would be detailed in the final operational OSRP before spudding the well).

6. Response guides for specific strategies, including:
   - the types of spills, including crude oil and Arctic P-50 diesel fuel characteristics
   - a subsea blowout scenario, including possible flow rates and duration
   - the use of a pre-approved real-time NEBA for decision making
   - the deployment of containment booms
   - the deployment of skimmers
   - the application of in situ burning booms, small vessels and aerial igniters
   - the aerial application of dispersants
   - the subsea injection of dispersant

14.3.6.2 Oil Spill Response Plan Draft Contents (cont'd)

- the protection, cleanup and restoration of the shoreline
- the transfer, storage and final disposal of recovered oil and water
- a special guide that covers spilled oil that crosses into Alaskan waters or onto the shoreline

7. Response guides for tracking and surveillance, including:
    - ultraviolet and infrared scanners
    - forward-looking infrared radar
    - laser fluorosensors
    - synthetic aperture radar and side-looking airborne radar
    - ground-penetrating radar
    - satellite systems
    - ice drift buoys
    - aerial reconnaissance via TC's National Aerial Surveillance Program
8. Regional and site-specific information, including:
    - hardcopy and electronic links to operational maps
    - results of oil fate and spill trajectory modelling
    - EC's Beaufort Sea coastal sensitivity mapping
    - ice, oceanographic and weather databases
    - wildlife databases
    - cultural and traditional knowledge and Inuvialuit community information
    - Alaska environmental and shoreline sensitivity database
9. Details on resource inventories, including:
    - Imperial-owned equipment and materials
    - ExxonMobil resources
    - other Beaufort Sea operators and mutual aid agreements
    - local oil spill service providers (if available) and equipment
    - Canadian oil spill service providers and equipment
    - Alaska and international oil spill service providers
    - links to spill response equipment manufacturers
    - links to fixed-wing aircraft and helicopter supply companies
10. Additional contacts, including:
    - regulatory agencies information listing:
        - notification and contacts
        - roles and responsibilities
        - support

- relevant legislation and online links

- Inuvialuit information listing:
  - notification and contacts
  - roles and responsibilities
  - support as first responders, oil spill service providers and monitors
  - process for wildlife compensation

The draft OSRP will be reviewed with Inuvialuit to obtain their input before being finalized.

14.3.6.3 Spill Response Organization

If an incident occurs during operations, Imperial would take full responsibility for the response under its incident command organization. In most circumstances, Imperial would interface with the NEB as the lead federal agency for responding to a spill from a drilling platform and the NEB would coordinate the actions of federal and territorial agencies. For more information on the OSRP and an example of an incident command structure for dealing with a spill response, see Section 16.3.7.3, Oil Spill Response.

14.3.6.4 Spill Response Exercises

As required by the NEB, Imperial will test its spill response capability in the Beaufort Sea by conducting tabletop and field exercises before spudding the well and periodically throughout the program.

14.3.7 REDUCING POTENTIAL EFFECTS

One of the goals of any OSRP is to prevent or reduce the effects of a spill on the natural environment and on people in the Beaufort Sea region. Mitigation measures to manage and lower potential risks are developed during the planning stage, when responding to a spill event, and during post-incident follow-up.

Mitigation measures during drilling program planning would include:

- having a robust SSHE management system in place (e.g., the OIMS)
- having sufficient knowledge about the environment and people that could be affected by a spill
- understanding worldwide experiences and lessons learned from past incidents
- having a database of important and sensitive areas for spill response protection (e.g., the Beaufort Sea Environmental Sensitivity Atlas)
- using models to predict oil transport, fate and effects using a set of scenarios based on the well location and local and regional physical and biophysical conditions

14.3.7 REDUCING POTENTIAL EFFECTS (cont'd)

- applying NEBA in consultation with government scientists, regulators, Inuvialuit and others to obtain agreement on the best use of response options, such as dispersants and controlled in situ burning
- having criteria for end-point goals for response and cleanup activities

When responding to a spill event, mitigation measures would include:

- initiating a response in a safe, timely, efficient and effective manner, based on a carefully developed OSRP
- initiating an optimum response strategy while leveraging the applicable response tools, such as:
  - dispersants (aerial and subsea)
  - equipment to contain, recover and disperse the spill
  - controlled in situ burning equipment
  - protective booms for use around priority areas
- initiating real-time spill tracking and surveillance capability as oil:
  - is released from the subsea wellbore
  - moves through the water column by currents
  - is deposited on or under ice or on the surface of open water
- using real-time modelling, based on the tracking and surveillance data, to predict further transport and plan responses accordingly
- applying real-time NEBA to determine the best overall spill responses (e.g., application of dispersants) based on the specific situation
- determining the real-time response encounter rate and effectiveness and any modifications to improve the response
- using real-time wildlife monitoring and mitigation, as appropriate and practicable, to conduct such actions as:
  - using marine bird hazing to keep birds away from the spill area
  - practicing wildlife capture and release, including capturing and cleaning polar bears
  - using icebreakers to open leads to provide access for whale migrations

Post-spill follow-up could include:

- continuing monitoring to assess short- and long-term residual effects
- implementing restoration and reclamation plans for shoreline cleanup, as determined by consultations with regulators and Inuvialuit
- implementing wildlife harvesting compensation under the IFA, as required
- applying lessons from the incident to continuously improve the OSRP

14.3.8 POTENTIAL ENVIRONMENTAL EFFECTS OF ACCIDENTAL SPILLS

In the unlikely event that a spill does occur, and there are environmental effects, Imperial will act to mitigate these effects by using a variety of spill countermeasures. The potential effects of spills and the proposed mitigation measures are considered for two hypothetical spill scenarios:

- a small operational spill of Arctic P-50 diesel fuel at a nearshore harbour site (minor spill)
- a large offshore spill involving an extended subsea blowout at a drill site within EL 477 during September and October (major spill)

14.3.8.1 Effects Assessment Methods

The effects assessment methods used to assess accidental spills are similar to those used in Section 14.2, Routine Activities, except where noted.

The VECs used to assess an accidental offshore spill are the same as those in Section 14.2, with two additional VECs, marine plankton and the epontic community. These two VECs are key components of the Beaufort Sea food web and might be vulnerable to effects of spills and the mitigation measures (see Table 14-17).

Table 14-17: Additional VECs for Spills and Spill Response

VEC	Description	Rational for Selection
Marine plankton	• Includes phytoplankton, zooplankton and planktonic life stages of fish (eggs, larvae) and invertebrate species, including polar cod.	• Ecological importance in the RSA. • Potentially effected by proposed program activities.
Epontic community	• Includes ice-associated algae, invertebrates and ice-associated fish, such as polar cod.	• Ecological importance in the RSA. • Potentially effected by proposed program activities.

The potential for a spill to interact with VECs was assessed and interactions were determined (see Table 14-18).

Although mitigation measures (i.e., spill response techniques) might reduce risks from spills to certain VECs, they might increase the risks to other VECs. In cases where this might occur, the increases in risk are noted in the assessment of significance tables.

14.3.8.2 Minor Spill

During drilling, vessels could travel between a harbour (e.g., Tuktoyaktuk Harbour) and the offshore drilling sites. These vessels would carry fuel (e.g., Arctic P-50 diesel) or cargo that could accidentally be spilled. These accidental discharges are most likely to occur in or near harbours or at the offshore drilling sites. If a spill were to occur, they would be infrequent, relatively small (a few litres or few cubic metres) and would involve petroleum products (e.g., diesel fuel).

14.3.8.2 Minor Spill (cont'd)

If small spills occur, their environmental impact would also be relatively small and localized. With proper spill response and use of mitigation measures the effects of spills could be further reduced so that residual effects should not be evident beyond one year.

Table 14-18: Selected VECs

VEC	Hydrocarbon Vapour	Oil Slick	Oil in Ice [1]	Dispersed Oil	Oil on or in the Seafloor	Oiled Shoreline	Indirect Effect [2]
Atmospheric environment	•						
Marine plankton				•			
Epontic community			•				
Marine avifauna		•	•			•	
Marine mammals		•	•	•		•	
Marine and anadromous fish			•	•	•		
Benthos				•	•		
Coastal landscapes						•	
Traditional land and resource use	•	•	•	•	•	•	•

Note:
1. Oil in, on or under ice, in leads or among ice chunks
2. Contamination of harvested species (e.g., fish)

14.3.8.2.1 Potential Effects

A small spill of non-persistent diesel fuel within a harbour was used as the basis for the effects assessment. The environmental fate, persistence and movement of the spilled oil would depend on several factors, including the:

- nature of the product spilled
- quantity of oil spilled
- wind and current conditions
- spill countermeasures used

Spill impact would depend on the location and timing of the spill and factors that control the movement of the oil.

Spill Fate in Open Water (July to October)

The fate of spilled oil would depend on prevailing wind conditions. Under low or moderate winds and in moderate sea states, a petroleum product like diesel fuel would spread quickly into thin slicks and sheens that would be moved about by the winds until they strand on nearby shorelines. Most of the oil would evaporate, a small proportion might disperse into the water and the remainder might strand on nearby shorelines. Levels of shoreline oiling should be low, but would be greatest near the spill site and less at a distance.

Under high winds and sea states, a substantial portion of the diesel fuel might be entrained into the water column producing localized elevated oil concentrations in water. These would quickly dissipate by diffusion until oil concentrations return to background levels within days.

Spill Fate in Broken Ice (November to June)

This is a spill into an area of broken ice during the ice-covered period. The fate of spilled oil would depend on the nature of the ice. Generally, oil spilled in ice would be trapped in the spaces between the ice chunks and would spread more slowly than in open water. Most of the hydrocarbons in a diesel fuel spill would evaporate, but a very small amount could disperse. If the spill takes place during late spring, sheens would be released slowly from the melting ice and would strand in low concentrations on nearby shorelines. A spill during freeze-up or in mid-winter would become encapsulated in the ice until spring, then released onto the surface of melt pools and dissipate as sheens as the ice melts.

14.3.8.2.2 Mitigation Measures

For spills in open water, much of the spill would be contained near the source and recovered. If the diesel fuel has the opportunity to spread, it would spread and thin quickly and would be moved by winds and currents. Some diesel fuel might be recovered by booming and skimming before the remaining small amounts strand in low concentrations. Any higher concentrations of stranded diesel fuel could be removed with sorbents. Heavily contaminated shoreline substrate can be removed for decontamination or disposal off site.

For spills in broken ice, much of the diesel fuel that is contained in the spaces between ice chunks will be recovered quickly or burned in situ. Sheens released from the ice during the spring melt can be sorbed. Any sections of shoreline that become contaminated can be cleaned.

14.3.8.2.3 Assessment of Effects on VECs

Table 14-19 provides an assessment of the effects of a minor spill, including information on:

- the potential interactions between VECs and spill processes (e.g., oil slicks, clouds of hydrocarbon vapour, oiled shorelines)
- spill effects on specific VECs and the mitigation measures

Atmospheric Environment

Air Quality – Some of the more volatile hydrocarbon compounds of the spilled oil will evaporate quickly, releasing VOCs into the air near the slick. This process is completed within a few hours or days of the spill. Clouds of VOCs dissipate quickly, lasting only a few hours. The vapours from products like diesel fuel have an odour, but brief exposures to low concentrations in the air do not pose a health hazard.

Table 14-19: Effects, Mitigation and Significance – Minor Spill

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects				Significance of Residual Effect
			Magnitude	Extent	Duration	Frequency	
Atmospheric environment	Volatile organic hydrocarbons in air over slick.	• Contain and remove contaminating hydrocarbons from water and shorelines.	Medium	Localized	Short term	Occasional	Not significant
	Increase in noise.	• Spill response might raise noise levels.	Low	Within LSA	Short term	Occasional	Not significant
Marine plankton	In low to moderate winds exposure is low. In high winds exposure would be higher but localized and temporary.	• Contain and remove contaminating hydrocarbons from water surface.	Low	Localized	Short term	Occasional	Not significant
Epontic community	Absent during open-water season. Exposure is unlikely during ice-cover season. If a spill is in broken ice, the exposure would be localized.	• Contain and remove contaminating hydrocarbons from water surface.	Low	Localized	Short term	Occasional	Not significant
Marine mammals	Negligible to moderate level of exposure, depending on conditions. Exposures are brief and localized.	• Contain and remove as much oil as possible from the surface of the water and shorelines.	Low	Localized	Short term	Occasional	Not significant
Marine and anadromous fish	Negligible to high level of exposure, depending on conditions. Exposures would be brief and localized.	• Contain and remove as much oil as possible from the surface of the water and shorelines.	Low	Localized	Short term	Occasional	Not significant
Benthos	Negligible to high level of exposure, depending on conditions. Exposures would be localized.	• Contain and remove as much oil as possible from the surface of the water and shorelines.	Low	Localized	Medium term	Occasional	Not significant
Coastal landscapes	Negligible to high level of exposure, depending on conditions. Exposures would be brief and localized.	• Contain and remove as much oil as possible from the surface of the water and shorelines.	Medium	Localized	Short term	Occasional	Not significant
Traditional land and resource use	Local harvesting areas of harvested species (e.g., fish) might be contaminated with oil.	• Prevent spreading and movement of oil and clean up as quickly as possible. Monitor persistence and extent of hydrocarbons contamination.	Low	Localized	Short to medium term	Occasional	Not significant

Atmospheric Environment (cont'd)

In situ burning of oil in ice will generate a smoke plume, but the concentration of particulates in the plume (the contaminant of greatest concern in the smoke) will dissipate within a few kilometres downwind of the burn. Careful timing of the burn, with respect to forecast winds, will ensure no effects from the smoke.

Noise – Depending on the nature and level of spill cleanup activities, there might be some noise involved during the cleanup activity.

Marine Plankton

Phytoplankton and zooplankton are sensitive to hydrocarbons. During a spill in the open-water season, exposures would depend on wind conditions. For a spill in light to moderate winds, plankton would experience very limited exposure to oil because only small amounts of oil would disperse into surface waters from slicks. During a spill in higher winds, oil will be entrained in the water and plankton exposed, but the area of exposure will be small.

A surface spill into an area of broken ice during the period of ice cover will be contained in the ice. There will be little mixing energy available to entrain oil into the underlying water and exposures to plankton will be limited.

Epontic Community

A surface spill into an area of broken ice during the period of ice cover will be contained in the ice, so exposures would be localized.

The epontic community is not present during the open-water season.

Benthos

The benthic biota occurring in shallow nearshore waters include crustaceans and mollusc species that are important as ecosystem food chain components and as food sources for ISR communities (e.g., crabs, mussels, flatfish). Risks to benthos from spills will depend on spill conditions. Spills in open coastal waters in light or moderate winds pose a limited risk because in light winds little oil disperses from slicks. However, even in light winds some oil will reach shallow nearshore benthic areas when oil stranded on shorelines is resuspended in the water and settles in nearby shallow subtidal areas. In high winds and waves, slicks can be mixed into sediment-laden nearshore waters and then settle to the seafloor. Sedimented oil might injure or contaminate benthic species and could take years to degrade.

Effects on benthos and contamination will be mitigated by recovering spilled oil from the sea surface and cleaning oiled shorelines.

Marine and Anadromous Fish

Marine and anadromous fish species might be exposed to spills in shallow nearshore areas. In open areas with light winds, oil exposures will be minimal

Marine and Anadromous Fish (cont'd)

and short lived. Under these conditions, only small amounts of oil will disperse into the water column, and any oil that does disperse will dilute quickly to low levels. Under these conditions there is little potential for injuries or contamination to fish. More significant but short-lived exposures might occur if high winds mix slicks into surface waters. More prolonged exposures might occur if oil is spilled into enclosed areas, such as a small lagoon where there is limited potential for diluting the oil. Under these conditions injuries and tissue contamination might occur. Recovery time will be determined by the fate and persistence of the oil in the water and sediments. However, the risks to local populations will be small because the areas affected would be small and isolated.

Effects on marine and anadromous fish and contamination will be mitigated by efficiently recovering spilled oil from the sea surface and cleaning oiled shorelines.

Marine Avifauna

Local waterfowl species (e.g., king eiders, long-tailed ducks) and to a lesser degree shorebirds are vulnerable and sensitive to oiling. A small spill in a harbour occurring in open water could pose some risk to local birds. At the population level, risks from small spills will be low if they occur when populations are widely dispersed in the Beaufort Sea region. However, risks could potentially increase during the open-water season when some species aggregate in coastal waters for moulting or staging (e.g., long-tailed ducks and eiders). Risks might also be greater if oil is spilled in areas of broken ice that are used by migrating species in the spring.

Effects on marine avifauna will be mitigated by efficiently recovering spilled oil from the sea surface, burning oil trapped in leads and cleaning oiled shorelines.

Marine Mammals

Marine mammals, including polar bears, seals and whales vary in their sensitivity to oil slicks. Some species might be injured if exposed to thicker parts of slicks from a fuel oil spill. Individuals of these species might be injured if oiled by a small spill in a harbour. However, because the populations of most species are widely distributed during the open-water season, the risks at the population level are low. Risks might be slightly greater for the Beaufort Sea beluga whale population, because large numbers of whales concentrate in a few nearshore areas in the Mackenzie Delta in July. Even then, the risks are not great because, beluga whales are relatively insensitive to oil slicks (compared to other marine mammals), and the proportion of the population present on any given day is relatively modest.

Effects on marine mammals will be mitigated by efficiently recovering spilled oil from the sea surface, burning oil trapped in leads and cleaning oiled shorelines.

Coastal Landscapes

Shoreline oiling by spills is of concern because:

- some shoreline areas are habitat for nesting or migrating birds
- some coastal areas are important for traditional harvesting at certain times of the year
- oil stranded on shorelines could be resuspended and deposited in shallow nearshore areas where it serves as a source of contamination for nearshore benthic species

The level and extent of shoreline oiling will be reduced by recovering some of the spilled oil at sea, using booms to protect nearshore areas and cleaning oiled shorelines.

Traditional Land and Resource Use

The ISR communities harvest wildlife and fish in local coastal and nearshore areas at certain times of the year. This traditional harvesting and other activities could be disrupted if shorelines, coastal waters, the seafloor or the biota are contaminated with oil. Many of these harvesting activities (e.g., the beluga whale harvest) are very important culturally and economically to the ISR communities. Small spills of the type considered here will probably not affect any harvested population sufficiently to affect the harvest. However, the presence of oil slicks, oiled shorelines or contaminated fish or shellfish might be sufficient to disrupt seasonal harvesting activity.

Contamination from a small local spill will be mitigated by recovering as much oil as possible at sea and by cleaning oiled shorelines. Effects on local fishing caused by local seafloor contamination will require monitoring the environment and local harvested stocks to track the persistence of contamination, and determine when it is safe to resume harvesting activities.

Significance of Residual Effects

A small spill poses some risks to a number of VECs. The level of impact will depend on a variety of factors. Mitigation measures will reduce the potential impact of a small spill on the local ecosystem and communities, such as:

- offshore containment and recovery of the oil at sea
- shoreline protection using diversion booms
- shoreline cleaning and post-event monitoring

14.3.8.3 Major Spill

Although the likelihood of a major spill from offshore exploration drilling is extremely low, it is possible. These spills might involve small discharges of fuel or drilling liquids from the drilling unit or much larger losses of produced liquids from the well itself. The assessment of effects considers a hypothetical large spill from a subsea well blowout within EL 477 during the open-water drilling season,

14.3.8.3 Major Spill (cont'd)

with discharges lasting for an extended time. If such a spill were to occur, the spill fate and environmental effects would depend on the conditions of the spill, weather and ice, and the type and effectiveness of spill mitigation measures used.

14.3.8.3.1 Potential Effects

The assessment of effects is based on a large spill offshore involving an extended subsea blowout at a drill site within EL 477 during September and October.

The fate and trajectory of this hypothetical spill would depend on the spill conditions (e.g., spill type and location, oil type and spill volume), weather conditions (speed and direction of winds and currents, water temperature), ice conditions and the type and effectiveness of mitigation measures.

Spill Fate in Open Water (July to October)

Oil and gas discharged from a subsea blowout would form a plume of oil droplets, gas and water that rises quickly to the surface, entraining water from the surrounding area as it rises. The plume would surface near the spill site and form an oil slick that would be deflected down current, away from the plume. Under low or moderate winds and sea states, the oil slick would spread quickly and break up into large, thick patches of oil surrounded by a sheen (i.e., a layer of oil a few millimetres thick). These oil patches would be moved downwind and down current, away from the spill site. A portion of the oil in the patches would be lost to the atmosphere by evaporation, and the remaining oil patches might accumulate water to form a water-in-oil emulsion. In light winds, only small amounts of oil would disperse naturally into the water. Some of this oil would slowly agglomerate with suspended matter in the surface water and, over time, settle to the seafloor over a large area at some distance from the blowout site. In higher winds more oil would disperse and ultimately settle to the seafloor.

Depending on the wind direction, surface oil might move shoreward (i.e., southward) across the Mackenzie Shelf to strand on the mainland shore from the Tuktoyaktuk Peninsula to the Yukon Coast and Alaska North Slope. Oil encountering the coastal zone could contaminate coastal lagoons and estuaries and strand on shorelines. Some of the stranded oil might be resuspended by waves and tides and deposited in adjacent shallow subtidal areas. If the wind were from the south, then oil would move northward to strand on the edge of the polar pack ice. Oil reaching the edge of the pack ice could accumulate and spread among the floes at the edge of the pack. Oil could become encapsulated in ice during freeze-up. This trapped oil might be transported with the ice pack through the winter before being released into surface melt pools and fields of broken ice during breakup the following spring.

Spill Fate in Ice (November to June)

Oil that is discharged from a blowout late in the season might persist in surface slicks at sea and become encapsulated in the ice during freeze-up. The oil would remain encapsulated in the ice over the winter and then be released into melt pools in the spring.

14.3.8.3.2 Mitigation Measures

Mitigation activities will include:

- same well intervention
- monitoring
- mechanical containment and recovery
- use of dispersants
- in situ burning
- shoreline protection and cleanup

14.3.8.3.3 Assessment of Effects on VECs

Effects of the spill will depend on the:

- location and size of the spill
- persistence and the direction of movement of the oil spill
- effectiveness of mitigation measures used

Table 14-20 provides an assessment of the effects of a major spill, including information on:

- the potential interactions between VECs and spill processes (e.g., oil slicks, clouds of hydrocarbon vapour, oiled shorelines)
- spill impacts on specific VECs and the role of mitigation measures

Atmospheric Environment

Air Quality – Elevated levels of VOCs will develop in the air above the slick at the spill site. Most VOCs will evaporate from the slicks within days, while the slicks are still far offshore. In all likelihood VOC levels will not pose a safety or health risk. The VOC levels will be mitigated by controlling the discharge from the wellhead at the seafloor and applying dispersants on freshly surfaced slicks. In situ burning of oil in fire booms or in ice will generate a smoke plume, but the concentration of particulates in the plume (the contaminant of greatest concern in the smoke) will dissipate within a few kilometres downwind of the burn. Careful timing of the burn, with respect to forecast winds, will ensure no effects from the smoke.

Noise – The high-velocity jet of oil, water and gas escaping from the subsea blowout might produce subsurface noise effects.

Benthos

Some oil–sediment aggregate from the subsea blowout plume might settle on the seafloor near the blowout site. This might serve as a source of contamination for nearby benthos for a few years, until the oil weathers and degrades or becomes overlain by clean sediments and is sequestered.

Table 14-20: Effects, Mitigation and Significance – Major Spill

VEC	Program–VEC Effect	Mitigation	Measures of Residual Effects: Magnitude	Extent	Duration	Frequency	Significance of Residual Effect
Atmospheric environment	Increase in air contamination at the spill site.	• Subsea containment and dispersal. • Monitor air quality. • Chemical dispersion and burning at spill site.	Medium	Localized	Short term	Occasional	Not significant
	Increase in noise levels at spill the site.	• Burning will cause smoke. Some noise from subsea or surface blowout.	Low	Localized	Short term	Occasional	Not significant
Marine plankton	Surface spill – low level localized exposure to oil.	• Spill control.	Low	Localized	Short term	Occasional	Not significant
	Surface dispersants – high exposure level in surface waters near and under the slick.	• Spill control.	Low	Localized	Short term	Occasional	Not significant
	Subsea spill – organisms entrained into blowout plume.	• Well control.	Low	Localized	Short term	Occasional	Not significant
Epontic community	Exposure unlikely during an open-water spill.	• Dispersants and in situ burning.	Low	Localized	Short term	Occasional	Not significant
Benthos	Subsea blowout – some seafloor contamination near the blowout site. Surface spill – limited low level contamination.	• Subsea blowout – subsea containment and dispersal.	Low	Localized	Medium term	Occasional	Not significant
Marine and anadromous fish	Exposure negligible to low, except when dispersants are used.	• Contain and remove oil. Monitor tissue hydrocarbon contamination in harvested areas.	Low	Localized	Short term	Occasional	Not significant
Marine avifauna	Low to high level of effects on population possible over large areas.	• Reduce surface slicks offshore as much as possible with dispersants and burning. • Protect sensitive coastal areas with selective booming.	Low to high	Extensive	Medium to long term	Occasional	Significant
Marine mammals	Sensitivity to oil – low to high, depending on species. Low to moderate level of exposure, depending on conditions. Exposures are brief and localized.	• Disperse and burn as much oil as possible from the water surface near the spill site and clean the shoreline.	Low	Extensive	Short term	Occasional	Not significant
Coastal landscapes	Low to high level of exposure, depending on conditions.	• Collect, disperse and burn as much oil as possible near the spill site. • Clean the shoreline.	Medium	Extensive	Short term	Occasional	Not significant
Traditional land and resource use	Many harvesting areas might be contaminated with oil.	• Collect, disperse and burn as much oil as possible near the spill site. • Clean the shoreline.	High	Extensive	Short to medium term	Occasional	Significant

Benthos (cont'd)

In offshore surface spills, only a small amount of the spilled oil becomes entrained into the water to settle on the seafloor. Oil droplets entrained into surface waters slowly agglomerate with sediment suspended in the water column and slowly settle on the seafloor. Because this is a slow process, the entrained oil could drift considerable distances from the spill site and spread to cover a large area before it settles. As a result, the concentration of oil in any location will be low and the oil highly weathered.

Marine Avifauna

Large numbers of waterfowl (i.e., sea ducks and geese) and other types of birds (gulls) migrate through, or stop over in, the Beaufort Sea in the mid to late open-water season. These birds are sensitive to oiling and are vulnerable to contacting surface slicks from a major spill. For some species, large proportions of the regional breeding populations concentrate in coastal areas to moult or stage before their autumn migration. Bird species that have a high concentration of their populations that stay in coastal areas for long periods of time are vulnerable to the effects of a major spill.

These bird populations can be protected by dispersing or burning as much oil as possible at or near the spill site, or protecting or cleaning high-use coastal areas where birds aggregate.

Marine Mammals

The potential effects of a large spill on Beaufort Sea marine mammal populations will vary by species. Risks to bears, seals and some whales (e.g., beluga whale) might be greatest from surface contamination and inhalation of oil from slicks. Some surface-feeding baleen whale species might be at risk of ingesting slicks of untreated oil.

Polar bears are highly sensitive to oiling because they rely on their fur for insulation, and oil can disrupt the fur's insulating potential. Some polar bears might become oiled during a major offshore spill in the open-water months. However, polar bears are a solitary species and populations are widely dispersed throughout the year. Consequently, the likelihood of a significant proportion of the local population of polar bears becoming oiled during a spill is low.

Ringed seals and bearded seals are less sensitive to oiling than polar bears and apparently can tolerate some exposure to oiling. In the Beaufort Sea, ringed seals are concentrated over the Mackenzie Shelf for part of the open-water season and some seals might encounter oil from a major spill. However, their relative insensitivity to oil suggests that potential impacts are not significant.

Beluga whales are relatively insensitive to oiling because the species relies on a layer of blubber for insulation. Beluga whales are widely dispersed throughout the Beaufort Sea during the open-water season making risks from a major spill not significant.

Marine Mammals (cont'd)

Bowhead whales are likely relatively insensitive to surface oiling, but as baleen whales they might be vulnerable to ingesting oil while feeding. Geraci and St.Aubin (1985) suggested that for large baleen whales, a dose of hundreds of litres of oil would be required to bring about toxic effects. If a large offshore blowout spill occurred, high concentrations of fresh oil would occur only in the immediate vicinity of the blowout site. Oil from the spill might become widely distributed in the Beaufort Sea, but away from the spill site the oil would be present in low concentrations in the form of small patches and tar balls. The preferred feeding areas of bowhead whales in the Beaufort Sea are long distances away from the potential spill site. Although some baleen whales might accidentally ingest small amounts of oil while feeding, the likelihood of ingesting a large dose is small. Therefore, the risk of effects on the bowhead whale population from an offshore blowout is not significant.

Marine mammal populations can be protected by dispersing or burning as much of the oil as possible at or near the spill site.

Marine Plankton

Marine phytoplankton and zooplankton are sensitive to hydrocarbons, but they will experience limited exposure to oil spills on the sea surface. Only small amounts of oil would disperse into surface waters from slicks, so only organisms in the upper few metres of the water column will be exposed to elevated hydrocarbon concentrations. The same is true during booming and skimming and in situ burning operations. Chemical dispersion of surface slicks will drive large amounts of dispersed oil into the surface waters. However, even when surface dispersants are used, only marine plankton in the surface waters immediately under the treated slicks will experience injurious concentrations of dispersed oil.

Subsea blowouts pose chemical and physical risks to plankton. Subsea blowouts generate a turbulent rising plume of water, oil and gas, which will entrain water and plankton that it contacts, with potentially damaging results. If dispersants are injected into the blowout plume subsea, then the plume might also include damaging concentrations of dispersed or dissolved hydrocarbons. Effects on plankton will depend on the location, discharge rate, duration and water depth of the blowout.

Epontic Community

Surface oil that is trapped in ice at freeze-up becomes encapsulated in the ice so that epontic organisms would not be exposed.

Marine and Anadromous Fish

Fish will experience very limited exposure to oil during spills on the sea surface. Only small amounts of oil will disperse into surface waters from slicks, so only organisms in the upper few metres of the water column will experience elevated hydrocarbon concentrations. Booming and skimming operations and in situ burning do not increase the potential for exposure to oil. Chemical dispersion of surface slicks will drive large amounts of dispersed oil into the surface waters. However, even when surface dispersants are used, elevated oil concentrations will only develop in the upper few metres of the water column immediately under the treated slicks. As a result, the potential for significant effects on marine and anadromous fish is low.

The effects on fish exposed to oil slicks resulting from subsea blowouts are similar to that of fish exposed to surface oil spills. If dispersants are injected into the blowout plume, the cloud of dispersed oil that forms when the plume reaches the sea surface might contain potentially injurious concentrations of oil. Effects on marine and anadromous fish will depend on the location, discharge rate, duration and water depth of the blowout, but the risks will not be significant.

Coastal Landscapes

Oil from a blowout can contaminate shoreline areas. Shoreline oiling caused by spills is of concern because:

- some shoreline areas are habitat for nesting or migrating birds
- some coastal areas are important for traditional harvesting at certain times of the year
- oil stranded on shorelines could be resuspended and deposited in shallow nearshore areas where it serves as a source of contamination for nearshore benthic species

The level and extent of shoreline oiling will be reduced by dispersing or burning the oil offshore or by using booms to protect nearshore areas. Shoreline cleaning will reduce the effects on shorelines from the persistence of oil.

Traditional Land and Resource Use

A large offshore spill has the potential of causing significant oil contamination in widespread coastal areas of the Beaufort Sea. This could disrupt traditional harvesting activities in these areas for years until the oil is removed. This disruption could have a significant effect on ISR communities.

The risks to most harvested stocks are probably not significant, but some harvested bird populations (e.g., king eider) are highly sensitive and vulnerable and might be significantly affected.

Significance of Residual Effects

A large spill poses some risks to a number of VECs. The level of impact will depend on a variety of factors. Mitigation measures will reduce the potential impact of a large spill on the local ecosystem and communities. These measures include:

- dispersants to reduce concentrations of oil and accelerate the degradation of oil in water

Significance of Residual Effects (cont'd)

- in situ burning
- shoreline protection using diversion booms
- shoreline cleaning and post-event monitoring

A major spill could affect some VECs, such as:

- coastal bird species
- plankton that come in direct contact with oil
- coastal landscapes
- traditional harvesting

14.3.9 EMERGING TECHNOLOGIES

New spill response technologies are emerging or are available that could improve the capability to respond to a spill, including spills in ice conditions. Examples of these new technologies include:

- high-capacity oleophilic disc skimmers
- a medium-scale oleophilic skimmer and smoke-free burner combination
- paravanes to replace a second boom-tender vessel
- high-speed single vessel sweep systems
- herding agents to thicken oil in open water and drift ice to allow the oil to be burned
- next-generation herding agents
- fire booms used in loose drift ice
- gelled gasoline used as an igniter and applied from a fixed-wing aircraft
- gelled dispersants used for viscous, weathered or emulsified oils
- vessel-based dispersant application systems that would allow for single-pass applications
- vessel-based paravane-mounted dispersant application nozzles
- articulated spray arms used to apply dispersant to oil in pack ice
- mineral fines to disperse oil in pack ice
- icebreakers to access and mix oil and dispersant or mineral fines in pack ice
- spill detection systems for use in night operations

There are many research and development (R&D) programs ongoing or planned for the near future that could result in other improvements to Arctic oil spill response capability. These include:

- The International Association of Oil and Gas Producers (OGP) Oil Spill Response Technology Joint Industry Programme, which funds research on many aspects of oil spill response in Arctic waters, including mechanical recovery, dispersants and controlled in situ burning.
- The API has convened a joint industry task force on oil spill preparedness and response. The oil spill preparedness and response group has framed a comprehensive program to address the major areas of spill preparedness, response and restoration. This ambitious program consists of seven major work streams and is comprised of 25 distinct projects. The work streams are:
    - oil spill response planning
    - oil sensing and tracking
    - dispersants
    - controlled in situ burning
    - mechanical recovery
    - shoreline protection
    - alternative response technologies
- The OGP-IPIECA has developed a joint industry program that is addressing aspects of controlled in situ burning impacts.
- The Environmental Studies Research Funds is assessing a five-year plan for its northern R&D.
- The US Bureau of Safety and Environmental Enforcement (BSSE) continue to fund a significant amount of research on spill response in Arctic waters.
- The DFO, BSEE and US EPA are studying aspects of subsea dispersant injection.
- The Norwegian Clean Seas Association (NOFO) is working on a vessel-based dispersant spray boom combined with a boom paravane, ways to deflect oil offshore towards skimmers and shipboard radar systems to allow detection and monitoring of slicks in poor visibility conditions.
- The US Coast Guard is conducting oil spill response equipment tests in ice conditions and researching the detection of submerged oil.
- Alaska Clean Seas is involved in several studies, including using nuclear magnetic resonance to detect oil under ice, and ways to improve marine mammal response in the event of a spill.
- Many oil companies, including Imperial, ExxonMobil and BP, fund individual R&D projects on Arctic spill subjects.

Imperial and its partners, ExxonMobil and BP, maintain close contact with the organizations involved in these R&D efforts by:

- providing funding
- participating on technical committees
- directly managing projects
- reviewing reports

14.4.1 AREAS OF CULTURAL AND HISTORIC SIGNIFICANCE CONSIDERED

The primary locations considered in the effects assessment are coastal locations. Coastal locations within the ISR have traditionally been used by Inuvialuit for various purposes, including:

- resource harvesting
- ceremonial activities, including those of particular cultural significance
- burial sites

Secondary cultural and historical resource sites considered are located further inland (e.g., in the Mackenzie Delta).

14.4.2 POTENTIAL PROGRAM EFFECTS

The program could potentially affect cultural and historic resources by:

- erosion of coastal areas as a result of waves generated by vessel wakes during transit (e.g., during resupply activities)
- shoreline fouling as a result of an oil spill, including fouling of inland areas as a result of a storm surge

Because the EL areas are located about 125 km north-northwest of Tuktoyaktuk in water depths ranging from 60 to 1,500 m, the likelihood of finding any archaeological sites in the EL areas where drilling activities would take place is remote. Furthermore, the shore-based facility will be located in Tuktoyaktuk and is not expected to have a negative effect on any cultural or historical resources.

15.1.1 PURPOSE OF A CUMULATIVE ENVIRONMENTAL EFFECTS ASSESSMENT

Cumulative environmental effects could result from the combined activities of Imperial's exploration program and from other projects or activities that might occur in the Southern Beaufort Sea. The cumulative effects assessment determines whether the program is likely to have an effect on a VEC in consideration of other projects that have similar effects and overlap with the program in both space (spatially) and time (temporally).

The cumulative effects assessment considers the regional context to identify potential cumulative effects with other projects and activities in accordance with the Canadian Environmental Assessment Agency's *Cumulative Effects Assessment Practitioners Guide*, 1999. The cumulative environmental effects assessment builds on the results of the program-specific environmental effects assessment (see Section 14, Analysis of Potential Significant Environmental Effects).

The region's natural and human environments have been affected by past and ongoing human activities. The description of the existing (baseline) environment reflects the effects of these other anthropogenic pressures. The evaluation of cumulative environmental effects considers the nature and degree of change from these baseline environmental conditions as a result of the proposed program, in combination with other planned projects and activities.

The assessment of cumulative effects focuses on cumulative environmental effects for reasonably foreseeable projects or activities (i.e., those that are likely or reasonably certain to occur). These projects or activities have been identified through publically available documents, such as existing plans, permit applications or formal announcements, e.g., information on forecasted oil and gas activities in the Beaufort Sea (2012 – 2027) presented at the BREA Results Forum in Inuvik (Callow 2013). Activities might also be reasonably foreseeable if they are uncertain in some aspects, but probable. Generally, because the program pre-spud activities will only start in 2016, with drilling beginning in 2020, it is difficult to predict with any certainty what other projects and activities will overlap temporally with the program. Therefore, the cumulative effects assessment focuses on potential spatial overlap, assuming that some of the projects and activities identified will occur simultaneously with the program.

15.1.2 IDENTIFICATION OF OTHER PROJECTS AND ACTIVITIES

A scoping exercise has been conducted to identify other past, present, and future projects and activities, the effects of which might interact cumulatively with those of the program. The projects and activities identified were limited to those within the RSA during the last decade, current projects and reasonably foreseeable future projects. For a summary of these projects and activities see:

- Table 15-1, for past projects and activities in the RSA
- Table 15-2, for present projects and activities in the RSA
- Table 15-3, for reasonably foreseeable projects and activities in the RSA

These tables focus on vessel traffic and the use of local sea ice during winter.

Table 15-1: Past Projects and Activities in the RSA

Year *	Developer	Location in the Canadian Sector of the Beaufort Sea	Type of Activity
Before 2000	DFO and the FJMC	Beaufort Sea	Beluga whale stock assessments (through overflights) and tagging programs.
2000 and ongoing	GNWT and CWS	Beaufort Sea	Helicopter flights to radio collar polar bears.
2001-2003	Devon Canada Corp.	EL 420	3-D seismic exploration.
2005-2006	Devon Canada Corp.	Paktoa C-60 (EL 420)	Natural gas exploration well drilling.
2001, 2003-2005, 2009	DFO and NRCan	Mackenzie Shelf and continental slope	Sonar surveys to investigate seafloor characteristics related to Arctic coastal and offshore hydrocarbon development.
2008	Imperial	Ajurak (EL 446, now EL 476)	3-D seismic exploration.
2009	BP	Pokak (EL 449, now EL 477 and EL 451)	3-D seismic exploration.
2009 and 2011	Imperial	Ajurak (EL 446, now EL 476)	FDCP
2010	ArcticNet and BP	EL 451, 453, 446 (now EL 476) and EL 449 (now EL 477)	FDCP
2011 and 2012	ArcticNet	Mackenzie Shelf and Amundsen Gulf	Baseline environmental marine data collection (collected during BREA program).
2006-2008, 2010, 2012	GX Technology Canada Ltd.	Mackenzie Shelf and continental slope, offshore of the Tuktoyaktuk Peninsula and Banks Island	2-D seismic exploration.
2012	Chevron Canada Ltd.	EL 448 and EL 460	3-D and 2-D seismic exploration.
2012	GNWT-ENR	Southern Beaufort Sea	Polar bear population estimates through transect flights over the entire southern Beaufort Sea.
2012	BREA and Joint Secretariat	Beaufort Sea	Overflights of transects in offshore and deepwater areas of the Beaufort Sea to detect polar bears.

Table 15-1: Past Projects and Activities in the RSA (cont'd)

Year *	Developer	Location in the Canadian Sector of the Beaufort Sea	Type of Activity
2006-2009, 2012	DFO	Mackenzie Shelf and continental slope, offshore of the Tuktoyaktuk Peninsula	Baseline fish information: fish, fish habitat and marine ecosystem (collected during BREA program).
Ongoing	Various vessels	Tuktoyaktuk Harbour and adjacent nearshore and offshore waters	Boat traffic (e.g., hunting and fishing, supply barges, tourism vessels, CCG, naval operations).
Ongoing	Various winter activities	Coastal and nearshore areas around Tuktoyaktuk Harbour and the Tuktoyaktuk Peninsula	Ice road construction and use, snowmobile traffic (for hunting and travel purposes) and dogsled travel (for subsistence and sport hunts).
Note: Exploration and development activities during the 1970s, 1980s and 1990s are not considered in this table.			

Table 15-2: Present Projects and Activities in the RSA

Year *	Developer	Location in the Canadian Sector of the Beaufort Sea	Type of Activity
2013	GNWT and CWS	North Beaufort Sea	Radio collaring of polar bears of the north Beaufort Sea polar bear population to determine boundaries.
2013	ArcticNet	Mackenzie Shelf and Amundsen Gulf	Baseline environmental marine data collection (collected during BREA program).
2013	DFO	Mackenzie Shelf and continental slope, offshore of the Tuktoyaktuk Peninsula	Baseline fish information: fish, fish habitat and marine ecosystem (collected during BREA program).
2013	NRCan, KOPRI, DFO, MBARI and USGS	Mackenzie Shelf and continental slope, 22 to 200 km offshore of the Tuktoyaktuk Peninsula	Geophysical surveys, geologic sampling and oceanographic measurements.
2013 to 2015	Franklin Petroleum	EL 485 and EL 488-493	3-D and 2-D seismic exploration.
Ongoing	Various vessels	Tuktoyaktuk Harbour and adjacent nearshore and offshore waters	Boat traffic (e.g., hunting and fishing, supply barges, tourism vessels, CCG, naval operations).
Ongoing	Various winter activities	Coastal and nearshore areas around Tuktoyaktuk Harbour and Tuktoyaktuk Peninsula	Ice road construction and use, by snowmobile (for hunting and travel purposes) and dogsled travel (for subsistence and sport hunts).
Note: KOPRI = Korea Polar Research Institute MBARI = Monterey Bay Aquarium Research Institute USGS = United States Geological Survey * Exploration and development activities during the 1970s, 1980s and 1990s are not considered in this table.			

Table 15-3: Reasonably Foreseeable Future Projects and Activities in the RSA

Year [1]	Developer	Location in the Canadian Sector of the Beaufort Sea	Type of Activity [2]
2013 to 2015	Franklin Petroleum	EL 485 and EL 488-493	3-D and 2-D seismic exploration.
Unknown	ConocoPhillips	Amauligak Block (SDL 126) about 50 km northwest of Tuktoyaktuk	Potentially oceanographic, geotechnical, geophysical surveys, drilling and oil production.
Ongoing	Various vessels	Tuktoyaktuk Harbour and adjacent nearshore and offshore waters	Boat traffic (e.g., hunting and fishing, supply barges, research, tourism vessels and cruise ships, CCG, naval operations).
Ongoing	Various winter activities	Coastal and nearshore areas around Tuktoyaktuk Harbour and the Tuktoyaktuk Peninsula	Ice road construction and use, snowmobile traffic (for hunting and travel purposes) and dogsled travel (for subsistence and sport hunts).

Note:
1. Exploration and development activities during the 1970s, 1980s and 1990s are not considered in this table.
2. Activities are limited to those that are ocean-based. Aerial overflights have not been considered.

15.1.2.1 Possible Future Projects and Activities

Past and ongoing human activities have been taken into consideration as part of the program-specific effects assessment (see Section 14, Analysis of Potential Significant Environmental Effects). The cumulative effects assessment focuses on planned future projects and activities, which might include:

- Offshore petroleum exploration (seismic and drilling programs) – Chevron could be active on its EL 480 and EL 481 for the duration of the program, with seismic surveys, geological/geophysical surveys or drilling. ConocoPhillips could also be active on its Amauligak licence (EL 482), located between the Pokak and Ajurak licence areas, and in Tuktoyaktuk. Activities in these areas could include a range of surveys, development drilling and potential production.
- Seismic work – Franklin Petroleum will be undertaking a seismic program in and near EL 485 and ELs 488-491, and possibly in and near EL 492 and EL 493 between 2013 and 2015. Although there will likely be no temporal overlap of this seismic program with Imperial's proposed exploration program, seismic survey firms such as GXT ION or CGS Nopec, could do additional multi-client surveys over large parts of the Beaufort Sea. However, these are not considered reasonably foreseeable at this time.
- Port development – There is potential for a port development at Bathurst Inlet, which is located at the east end of Coronation Gulf along the southern Northwest Passage. If this port is developed, then relatively large bulk carriers (merchant vessels) in the 30,000 to 60,000 dead weight tonnage range would be transiting the Beaufort Sea (probably through the deeper offshore water) to and from Bathurst Inlet. These ships would be carrying ore concentrates to Asia-Pacific destinations or bringing in supplies (fuel, equipment, containers and modules) as back haul for constructing or maintaining mines. A port and road project has been proposed for Nunavut and is being pursued by organizations in Nunavut.

- Communications – Arctic Fibre Inc. plans on laying a fibre-optic communication cable on the seafloor between Alaska, eastern Canada and southern Greenland by 2014. It is expected that there will be no temporal overlap between Arctic Fibre Inc.'s plans and Imperial's program.
- CCG operations – Future plans include:
    - conducting scientific surveys on icebreakers, e.g., the CCGS *Louis S. St-Laurent* and the CCGS *Amundsen*
    - providing search and rescue services
    - providing sovereignty patrols
    - providing oil spill response
    - maintaining navigation aids
    - providing support to civil authority
- Cruise ships and adventure tourism – Historically, this type of tourism has included motor yachts, large and small sailing boats, Russian icebreakers acting as cruise ships and small cruise ships with ice-strengthened hulls that have transited (or want to transit) the Northwest Passage. It is likely that this kind of tourism will become more frequent in the future.
- Scientific surveys – The likely extent of research activity between 2020 and 2023 is uncertain, but current initiatives include:
    - offshore fish surveys conducted as part of the BREA initiative
    - the Woods Hole Oceanographic institute assessment of the western Arctic boundary current
    - Canada-Korea-US Beaufort Sea Research Program
- Naval operations – These are distinct from coast guard operations and could include Royal Canadian Navy operations or US Navy surface or submarine operations.
- Activities in and around Tuktoyaktuk Harbour – Yearly activities through the Mackenzie Delta channels and the nearshore waters off Richards Island and the Tuktoyaktuk Peninsula, including Tuktoyaktuk Harbour include activities during:
    - Summer – Residents from Inuvik, Aklavik and Tuktoyaktuk travel regularly through these areas. Families and hunters travel by boat to reach their fishing and whaling camps, for summer seal harvesting and to visit relatives in their bush camps.
    - Fall – These areas might be used as hunting grounds for waterfowl and later for caribou.
    - Winter – The frozen channels and the ocean on the northwestern shore south of Tuktoyaktuk in Kugmallit Bay are used for vehicle travel on ice roads. The entire nearshore area is extensively travelled by snowmobile,

15.1.2.1 Possible Future Projects and Activities (cont'd)

mostly for hunting polar bear, seal and caribou and for reaching remote traplines.

- Spring – Snowmobile traffic along the northwestern shore south of Tuktoyaktuk in Kugmallit Bay facilitates waterfowl and caribou harvest.

- Barge supply transportation – Regular barge activity in the program area involves multiple trips into Tuktoyaktuk from the Mackenzie River system from July to late September. Other regular barge resupply activities include trips from Tuktoyaktuk to Sachs Harbour, Ulukhaktok and Paulatuk from about mid to late July. Trips also take place from Tuktoyaktuk to Cambridge Bay, Kugluktuk, Gjoa Haven and Taloyak during August and September. Additional barge activities include meeting the refuelling requirements of North Warning System sites and travelling to Alaska. All barge-related activities are influenced by weather and ice conditions. Therefore, the specific routes to these locations will vary based on local conditions.

- Overflights for research purposes – DFO, the CWS and the GNWT have and will continue to conduct overflights of areas in the Beaufort Sea to assess marine mammal populations (whales and polar bears). These overflights are either low-level flights along predetermined transect lines or helicopter flights to tranquilize and radio collar polar bears. These projects usually constitute a government wildlife enhancement project and are not subject to screening under the EISC. Therefore, details are often not available in the public domain.

15.2.1 MOBILIZATION, DEMOBILIZATION AND SUPPORT

Program mobilization, demobilization and support activities could potentially result in cumulative effects. The activities that have been identified for the program (see Section 6, Summary of Proposed Development) include:

- the presence and transit of vessels to and from the offshore drill site from areas outside the Beaufort Sea and from Tuktoyaktuk
- aircraft support to and from the drill site
- transfer of supplies and consumables by support vessels and potentially by helicopters
- routine discharges from vessels

In addition, if the projects and activities previously identified in 15.1, Overview (especially oil and gas development, research surveys and port developments) occur at the same time as the program, there would be an increase in:

- vessel traffic in the Beaufort Sea
- aircraft support
- routine discharges from vessels

Aircraft support is regulated by the Transport Canada Civil Aviation and other aviation authorities. Given the program's proposed mitigation measures, adverse cumulative effects are predicted to be negligible.

Routine discharges from vessels are regulated through international maritime law including the *Canada Shipping Act*, the *Arctic Shipping Pollution Prevention Act* and the *Arctic Waters Pollution Prevention Act*. Cumulative effects from increased routine discharges are predicted to be not significant.

Effects from transferring supplies and consumables for the program will be localized and negligible, and are not expected to interact cumulatively with other projects and activities.

15.2.1.1 Legacy of Historic High Levels of Industrial Activity

If any of the previously identified projects and activities overlap temporally with the program, the increased vessel presence and traffic in the Beaufort Sea is likely to increase:

15.2.1.1 Legacy of Historic High Levels of Industrial Activity (cont'd)

- the noise levels along transit routes, mainly affecting marine mammals
- the likelihood of ship strikes for whales

However, during the 1970s and 1980s industrial traffic levels in the Canadian sector of the Beaufort Sea were high with no evidence that the beluga and bowhead whale populations had declined, but rather that both populations had increased during that period of activity. Activity during the 1970s and 1980s included:

- conducting extensive seismic exploration
- operating four to six offshore wells from drillships
- drilling from conical drilling units, single steel drilling caissons and artificial islands at the same time
- operating four icebreakers full time
- operating various other supply ships and crew boats
- operating some of the largest and noisiest offshore dredging equipment in the world

All of this activity was supplemented by large amounts of helicopter traffic to and from the drilling platforms.

It is unlikely that cumulative activities in the Beaufort Sea between 2020 and 2023 will exceed historical levels. The combined activities will likely increase the noise level in the Beaufort Sea, but it is not likely to mask animal hearing or communication. The likelihood of ship strikes might increase marginally. However, given the standard mitigation methods for vessel traffic in the Arctic, cumulative environmental effects are not predicted to be significant (see Section 16, Proposed Mitigation Measures to Address Potential Impacts).

Aircraft support for the program will increase the number of overflights in the area. This increase might affect subsistence harvest and guided sport hunts. Cumulative effects from overflights could also be observed in wildlife species near the flight pass, such as:

- polar bears
- grizzly bears
- barren-ground caribou
- birds

The EISC *Flight Altitude Guidelines*, which were designed to reduce potential effects on wildlife and bird species, will be implemented during all program-related overflights. Therefore, cumulative effects related to aircraft support are predicted to be not significant.

15.2.2 DRILLING PROGRAM

Program activities associated with offshore drilling will include:

- icebreaking and ice management
- drilling of the well and related activities
- well testing

Between 2020 and 2023, Imperial intends to drill one or more exploratory wells on either EL 476 or EL 477.

15.2.2.1 Drilling Activities

Except for icebreaking activities, the activities related to drilling and testing the well are highly localized and it is unlikely that they will interact cumulatively with other exploratory drilling taking place in the Beaufort Sea.

All activities carried out under the drilling program might temporarily interact with the atmospheric environment in a localized area. However, the short duration and localized extent of potential effects, combined with standard mitigation measures outlined in Section 16, Proposed Mitigation Measures to Address Potential Impacts, are the reasons that cumulative effects are predicted to be not significant.

15.2.2.2 Icebreaking

All drilling unit operations for the program might require icebreaking support. Icebreaking might be required:

- at the beginning and end of each drilling season
- for ice management around the drilling unit location using an ice management system

Noise from icebreaking has the potential to affect marine mammals (see Section 14.2.6, Icebreaking and Ice Management). With an increased number of offshore projects, it is likely that icebreaking activities will increase in frequency. However, with the mitigation developed for the program and because the effects of icebreaking on marine mammals would be short term, the likely cumulative effects are predicted to be not significant.

Communications with local communities and co-management organizations can establish sensitive areas and identify time frames during which icebreaking activities would need to be avoided. If standard mitigation measures (see Section 16, Proposed Mitigation Measures to Address Potential Impacts) are implemented and the use of icebreakers is reduced to the extent possible, cumulative effects on sea ice habitat are predicted to be not significant.

Late-season supply ship activity into and out of Tuktoyaktuk Harbour might require icebreaker support, which might interfere with local residents travelling by snowmobile or dogsled and the movements of some wildlife species.

15.2.2.2 Icebreaking (cont'd)

However, the likelihood of direct encounters is minimal, and efficient communications with the communities and the presence of MMOs on board the icebreaking vessels will reduce the risk of direct encounters. Consequently, cumulative effects are predicted to be not significant.

15.2.3 ONSHORE SUPPORT

Various land-based facilities and services might be required to support the offshore drilling program (see Section 6, Summary of the Proposed Development). Activities associated with onshore support include:

- preparing and operating the shore-based facility
- constructing or upgrading dock infrastructure
- dredging near the dock area and possibly in other locations within Tuktoyaktuk Harbour
- collecting, storing, transporting and disposing of waste

All these activities are likely to interact with ongoing and future projects and activities in Tuktoyaktuk. If oil and gas exploration activity increases in the Beaufort Sea, Tuktoyaktuk will likely become an active housing, staging and overwintering area supporting offshore drilling projects. Existing use of Tuktoyaktuk Harbour by the Northern Transportation Company Ltd. and the CCG would also be expected to continue and might possibly increase. The construction of the Inuvik to Tuktoyaktuk Highway might also provide new opportunities for Tuktoyaktuk Harbour. The cumulative activities are likely to have a positive economic benefit to the community of Tuktoyaktuk.

The shore-based facility preparation and operation, and waste disposal related to the program are predicted to have a negligible effect (see Section 14.2.10, Dock Construction) as are cumulative effects.

Beginning in 2016, the residual effects of possible dock construction and any potential dredging in Tuktoyaktuk Harbour are likely to interact with activities from other projects. Cumulative effects can be expected from program activities interacting with:

- local boat traffic operating for hunting and fishing purposes
- supply barges (carrying industrial and personal supplies to all ISR communities)
- tourism vessels and cruise ships
- CCG operations
- naval operations
- other industrial and oil and gas activities that need to use the harbour

If standard mitigation measures are implemented (as outlined in Section 16, Proposed Mitigation Measures to Address Potential Impacts) and an efficient communication strategy is developed to inform all other users of the Tuktoyaktuk Harbour, then the cumulative effects are predicted to be not significant.

Imperial will ensure that community consultation will be carried out with regard to mitigation related to the likely effects of these activities, including likely cumulative interactions known at the time. It is predicted that the cumulative effects of dock construction and dredging on other projects or activities will not be significant.

15.2.4 CUMULATIVE EFFECTS ON TRADITIONAL LAND AND RESOURCE USE

Traditional harvesting activities are expected to be ongoing throughout the program. To mitigate effects on traditional harvesting of resources and any cumulative effects of the program in combination with other projects and activities, Imperial has and will continue to consult with local communities. These consultations will be used to identify sensitive areas and time frames in order to reduce or avoid conflicts with traditional harvesting activities. Given that predicted cumulative effects on the harvested species are likely to be not significant, it is, therefore, unlikely that traditional harvesting will be affected.

Imperial will also implement a wildlife compensation program to compensate Inuvialuit harvesters for actual subsistence or commercial loss resulting from routine program activities.

Compensation could cover:

- damage or loss of harvesting equipment
- loss or reduction of income
- loss or reduction in wildlife harvest
- adverse changes to the quality of the harvest

15.2.5 SUMMARY OF CUMULATIVE EFFECTS

Table 15-4 is a summary of the assessed cumulative effects of the program and their predicted significance as outlined previously in this subject. Cumulative effects might occur in the LSA because of interactions between individual activities. However, the mitigation of potential impacts within the program is predicted to result in low to negligible effects. Additional mitigation is not considered to be practicable or feasible. However, the predicted minimal impact of the proposed program, in combination with past, current and reasonably foreseeable activities, is predicted to result in no significant cumulative effects (see Table 15-1, Table 15-2 and Table 15-3 shown previously).

Table 15-4: Summary of the Program's Assessed Cumulative Effects and Predicted Significance

VEC	Cumulative Effects Assessment Steps						
	STEP 1		STEP 2		STEP 3		STEP 4
	Program-Specific Effects		Possible Interaction with Other Activities		Potential Cumulative Effects		
	Predicted Residual Effects	Predicted Significance	Spatial	Temporal	Predicted Residual Effects	Predicted Significance	Additional Mitigation
Mobilization, Demobilization and Support							
Atmospheric environment	Localized elevation in noise and air emissions	Not significant	Not expected	Occasionally	None	Not significant	None
Marine avifauna	Low-level sensory disturbance, bird strikes	Not significant	Not expected	Occasionally	None	Not significant	None
Marine mammals	Low-level sensory disturbance, ship strikes	Not significant	Not expected	Occasionally	None	Not significant	None
Terrestrial wildlife	Low-level sensory disturbance, harassment	Not significant	Not expected	Occasionally	None	Not significant	None
Coastal landscapes	Changes to coastal morphology	Not significant	Not expected	Occasionally	None	Not significant	None
Traditional land and resource use	Low-level sensory disturbance, increased vessel traffic	Not significant	Not expected	Occasionally	None	Not significant	None
Drilling Program							
Atmospheric environment	Localized elevation in noise and air emissions	Not significant	Not expected	Occasionally	None	Not significant	None
Benthos	Localized disturbance of communities	Not significant	Not expected	Occasionally	None	Not significant	None

Table 15-4: Summary of the Program's Assessed Cumulative Effects and Predicted Significance (cont'd)

VEC	Cumulative Effects Assessment Steps						
	STEP 1		STEP 2		STEP 3		STEP 4
	Program-Specific Effects		Possible Interaction with Other Activities		Potential Cumulative Effects		
	Predicted Residual Effects	Predicted Significance	Spatial	Temporal	Predicted Residual Effects	Predicted Significance	Additional Mitigation
Drilling Program (cont'd)							
Marine and anadromous fish	Localized disturbance	Not significant	Not expected	Occasionally	None	Not significant	None
Marine avifauna	Localized disturbance	Not significant	Not expected	Occasionally	None	Not significant	None
Marine mammals	Low-level sensory disturbance, sea ice habitat alteration	Not significant	Not expected	Occasionally	None	Not significant	None
Terrestrial wildlife	Low-level sensory disturbance, sea ice habitat alteration	Not significant	Not expected	Occasionally	None	Not significant	None
Traditional land and resource use	Low-level sensory disturbance, sea ice alteration, increased traffic	Not significant	Not expected	Occasionally	None	Not significant	None
Onshore Support							
Atmospheric environment	Localized elevation in noise and air emissions	Not significant	Not expected	Occasionally	None	Not significant	None
Benthos	Temporary localized disturbance	Not significant	Not expected	Occasionally	None	Not significant	None
Marine and anadromous fish	Low-level sensory disturbance, disturbance to habitat	Not significant	Not expected	Occasionally	None	Not significant	None
Marine avifauna	Low-level sensory disturbance	Not significant	Not expected	Occasionally	None	Not significant	None

Table 15-4: Summary of the Program's Assessed Cumulative Effects and Predicted Significance (cont'd)

VEC	Cumulative Effects Assessment Steps						
	STEP 1		STEP 2		STEP 3		STEP 4
	Program-Specific Effects		Possible Interaction with Other Activities		Potential Cumulative Effects		
	Predicted Residual Effects	Predicted Significance	Spatial	Temporal	Predicted Residual Effects	Predicted Significance	Additional Mitigation
Onshore Support (cont'd)							
Marine mammals	Low-level sensory disturbance, disturbance to habitat, habituation to camp activities and waste, increased human–wildlife encounters	Not significant	Not expected	Occasionally	None	Not significant	None
Terrestrial wildlife	Habituation to camp activities and waste, increased human–wildlife encounters	Not significant	Not expected	Occasionally	None	Not significant	None
Traditional land and resource use	Low-level sensory disturbance, increased traffic, alteration to harbour area	Not significant	Not expected	Occasionally	None	Not significant	None

OVERVIEW

16.1.1 PURPOSE OF MITIGATION MEASURES

Mitigation measures are specific features, physical controls or management measures that are integrated into the design, construction and operation of the program. These measures are intended to avoid, minimize or alleviate potential program-related effects on the physical, biological or human environment during all phases of the program's lifecycle.

Imperial has developed mitigation measures for the program. Some of these measures were previously mentioned in Section 14, Analysis of Potential Significant Environmental Effects, as part of determining the significance of residual effects. These mitigation measures are based on comments and concerns identified through the public consultation process, industry best practice and preliminary feedback from discussions with regulators. As the program design continues to evolve, additional program-specific mitigation measures might be developed and incorporated into the design.

16.1.2 STAKEHOLDER INPUT TO MITIGATION

Input from stakeholders in ISR communities was important during the mitigation development process. Imperial is committed to ensuring that individuals who use and have cultural ties to the program area are consulted early and often about their concerns. Stakeholder comments will be considered and addressed during design, construction and operation of the program. Comments will be used to help mitigate potential effects on the physical environment, in particular the wildlife resources upon which stakeholders depend. The integration of traditional knowledge is a key component of mitigation planning. Federal, provincial and territorial regulators have and will continue to be consulted during all program phases. Imperial will look for opportunities to reduce the program's environmental footprint and is committed to continuous improvement of environmental performance.

16.2.1 PREVENTION AND MITIGATION OF ROUTINE ACTIVITIES

Some prevention measures will apply at all stages of the program's life cycle. In general, these measures are tied to best practices and use of best available technology, including:

- maintaining a continual on-site environmental compliance presence during all program phases and activities, in accordance with Imperial's OIMS and EMDC drilling's OIMS for drilling-related activities
- establishing an environmental compliance and cultural awareness training program for program personnel
- conducting permit compliance training with all employees
- conducting periodic SSHE compliance assessments

Table 16-1 lists the mitigation measures developed for the program's routine activities. These measures include best practices for oil and gas development projects that account for the unique Arctic environment. In addition to the VEC-specific mitigation measures, Imperial will develop and implement an EPP that provides specific procedures and protocols to address all program-related activities, such as site preparation, drilling, other offshore operations and transits to or from Tuktoyaktuk Harbour.

16.2.2 PREVENTION AND MITIGATION OF NON-ROUTINE EVENTS

To prevent and respond to fuel spills, Imperial will:

- maintain adequate oil spill response equipment and personnel to respond to terrestrial and marine spills
- train personnel in acceptable refuelling procedures and establish specified refuelling locations
- use secondary containment at temporary fuel storage and transfer locations, including using drip pans and liners, which will be mandatory in accordance with Imperial's policies and procedures
- implement an OSRP that covers incidents at sea and onshore, including information on:
    - spill kits (i.e., number, type, contents and location)

16.2.2 PREVENTION AND MITIGATION OF NON-ROUTINE EVENTS (cont'd)

- crew spill response training and vessel spill response certification
- spill response communication plans and contact information
- the Oil Record Book, as required under MARPOL 73/78, International Convention for the Prevention of Pollution from Ships

- implement management plans:
  - a Safety Plan
  - an IMP
  - an ERP

For information on oil spills, including a subsea release or oil drifting or moving on the surface, see section 16.3, Management Plans.

Table 16-1: Mitigation Measures for Routine Program Activities

VEC	Mitigation Measures
Coastal landscapes, including water quality and sediment quality related to dredging	• Develop and implement a comprehensive Dredging Management Plan for dredging activities that might be required alongside the dock or pier in Tuktoyaktuk Harbour at the shore-based facility, at the entrance to the harbour or along the fairway (marine resupply corridor) to deeper water offshore. This plan will include mitigation identified during a separate and comprehensive environmental assessment of dredging that Imperial will conduct, if another party does not perform the dredging and Imperial decides to perform the dredging itself. The Dredging Management Plan will include performance criteria, and incorporate suggestions and recommendations from northern residents and other stakeholders, including regulators, as appropriate. This plan will also cover selection of equipment appropriate for areas or locations that need to be dredged with minimal disturbance. • Mitigation measures include: • Accurately marking the areas to be dredged on large-scale charts before starting dredging so all dredging will take place inside the perimeter of these marked areas. This will allow for accurate vessel positioning during dredging. • Installing a silt curtain to contain or control resuspended sediments, and contribute to meeting the performance criteria developed for dredging. • Taking additional steps to prevent or limit resuspension of contaminated material if it is determined that sediment near the dock or pier at the shore-based facility is contaminated with hydrocarbons or metals from non-program operations. • Disposing of all sediment (spoil) removed during dredging at an approved offshore location in accordance with applicable regulations and permits. Spoil placement will be monitored with a measurement program that is based on the volume of material to be dredged. Samples for analysis will be collected before, during and after the spoil is placed in the disposal area. • Have a qualified environmental monitor on site during program activities. • Operate program vessels in a manner that will avoid spills to the marine environment. • Perform dredging (if required) during the marine/estuarine fisheries winter work window for the area, where practicable (i.e., July 1 to October 1 and December 1 to February 15). Subject to agreement by applicable regulatory agencies and the implementation of appropriate controls, some work might need to occur outside of these windows to accommodate the construction schedule and sequencing.

Table 16-1: Mitigation Measures for Routine Program Activities (cont'd)

VEC	Mitigation Measures
Coastal landscapes, including water quality and sediment quality related to dredging (cont'd)	• Follow best management practices for dredging operations, as applicable, as identified by the International Association of Dredging Companies and the International Finance Corporation. Additional related guideline information is also provided by the IMO London Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter (and the 1996 protocol) and the guidelines developed for the disposal of dredged materials at sea.
Marine avifauna	• Identify the areas where birds congregate (i.e., for feeding, breeding and rearing, and moulting), including protected areas or key subsistence harvesting locations or other sensitive bird habitat locations and avoid these areas where possible. • Ensure that vessels maintain operational protocols for maximum speeds and standard courses, where possible, to reduce potential bird strikes or other negative effects. Icebreaking activities at the drill site and along supply routes might require rapid changes in speed and course to respond to changing ice conditions, as necessary for safe operations. • Shield or reduce external lights at night to limit the effect of program-related light sources, where possible. • Ensure that birds that might land on vessels are left undisturbed, where practical, and provide training to program personnel on how to handle injured or resting birds. Only personnel who have a CWS handling permit would perform this task. • Establish and implement an Air Operations Plan to provide minimum operational altitudes and speeds, and other safe operating procedures and protocols (including mapping sensitive bird habitat locations along potential program flight paths) to minimize potential interactions with birds. • Conduct flaring only when necessary for well testing, in accordance with regulatory requirements and industry guidelines. • Operate all program vessels operating in Tuktoyaktuk Harbour at reduced speeds.
Marine mammals	• Implement an MMMP that includes marine mammal monitoring (to be undertaken by qualified observers) for all vessel-related activities. Establish safe vessel operations protocols (including safety perimeters, speed and course restrictions, and suspension of work requirements) to avoid marine mammals and sensitive marine mammal habitats along the marine resupply corridor route and at the drill site, whenever possible. These actions will reduce the likelihood of a vessel strike that leads to injury or mortality. • Establish and implement an Air Operations Plan to provide minimum operational altitudes and speeds and other operating procedures and protocols (including mapping locations of sensitive marine mammal habitats and locations along potential flight paths) to minimize potential interactions with marine mammals. This plan will cover inbound and outbound fixed-wing aircraft and helicopter operations carrying passengers or cargo or from the fleet offshore. • Establish and implement an ERP that provides procedures and protocols for addressing all accidents, spills or items of a similar nature to ensure that appropriate measures are in place to mitigate the potential effects of an accidental release or malfunction affecting marine mammals, including follow-up protocols to investigate and determine root causes and identify lessons learned. • Develop and implement a program-specific Polar Bear Interaction and Management Plan that includes procedures and protocols for polar bear interactions.
Offshore water quality and sediment quality during drilling	• If ballast water discharge were required, it would be governed by a Ballast Water Management Plan that will be developed and implemented for program vessels. The plan would be developed and implemented in accordance with the IMO convention on exchange of ballast water and associated sediment. • Separate drilling fluid from cuttings during drilling operations. The cleaned or washed cuttings will be placed in a designated area on the seafloor by pumping them down a delivery system below the sea surface. Residual fluid on the separated cuttings will be measured as part of the disposal process. As part of the Environmental Effects

Table 16-1: Mitigation Measures for Routine Program Activities (cont'd)

VEC	Mitigation Measures
Offshore water quality and sediment quality during drilling (cont'd)	Monitoring Plan, a seafloor sampling program will be developed to monitor the dispersal and distribution of cuttings on the seafloor and the effects of burial on the benthic community in the affected area. • Develop and implement a program-specific WMP in accordance with the NEB's *Offshore Waste Treatment Guidelines* and other federal regulations or guidelines that apply in Canadian waters, and federal or territorial regulations or guidelines that apply onshore. • Maintain records of all program-related discharges. • Provide program personnel with opportunities for continuous improvement and training in the handling and disposal of waste in compliance with Imperial's OIMS requirements and EMDC drilling's OIMS for drilling-related activities.
Traditional land and resource use	• Ensure that the information collected during the traditional knowledge process is incorporated into the program design and operations. Continue the public consultation process to identify any new areas of significance or historical importance, ensuring that community confidentiality is maintained during the reporting process. • Implement a wildlife compensation program that would cover damages or loss of equipment, loss or reduction of income, loss or reduction of wildlife harvest and any adverse changes to the quality of the harvest. Compensation could include relocation or replacement costs for equipment, provision of wildlife products or a cash settlement. • Prohibit hunting by program personnel. Provide cultural resource sensitivity training and traditional harvesting sensitivity training to program personnel, as required. Imperial will consult with communities about who should be trained, when the training should happen, and how HTC members or other residents will be part of this process. • Minimize potential program effects on traditional land use and harvesting activities by avoiding sensitive locations and ensuring that operations are timed to limit any potential overlap with traditional harvesting activities or land use. • Avoid all areas identified as being of archaeological or cultural significance along the shoreline at, or near, the entrance to Tuktoyaktuk Harbour. It is unlikely that new traditional resources will be discovered by program personnel, but if this occurs, the appropriate authorities will be notified immediately. • Establish and implement a Northern Communications Plan for the program to communicate and inform local communities of program-related developments, ensuring a flow of information to the communities in a timely and efficient manner. This plan will include a process for liaising with the HTC in Tuktoyaktuk and HTCs in other communities, as required. Avoid scheduling public meetings and information sharing sessions at times when community members are hunting, fishing or engaged in other harvesting activities.
Terrestrial wildlife	• Establish vessel and aircraft operations routes and schedules designed to minimize wildlife disturbance. • Establish and enforce vehicle and vessel speed limits within the program area. • Institute a no hunting policy for program personnel. • Prepare and implement a Wildlife Interaction Plan and a program-specific Polar Bear Interaction and Management Plan. The Wildlife Interaction Plan will provide measures to address potential interactions with terrestrial wildlife at the shore-based facility and encounters with marine mammals and birds within the proposed marine resupply corridor and the EL areas. • Design and operate the shore-based facility to reduce effects on wildlife, marine seabirds and mammals, including effects related to nesting or denning sites. • Ensure that all program-related waste is disposed of properly and in accordance with regulatory requirements and industry best practice, including using wildlife-proof waste collection containers. Waste will be stored at the shore-based facility pending disposal at an approved facility. • Prohibit feeding wildlife.

16.3.1 ACCOUNTABILITY

Imperial and ExxonMobil will fill key management and technical positions with qualified personnel experienced for the proposed Arctic and offshore operations. These personnel would have the authority and responsibility to make decisions that ensure operations are performed in a safe and environmentally responsible manner. Imperial will take responsibility and oversight of their contractors' actions and activities.

In the unlikely event of an incident that could affect the livelihood of local residents, damage to the environment or Inuvialuit culture and lifestyle, Imperial's solid financial status and the compensation procedures it has in place, including fair and timely wildlife compensation, would ensure:

- appropriate compensation for individuals or local businesses
- restoration of the environment as quickly as possible

16.3.2 OPERATIONS INTEGRITY MANAGEMENT SYSTEM

16.3.2.1 Scope

Management plans are documents that detail Imperial's and ExxonMobil's commitments to excellence in safety and environmental management and will describe how Imperial would conduct its operations in the Beaufort Sea.

Imperial recognizes the unique challenges of operating in the Arctic and will ensure that its policies, practices and plans are executed to conduct its business in the Arctic safely and responsibly, in compliance with all applicable laws and regulations.

In conjunction with Imperial's OIMS and EMDC drilling's OIMS for drilling-related activities, a series of management plans will form the basis for the execution of the exploration program and associated activities, including:

- a bridging document to EMDC drilling's OIMS
- a Safety Plan
- an EPP
- a WMP
- an IMP
- an ERP, which might include an OSRP, if not provided in a separate document

16.3.2.1 Scope (cont'd)

- a Regulatory Compliance Plan
- an Environmental Effects Monitoring Plan

16.3.2.2 Operations Integrity Management System Framework

In the late 1980s, ExxonMobil initiated a full-scale, top-to-bottom review of its operations. The result was the creation of a new systematic and disciplined framework to manage and measure SSHE risks from global operations, built on the international expertise of ExxonMobil's affiliated companies. This framework is called OIMS. It establishes common expectations for addressing inherent risks and is applicable to every significant operation that ExxonMobil undertakes globally, including drilling. Each ExxonMobil affiliated company used the comprehensive OIMS to develop its own version of the system that considered its areas of operation, types of business and operations. Accordingly, EMDC also has a drilling-specific version of the OIMS. The EMDC drilling OIMS governs the specific work activities and designs required for safe drilling.

Each OIMS includes the following eleven elements:

1. Management leadership, commitment and accountability
2. Risk assessment and management
3. Facilities design and construction
4. Information and documentation
5. Personnel and training
6. Operations and maintenance
7. Management of change
8. Third-party services
9. Incident investigation and analysis
10. Community awareness and emergency preparedness
11. Operations integrity assessment and improvement

The OIMS guides the activities of employees and third-party contractors involved in operations. The management system is embedded in everyday work processes, and employees and contractors are required to be knowledgeable and compliant with OIMS as it pertains to their responsibilities.

In accordance with OIMS requirements, Imperial and ExxonMobil have developed and implemented an OIMS bridging document for the Beaufort Sea exploration drilling program. The bridging document describes Imperial's and ExxonMobil's roles and responsibilities in operating the exploration work in a safe and environmentally responsible manner.

16.3.3 SAFETY PLAN

16.3.3.1 Imperial's Safety Culture and Commitment

The safety of people (Imperial's workforce and the public) is integral to Imperial's operations and activities. Imperial's commitment to a culture of safety guides the conduct of every individual associated with Imperial's operations, whether employees, contractors or others working on behalf of Imperial, each person is responsible and accountable for safe performance on the job.

Imperial is committed to making continuous efforts to identify and eliminate or manage safety risks associated with its activities. With its long history of safe and responsible operations in the North, beginning in 1920 at Norman Wells, Imperial will continue to use proven safety practices in the execution of the exploration program.

The contents of the program's Safety Plan will incorporate the lessons learned from the NEB's AODR, including:

- Imperial's safety policy, which is a part of Imperial's management system and core values that establish the basic principles for the work to be conducted
- procedures for the safe movement of supply vessels to:
    - reduce the potential effects on ISR residents' travels over water or ice, as a result of vessel movements in Tuktoyaktuk Harbour and its marine approaches
    - ensure that supply vessels near whale harvesting areas do not interfere with whale-harvesting boats or activities
- procedures for the safe transport of personnel between the drilling unit and the shore-based facility by aircraft or supply vessel, and during ground transport at Tuktoyaktuk
- a process for documenting incidents or near misses and for providing feedback to make safety improvements during the execution of the exploration program

Specific to the drilling program, to ensure the safety of personnel working on the ice, Inuvialuit wildlife monitors would be employed to reduce interactions with wildlife.

16.3.4 ENVIRONMENTAL PROTECTION PLAN

16.3.4.1 Purpose

The EPP will describe the activities required to protect the environment from potential adverse effects resulting from the exploration program. In developing the EPP, the effects on socio-economic and cultural conditions resulting from a change in the environment caused by program activities will also be considered.

16.3.4.2 Scope

The contents of the program's EPP will include:

16.3.4.2 Scope (cont'd)

- identification of key specific social-cultural activities that might be affected by the drilling program
- mitigation measures to protect wildlife and wildlife harvesting activities, including key species such as beluga whales, polar bears and seals, and fisheries in Tuktoyaktuk Harbour and coastal waterfowl hunting
- traditional and scientific knowledge that could be used to develop mitigation measures
- aircraft flight plan rules to avoid coastal whaling and fishing camps, based on the EISC *Flight Altitude Guidelines*
- plans to reduce air emissions from vessels and shore-based activities
- plans to reduce noise and light from offshore vessels
- procedures for the selection and use of chemical substances, including drilling fluid components, with reference to the NEB's *Offshore Chemical Selection Guidelines for Drilling Activities on Frontier Lands*
- procedures for handling requests for compensation, in the event that program activities have an effect on wildlife or harvesting country foods
- procedures to ensure that the EPP is implemented and work is conducted to meet regulatory requirements

16.3.5 WASTE MANAGEMENT PLAN

16.3.5.1 Purpose

The WMP will describe the types of waste that could be generated during drilling program activities and the means by which waste would be managed. Figure 16-1 is a flowchart documenting waste management.

16.3.5.2 Scope

The program's WMP will include:

- a list of all applicable federal and international requirements
- a description of all waste products generated during operations, including storage, estimated volumes, treatment methods, handling and final disposal options
- opportunities for eliminating, reducing or recycling waste
- identification of best practices and technologies to be considered for waste management
- procedures for documenting and tracking waste through its life cycle

- sampling and analysis practices to ensure regulatory compliance with any requirements for discharging waste
- documentation showing that the WMP was developed in accordance with the NEB's *Offshore Waste Treatment Guidelines*

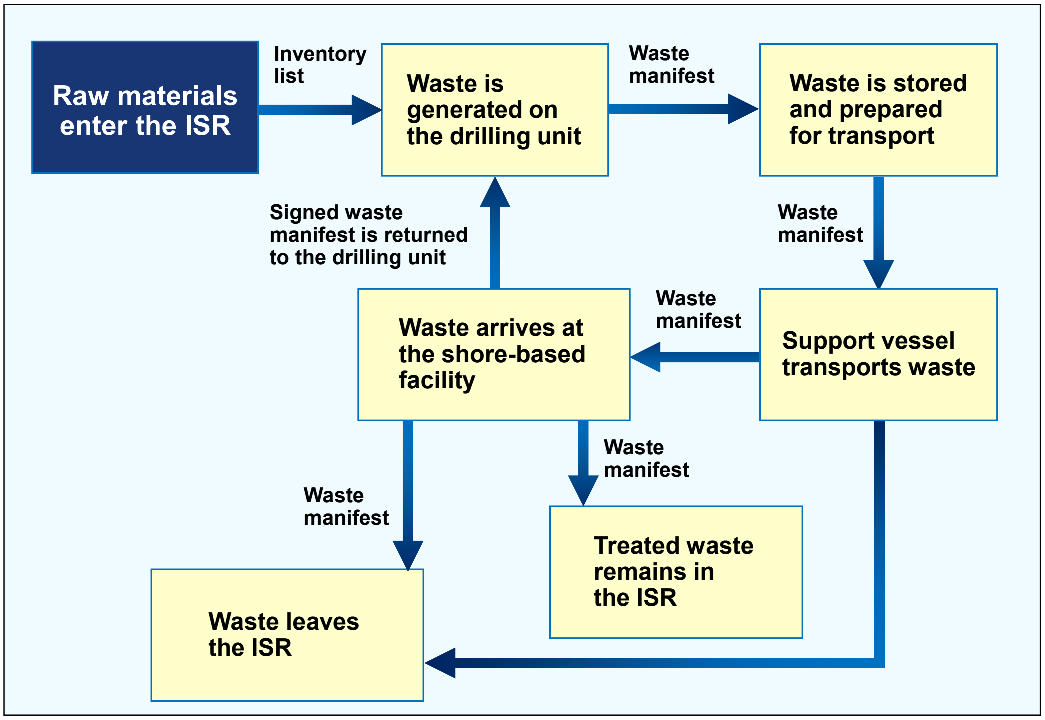


Figure 16-1: Waste Management Flowchart

16.3.6 ICE MANAGEMENT PLAN

16.3.6.1 Purpose

The IMP is an integral component of the exploration program execution and will describe the means by which the drilling unit operations would be safeguarded from ice.

16.3.6.2 Scope

The plan is to operate the drilling unit within ice conditions for which it has been designed. If ice is encountered that is beyond the drilling unit's design capabilities, then an IMP would provide the drilling unit's staff with suitable operational conditions.

The IMP will describe the process for monitoring and mitigating incoming ice to protect the drilling unit and personnel on board. The IMP will ensure that, if an ice hazard is approaching the drilling unit and the ice cannot be diverted or broken up, then the drilling unit would have sufficient time to secure the well and move off location.

16.3.6.2 Scope (cont'd)

The IMP will provide an ice hazard watch circle system that would be used to avoid ice hazards, allowing the drilling unit to safely stay on location and drill the well to the target depth. The ice hazard watch circle system uses a series of coloured circles (green, yellow, red) to monitor the degree of ice hazards in proximity to the drilling unit (see Figure 16-2). A yellow watch circle warning would occur days in advance of the ice incursion arriving at the drilling site, initiating a controlled disconnect from the well. While the well is being secured, the icebreakers would be trying to break up or divert the ice from entering the red watch circle. If an ice hazard enters the red watch circle, then the drilling unit would be disconnected from the wellhead and proceed to move off location. The decision to suspend the well and disconnect (i.e., controlled or emergency) will be based on a combination of factors, including:

- drilling unit design
- the weather forecast
- ice conditions in the area, ranging from 0/10 tenths to 10/10 tenths (some ice will usually be present near the drilling site)
- the type of ice in the area (i.e., first-year ice to multi-year ice)

The IMP will also identify the options for an ice management fleet to ensure safe operating conditions for the drilling unit during all seasonal ice conditions. The ice management fleet would be capable of:

- managing incoming ice, breaking it down to a target size and controlling the concentration of ice in the water
- accommodating a high degree of variability in the ice conditions from one year to another

An IMP will be prepared based on historical ice floe trends and measured data in the operating areas during the year of operation and would consider:

- ice conditions during entry into and exit from the Beaufort Sea
- icebreaking procedures to ensure that ice incursions that could potentially damage the drilling unit do not enter the yellow watch circle
- the drilling unit's design ability to withstand the impact of a specific size of ice incursion. If an ice incursion of greater size enters the yellow watch circle, then operations would cease and the wellbore would be secured.
- temporary locations offering protection for vessels that are forced to leave the drill site as a result of extreme weather or ice conditions

The number and type of icebreakers required would be described in the IMP.

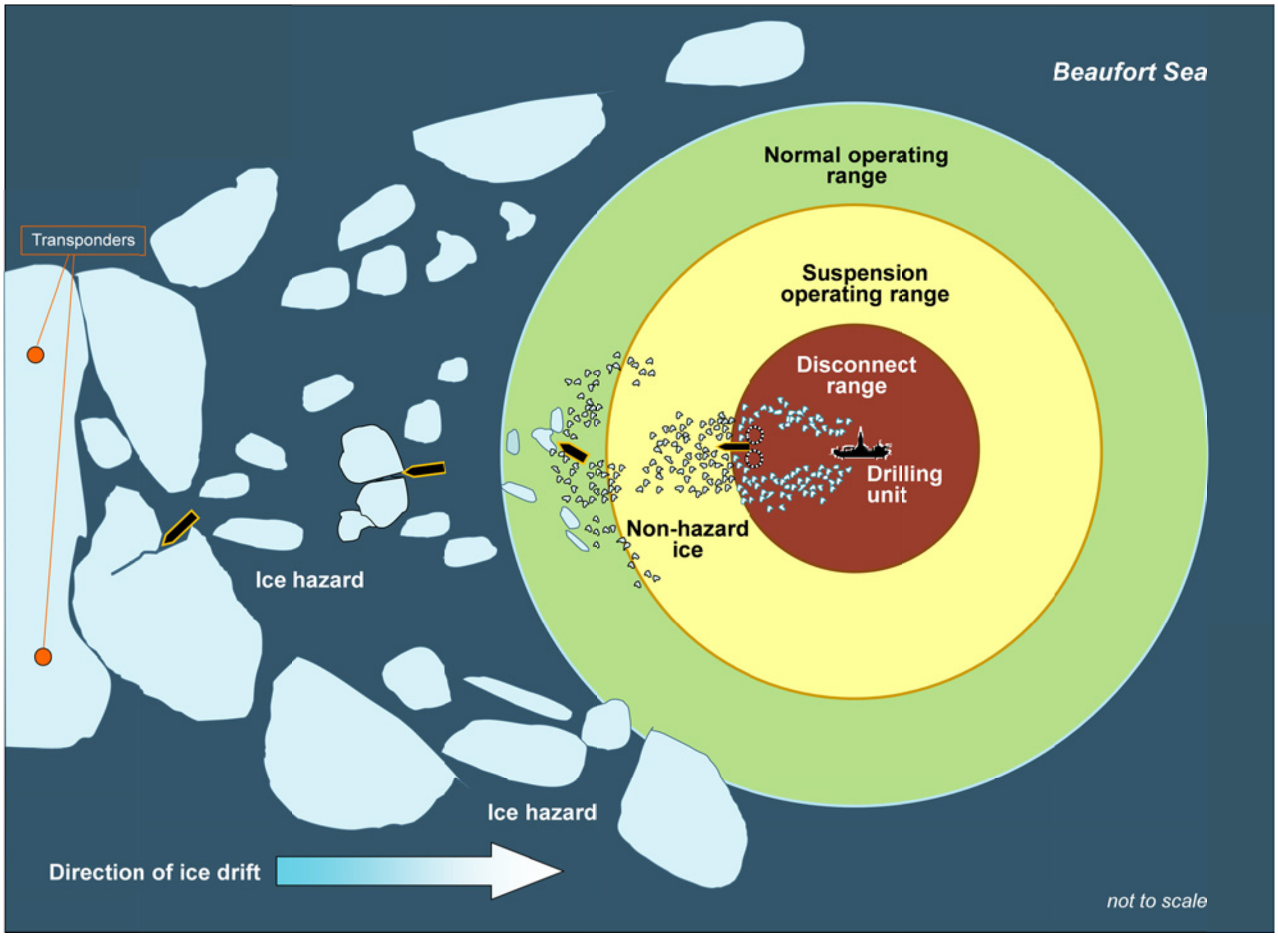


Figure 16-2: Ice Hazard Watch Circle System – Range from Drilling Unit

16.3.6.3 Ice Surveillance

Ice forecasting, as a part of the IMP, would use data from various sources, such as satellite images and on-board ice radar, to predict ice-drift vectors and develop operating sectors for the icebreakers. Ice monitoring could also use transponders placed on ice floes to monitor ice drift.

16.3.7 EMERGENCY RESPONSE PLAN

16.3.7.1 Purpose

The ERP will describe Imperial's procedures for responding to a range of emergency situations, including:

- an aircraft or vessel in distress
- an emergency in the air or on a vessel
- a medical situation requiring an emergency evacuation
- a fire on board a vessel

16.3.7.2 Scope

A typical ERP would include:

- a description of response priorities – a description of safety steps (i.e., protection of personnel, the environment and property)
- a description of the response organization, including information on:
  - guiding principles for command and control (chain of command)
  - the response organization
  - the incident command system
- a description of initial response requirements, including:
  - first-on-scene checklists for responders
  - requirements for internal and external reporting and notification
- response operating procedures and options, including:
  - a description of general and site-specific emergency response procedures
  - spill response procedures and details of specific selected strategies, i.e., offshore containment and recovery, shoreline cleanup, in situ burning, application of dispersant (both surface and possibly subsurface), transfer and storage of collected materials, disposal and decontamination
  - spill monitoring, tracking and sampling
- site-specific information, including information on the onshore and offshore logistics and infrastructure, location of the well or wells and staging sites for emergency response
- a resource inventory, including identifying:
  - the location of trained personnel, emergency transport (e.g., helicopters) and response equipment (e.g., fire control gear, spill containment equipment)
  - on-site equipment and location of shore-based equipment caches
- information about mutual aid, including:
  - identifying providers of third-party mutual-aid support that could assist with various incidents, if required
  - providing contact lists for mutual aid, protocols for assistance, inventory of response equipment available (e.g., fire control gear, spill containment equipment) and trained personnel
- the role of government agencies, including:
  - a description of the activities of government agencies as part of an incident response (e.g., the NEB, CCG, AANDC, EC, DFO)

- links to government groups and agencies, such as the Arctic Regional Environmental Emergency Team
- the role of Inuvialuit organizations

16.3.7.3 Oil Spill Response

The OSRP might be part of the ERP or covered in a separate document. In addition, each vessel would have its own Shipboard Oil Pollution Emergency Plan, as required by international and Canadian laws.

If an incident involving a spill occurs during Imperial's operations, Imperial would coordinate the response under its incident command structure. In most circumstances Imperial would communicate with the NEB in its role as the lead federal agency responsible for responding to a spill from a drilling platform. The NEB would coordinate the actions of federal and territorial agencies.

If a spill originated from a vessel, the CCG would be involved.

Oil spill response planning includes identifying worst-case scenarios and preparing for a response to such events.

Figure 16-3 is an example of a typical incident command structure for coordinating a spill response.

16.3.8 REGULATORY COMPLIANCE PLAN

16.3.8.1 Purpose

All applicable regulatory requirements, conditions and commitments made by Imperial during the environmental impact assessment and the regulatory approvals process would be documented in a Regulatory Compliance Plan, with measures in place to ensure that Imperial complies with the requirements. In the event that there were any occurrences of non-compliance, Imperial would take action to correct the problem and measures would be implemented to prevent a recurrence.

16.3.8.2 Scope

The program's Regulatory Compliance Plan will include:

- a list of applicable federal and territorial regulatory requirements
- a list of the NEB's OA and WA conditions for drilling
- other approval conditions
- a list of Imperial's commitments
- procedures to ensure that Imperial is meeting its regulatory requirements
- procedures for responding to any non-compliance situation

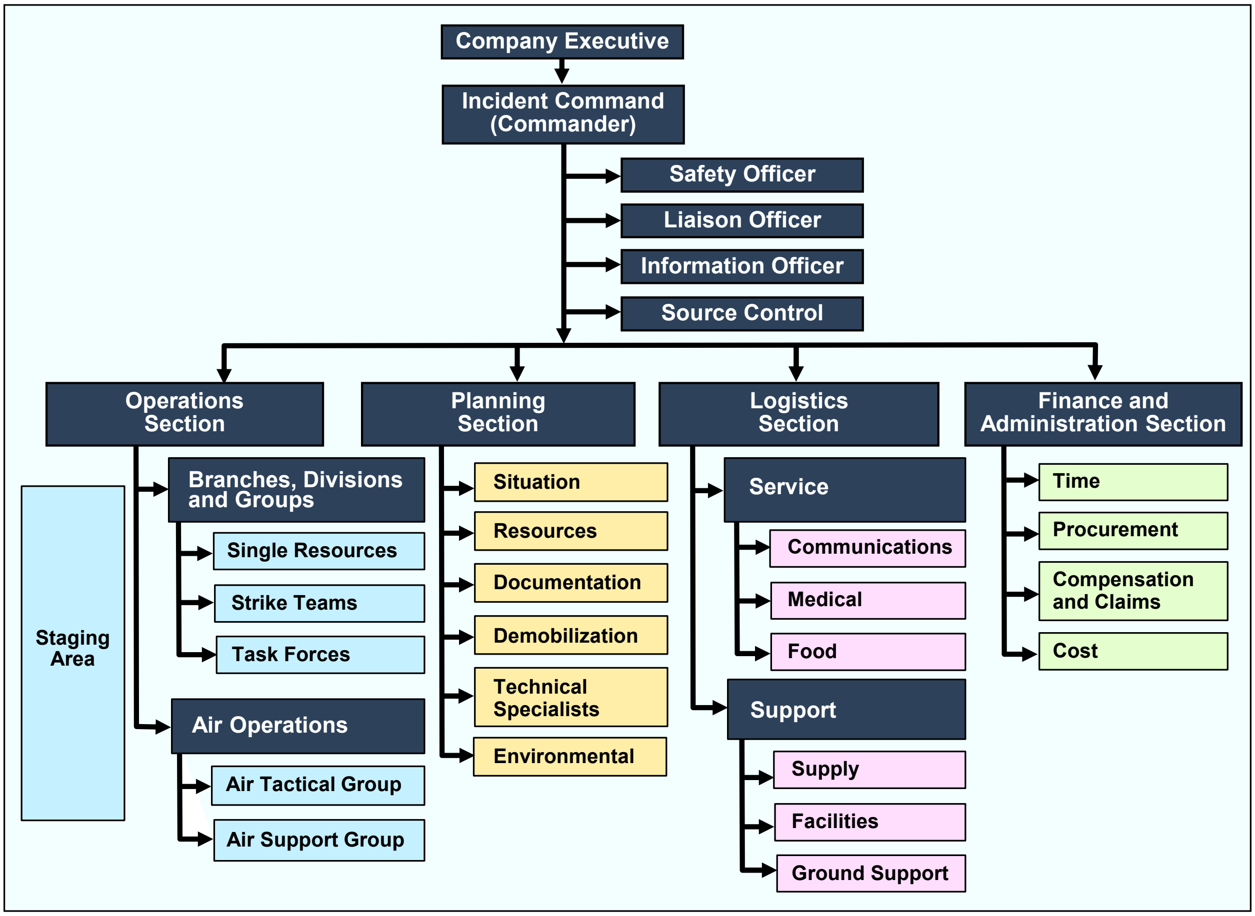


Figure 16-3: Typical Incident Command Structure for Spill Response

16.3.9 ENVIRONMENTAL EFFECTS MONITORING PLAN

16.3.9.1 Purpose

The Environmental Effects Monitoring Plan will document the effectiveness of Imperial's mitigation measures as described in the EPP. Effects that result from program activities would be compared to background or baseline conditions.

16.3.9.2 Scope

The program's Environmental Effects Monitoring Plan will be designed to monitor operations for effects on the environment or on Inuvialuit harvesting activities. For example, activities such as marine discharges of treated drill cuttings or dredging that might be required in Tuktoyaktuk Harbour would be monitored. The monitoring plan would include follow-up procedures to respond to reports of disruption of traditional activities, for example, on wildlife harvesting or effects on country foods.

If a spill incident resulted from drilling activity, either from a vessel or at the shore-based facility in Tuktoyaktuk, the monitoring program would provide for immediate assessment of any environmental effects and determine the best options for spill response by applying a NEBA.

Inuvialuit environmental monitors would be particularly well-qualified to record and observe wildlife near the drilling and icebreaking operations.

17.1.1 REGULATORY REQUIREMENTS

For offshore activities, Imperial will meet all applicable regulations and terms and conditions of its permits and approvals concerning final cleanup and decommissioning of its operations.

Final well abandonment procedures will be described as part of the WA submission to the NEB, as detailed in the *Filing Requirements for Offshore Drilling in the Canadian Arctic, Section 5.17, Well Suspension and Abandonment Program*.

17.1.2 CLEANUP AND RECLAMATION

The base case for the program is to leave the wellhead on the seafloor to provide an additional protective barrier. However, Imperial will make a final decision on whether to leave the wellhead on the seafloor or cut the surface casing off below the seafloor and separate and recover the wellhead.

If anchors were used for a moored drilling unit, they will either be retrieved or left on the seafloor. All other subsea equipment (e.g., guide base and pingers) will be recovered.

Most of the monitoring equipment placed on the ice as part of the ice management program will not be retrieved.

No surface evidence (e.g., tethered buoys) will remain at the well site after program completion.

17.1.3 DISPOSAL

Waste will be documented and tracked in accordance with the WMP developed for the program. The plan would cover all aspects of waste management from generation to final disposal.

17.1.3.1 Drilling Waste and Fluid

For the top hole and shallow sections of the well, water-based drill cuttings will be discharged onto the seafloor next to the well site. Drill cuttings that have been treated with NADF will be discharged from the drilling unit in accordance with the NEB's *Offshore Waste Treatment Guidelines*. These cuttings will be

17.1.3.1 Drilling Waste and Fluid (cont'd)

dispersed into the water column to settle on the seafloor in small concentrations over a large area down current from the well site.

When drilling is complete, any remaining drilling fluids will be contained on the drilling unit or supply vessels and transported out of the licence area (i.e., there will be no batch dumping of drilling fluids).

17.1.3.2 Domestic and Other Waste

Human and food waste from each vessel will be macerated before being discharged, as required by international ship conventions.

Other liquid and solid waste generated on vessels while offshore will be shipped to the shore-based facility for disposal or stored on board a wareship for shipment out of the licence areas.

17.1.4 DECOMMISSIONING

It is not expected that further offshore monitoring of the abandoned well site will be required.

17.2.1 REGULATORY REQUIREMENTS

For shore-based activities, Imperial will meet all applicable regulations and terms and conditions of its permits and approvals concerning final cleanup and decommissioning of its operations.

17.2.2 CLEANUP AND RECLAMATION

Once the program is complete, the contracted shore-based facility will be handed over to the facility owner, in accordance with the terms and conditions of the facility contract. This would likely include cleanup of the facility and any temporary or permanent facility construction or upgrades.

Unused materials, fuel and consumables will be removed from the shore-based facility and transported out of the region, unless other local uses are identified or ownership is explicitly transferred.

Any equipment or materials stockpiled or remaining in Inuvik or other locations in the ISR will be removed from the region unless a local use, legacy or new ownership is identified.

17.2.3 DISPOSAL

Waste will be documented and tracked in accordance with the program’s WMP. The plan will cover all aspects of waste management from generation to final disposal.

17.2.3.1 Waste Collection

Any waste received from offshore vessels will be appropriately identified and stored at the shore-based facility pending disposal. All waste collected at the shore-based facility will be transported, treated and disposed of at either an approved disposal site in the ISR, the NWT or further south.

Comingling of certain inert waste from the program, such as wood or pig iron, into the Tuktoyaktuk landfill will only be considered with the express permission of the government agency responsible for the management of the waste facility.

17.2.3.2 Dredging Waste

To allow shallow-draft supply vessels access to the shore-based facility, dredging might be required in some parts of Tuktoyaktuk Harbour, its entrance and near

17.2.3.2 Dredging Waste (cont'd)

the shore-based facility dock area. If dredging is required, a comprehensive assessment will be conducted to determine the most responsible method of disposing of dredging spoils, considering the environment and human health.

17.2.4 DECOMMISSIONING

The contractor for the shore-based facility will be expected to have developed a Decommissioning Plan for temporary or permanent facilities, where required by:

- the Hamlet of Tuktoyaktuk
- Inuvialuit organizations (e.g., co-management boards, such as the Inuvialuit Land Administration)
- the GNWT
- federal authorities, such as TC concerning navigable water requirements

The proposed development described in Section 6 of this Project Description has not been subject to a previous environmental assessment.

REFERENCES

Aboriginal Affairs and Northern Development Canada (AANDC). 2012. Peary Caribou - Background Information on Valued Components of the PEMT (Beaufort Sea and Mackenzie Delta). Available at: http://www.aadnc-aandc.gc.ca/eng/1315503716972/1315578195068. Accessed on April, 2013.

AECOM. 2010. Beaufort Sea Petroleum and Environmental Management Tool (PEMT). Prepared for Indian and Northern Affairs Canada. March 2010.

Aklavik (The Community of Aklavik, the Wildlife Management Council (NWT) and the Joint Secretariat). 2008. Aklavik Inuvialuit Community Conservation Plan/Akaqvikmiut Nunamikini Nunutailivikautinich: A plan for the conservation and management of natural resources and lands within the Inuvialuit Settlement Region in the vicinity of Aklavik, Northwest Territories. June 2008.

Aksenov, Y., V. V. Ivanov, A. J. G. Nurser, S. Bacon, I. V. Polyakov, A. C. Coward, A. C. Naveira-Garabato, and A. Beszczynska-Moeller. 2011. The Arctic Circumpolar Boundary Current, J. Geophys. Res., 116, C09017, doi: 10.1029/2010JC006637.

Alexander, S. A., D. L. Dickson, and S. E. Westover. 1997. Spring migration of eiders and other waterbirds in offshore areas of the western Arctic. In: Dickson, D. L., ed. King and common eiders of the western Canadian Arctic. Occasional Paper No. 94. Ottawa: Canadian Wildlife Service. 6-20.

Alexander, S. A., T. W. Barry, D. L. Dickson, H. D. Prus, and K. E. Smyth. 1988. Key areas for birds in coastal regions of the Canadian Beaufort Sea. Environment Canada. Canadian Wildlife Service. Edmonton, AB.

Allen, B. M., and R. P. Angliss. 2010. Polar Bear (*Ursus maritimus*): Southern Beaufort Sea Stock. Alaska Marine Mammal Stock Assessments, 2009. Revised January 1, 2010. NOAA Technical Memorandum – Alaska Fish and Wildlife Service 206. 9 pp.

Allen, B. M., and R. P. Angliss. 2011a. Beluga whale (*Delphinapterus leucas*): Beaufort Sea stock. In Alaska Marine Mammal Stock Assessments, 2011. NOAA-TM-AFSC-234 (Revised December 28, 2010).

Allen, B. M., and R. P. Angliss. 2011b. Ringed seal (*Phoca hispida hispida*): Alaska stock. Alaska Marine Mammal Stock Assessments. NOAA-TM-AFSC-234 (Revised December 23, 2010).

Allen, B. M., and R. P. Angliss. 2012. Bowhead whale (*Balaena mysticetus*): Western Arctic stock. Alaska Marine Mammal Stock Assessments. NOAA-TM-AFSC-245 (Revised November 17, 2011).

Alliston, W. G. 1980. The distribution of ringed seal in relation to winter icebreaking activities near Mckinley Bay, NT. January-June 1980. LGL Ltd. unpubl. rep. prepared for Dome Petroleum Ltd., Calgary, AB. 52 pp.

AMAP (Arctic Monitoring and Assessment Programme). 1998. AMAP Assessment Report: Arctic Pollution Issues. Arctic Council, Oslo, Norway. xii + 859 pp.

AMAP. 2006. AMAP Assessment 2006: Acidifying Pollutants, Arctic Haze, and Acidification in the Arctic. Arctic Council, Oslo, Norway. xii + 112 pp. Available at: http://www.amap.no/.

AMAP. 2007. AMAP Assessment 2007: Oil and Gas Activities in the Arctic: Effects and Potential Effects. Arctic Council, Oslo, Norway. Available at: http://www.amap.no/oga/.

Amstrup, S. C., and C. L. Gardner. 1994. Polar bear maternity denning in the Beaufort Sea. Journal of Wildlife Management, 58(1):1-10.

Amstrup, S. C., B. G. Marcot, and D. C. Douglas. 2007. Forecasting the range-wide status of polar bears at selected times in the 21st Century. U.S. Geological Survey, Alaska Science Center, Administrative Report. 126 pp.

Amstrup, S. C., G. M. Durner, I. Stirling, N. J. Lunn, and F. Messier. 2000. Movements and distribution of polar bears in the Beaufort Sea. Canadian Journal of Zoology 78(6):948-966.

Anderson Resources Ltd. 2001. Project description for the proposed Anderson Resources Ltd. Summer 2001/2002 marine seismic program. Report prepared by Inuvialuit Environmental and Geotechnical Inc., Calgary, AB, and Inuvik, NT.

Anisimov, O. A., D. G. Vaughan, T. V. Callaghan, C. Furgal, H. Marchant, T. D. Prowse, H. Vilhjálmsson, and J. E. Walsh. 2007. Polar Regions (Arctic and Antarctic). In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson (eds). Cambridge University Press. Cambridge, United Kingdom and New York, NY, USA. 653–685.

Arctic Laboratories Ltd and LGL Ltd. 1987. Beaufort Sea Ocean Dumpsite Characterization. Prepared by Arctic laboratories Ltd and LGL. Limited for Environment Canada, Yellowknife, NT. 100 p + appendices. ArcticNet 2011. Beaufort Regional Environmental Assessment (BRWA). Data Mining Project. 39 pp.

ArcticNet 2011. Beaufort Regional Environmental Assessment (BREA). Data Mining Project. 39 pp.

Ardyna, M., M. Gosselin, C. Michel, M. Poulin, and J.-É.Tremblay. 2011. Environmental forcing of phytoplankton community structure and function in the Canadian High Arctic: contrasting oligotrophic and eutrophic regions. Marine Ecology Progress Series, 442, 37-57.

Arrigo, K. R., D. K. Perovich, R. S. Pickart, Z. W. Brown, G. L. van Dijken, K. E. Lowry, M. M. Mills, M. A. Palmer, W. M. Balch, F. Bahr, N. R. Bates, C. Benitez-Nelson, B. Bowler, E. Brownlee, J. K. Ehn, K. E. Frey, R. Garley, S. R. Laney, L. Lubelczyk, J. Mathis, A. Matsuoka, B. G. Mitchell, G. W. K. Moore, E. Ortega-Retuerta, S. Pal, C. M. Polashenski, R. A. Reynolds, B. Scheiber, H. M. Sosik, M. Stephens, and J. H. Swift. Massive phytoplankton blooms under Arctic sea ice. Science, 336 (6087):1408. doi: 10.1126/science.1215065 (2012).

Asplin, M. G., J. V. Lukovich, and D. G. Barber. 2009. Atmospheric forcing of the Beaufort Sea ice gyre: Surface pressure climatology and sea ice motion. Geophysical Research Letters, 114, C00A06, 13 p.

Asplin, M. G., R. Galley, D. G. Barber, and S. Prinsenberg. 2012. Fracture of summer perennial sea ice by ocean swell as a result of Arctic storms, J. Geophys. Res., 117, C06025, doi: 10.1029/2011JC007221.

Asselin, N., D. G. Barber, I. Stirling, S. H. Ferguson, and P. R. Richard. 2011. Beluga (*Delphinapterus leucas*) habitat selection in the eastern Beaufort Sea in spring, 1975-1979. Polar Biol. 34:1973-1988.

Atkinson, D. E. 2005. Observed Storminess Patterns and Trends in the Circum-Arctic Coastal Regime. Geo-Marine Letters 25:98–109.

Atkinson, E. G., and J. W. Wacasey. 1989. Benthic invertebrates collected from the Western Canadian Arctic. Canadian Data Report of Fisheries and Aquatic Sciences. 745: iv + 132 p.

Au, W. W. L., D. A. Carder, R. H. Penner, and B. L. Scronce. 1985. Demonstration of adaptation in beluga whale echolocation signal. J. Acoust. Soc. Am. 77(2):726-730.

Avery, M. L., P. F. Springer, and N. S. Dailey. 1978. Avian Mortality at Man-made Structures: An Annotated Bibliography. FWS/OBS-78/58. Washington, DC.

Awbrey, F. T., J. A. Thomas, and R. A. Kastelein. 1988. Low frequency underwater hearing sensitivity in belugas, *Delphinapterus leucas*. J. Acoust. Soc. Am. 84(6):2273-2275.

Aylsworth, J. M., and A. Duk-Rodkin. 1997. Landslides and permafrost in the Mackenzie Valley. In Mackenzie basin impact study: final report. Edited by S. J. Cohen. Environmental Adaptation Research Group, Environment Canada. p. 117-121.

Barber, D. 2012. Comments and Presentation at the Beaufort Regional Environmental Assessment (BREA) Climate Change Workshop, Inuvik, NT. November 19-21, 2012. Pers. Comm.

Barber, D. G., J. V. Lukovich, J. Keogak, S. Baryluk, L. Fortier, and G. Henry. 2008. The changing climate of the Arctic. Arctic 61 (suppl. 1). p. 7-26.

Barber, D. G., K. Hochheim, G. McCullough, D. Babb, A. Crawford, A. Komarov, J. Lukovich, and M. Asplin. 2013. “An Integrated Sea Ice Project for BREA: Detection, Motion and RADARSAT Mapping of Extreme Ice Features in the Southern Beaufort Sea [and] Community Based Monitoring”. Presented at: Beaufort Regional Environmental Assessment (BREA) Results Forum. February 19-21, Inuvik, NT.

Barry, T. W. 1976. Seabirds of the Southeastern Beaufort Sea: Summary report. Technical Report No. 3A, Beaufort Sea Project, Department of the Environment, Victoria, BC. 41 pp.

Beaufort Sea Steering Committee. 1991. Report by Task Group 1: Worst Case Scenario, Report by SL Ross and COGLA, April 1991, Ottawa, ON.

Belkin, I. M., P. Cornillon, and D. Ullman. 2003. Ocean fronts around Alaska from satellite SST data. Proceedings of the Amer. Met. Soc., 7th Conference on Polar Met. And Oceanog., Hyannis, MA, USA. Paper 12.7, 15 p.

Bengston, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biol. 28:833-845.

Bintanja, R., R. G. Graversen, and W. Hazeleger. 2011. Arctic winter warming amplified by the thermal inversion and consequent low infrared cooling to space. Nature Geoscience 4, 758–761 (2011).

Boetius, A., S. Albrecht, K. Bakker, C. Bienhold, J. Felden, M. Fernández-Méndez, S. Hendricks, C. Katlein, C. Lalande, T. Krumpen, M. Nicolaus, I. Peeken, B. Rabe, A. Rogacheva, E. Rybakova, R. Somavilla, F. Wenzhöfer, and R. V. Polarstern. ARK-XXVII/3-Shipboard Science Party. 2013. Export of algal biomass from the melting Arctic sea ice. Science. 339:1430.

Bond, W. A. 1982. A study of the fish resources of Tuktoyaktuk Harbour, southern Beaufort Sea coast, with special reference to life histories of *anadromous coregonids*. Can. Tech. Rep. Fish. Aquat. Sci. 1119: vii + 90 p.

Borstad, G. A. 1985. Water Colour and Temperature in the Southern Beaufort Sea: Remote Sensing in Support of Ecological Studies of the Bowhead Whale. Can. Tech. Rep. of Fisheries and Aqua. Sci. No. 1350. 68 p.

Bourgain, P., and J. C. Gascard. 2011. The Arctic Ocean halocline and its interannual variability from 1997 to 2008. Deep Sea Research Part I: Oceanographic Research Papers. 58(7):745-756.

Bourne, W. R. P. 1979. Birds and gas flares. Marine Pollution Bulletin 10:124-125.

BP. 2010. *Deepwater Horizon* Containment and Response: Harnessing Capabilities and Lessons Learned. Report by BP, September 1, 2010, London, UK. Available at:

http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/incident_response/STAGING/local_assets/downloads_pdfs/Deepwater_Horizon_Containment_Response.pdf.

Bradstreet, M. S. W., D. H., Thomson, and D. B. Fissel. 1987. Zooplankton and bowhead whale feeding in the Canadian Beaufort Sea, 1986. In: Environ. Stud. No. 50. Canada Dept. Indian Affairs and Northern Devel., Ottawa, ON.

Braham, H. W., M. A. Fraker, and B. D. Krogman. 1980. Spring migration of the western Arctic population of bowhead whales. Marine Fisheries Review (September-October): 36-46.

BREA 2012. Beaufort Regional Environmental Assessment Annual Progress Report 2011-2012. September 2012.

Brewer, K. D., M. L. Gallagher, P. R. Regos, P. E. Isert, and J. D. Hall. 1993. ARCO Alaska, Inc. Kuvlum #1 exploration prospect/Site specific monitoring program final report. Rep. from Coastal and Offshore Pacific Corp., Walnut Creek, CA, for ARCO Alaska Inc, Anchorage, AK, USA. 80 p.

Bringue, M., and A. Rochon. 2008. Reconstruction of Late Holocene Sea Parameters on the Mackenzie Slope (Beaufort Sea Canadian Arctic), Preliminary Results, Arctic Change 2008 Annual Conference Proceedings, 1. Published.

Brown, A. L. 1990. Measuring the effect of aircraft noise on sea birds. Environment International, 16(4):587-592.

Brown, H. M., and R. H. Goodman. 1988. Dispersant Tests in a Wave Basin – Four Years of Experience. In the Proceedings of the 11th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar. Environment Canada, Ottawa, Canada, pp. 501-514. Popper, A. N. and M. C. Hastings. 2009. The effects of human-generated sound on fish. Integrative Zoology 4(1):43-52.

Brown, H. M., and R. H. Goodman. 1996. The use of Dispersants in Broken Ice. In the Proceedings of the 19th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar. Environment Canada, Ottawa, ON. pp. 453-460.

Brown, R. D., and P. Cote. 1992. Interannual landfast ice thickness in the Canadian high Arctic, 1950 1989. Arctic, 45, 273-284, 1992.

Brueggeman J. J., R. A. Volsen, R. A. Grotefendt, G. A. Green, J. J. Burns, and D. K. Ljungblad. 1991. Shell Western E&P Inc. 1990 walrus monitoring program. The Popcorn, Burger and Crackerjack prospects in the Chukchi Sea. Rep. from EBASCO Environmental, Bellevue, WA, for Hell Western E&P Inc., Houston, TX, USA.

Buist, I., S. Potter, K. Trudel, S. Shelnutt, A. H. Walker, D. Scholz, P. J. Brandvik, J. Fritt-Rasmussen, A. Allen, and P. Smith. In Situ Burning in Ice-Affected Waters: State of Knowledge Report. Draft report to International Association of Oil and Gas Producers, March 2013.

Burger, J. 1981. Behavioural responses of herring gulls Larus argentatus to aircraft noise. Environmental Pollution Series A, Ecological and Biological, 24(3):177-184.

Burns, J. J., and G. A. Seaman. 1985. Investigations of beluga whales in coastal waters of western and northern Alaska: II. Biology and ecology. Final report prepared for the US Department of Commerce, NOAA, NOS. Contract No. NA81RAC00049. Alaska Department of Fish and Game, Fairbanks. 129 pp.

Calef, G. W., E. A. DeBock, and G. M. Lortie. 1976. The Reaction of Barren-Ground Caribou to Aircraft. Arctic (29):201-212.

Callow L. 2013. Oil and gas Activity Forecast Beaufort Sea 2012-2017. Prepared for BREA Results Forum Inuvik, February 19-21, 2013.

Canada-Newfoundland Offshore Petroleum Board. 2009. Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands. CNSOPB, St. John’s.

Canadian Coast Guard. 2013. Ice Navigation in Canadian Waters - Chapter 3: Ice and Weather Environment. Retrieved 2013/04/04, from http://www.ccg-gcc.gc.ca/e0010733.

CanWest News Services. 2008. N.W.T. minister wants polar bear hunt ban reversed. http://www.canada.com/topics/news/story.html?id=6c588f46-da6e-4816-a4be-789a4836b478. Accessed March 2013.

Carlens, H., C. Lydersen, B. A. Krafft, and K. M. Kovacs. 2006. Spring haul-out behavior of ringed seals (*Pusa hispida*) in Kongsfjorden, Svalbard. Marine Mammal Science 22(2):379-393.

Carmack, E. C., and D. C. Chapman. 2003. Wind-driven shelf/basin exchange on an Arctic shelf: The joint roles of ice cover extent and shelf-break bathymetry. Geophysical Research Letters, 30.

Carmack, E. C., and E. A. Kulikov. 1998. Wind-forced Upwelling and Internal Kelvin Wave Generation in Mackenzie Canyon, Beaufort Sea. J. Geophys. Res. 103:18, 447-18, 458.

Carmack, E. C., and R. W. Macdonald. 2002. Oceanography of the Canadian Shelf of the Beaufort Sea: a setting for marine life. Arctic. 55 (Supp.1), 29-45.

Carmack, E. C., R. W. Macdonald, and J. E. Papadakis. 1989. Water mass structure and boundaries in the Mackenzie shelf estuary. J. Geophys. Res. 94:18, 043-18, 055.

Carmack, E. C., R. W. Macdonald, and S. Jasper. 2004. Phytoplankton productivity on the Canadian Shelf of the Beaufort Sea. Marine Ecology Progress Series, 277, 37-50.

Carmack, E., D. Barber, J. Christensen, R. Macdonald, B. Rudels, and E. Sakshaug. 2006. Climate variability and physical forcing of the food webs and the carbon budget on panarctic shelves. Progress in Oceanography 71. p. 145-181.

Canadian Environmental Assessment Agency. 1999. Cumulative Effects Assessment practitioners Guide. CEA Agency, Ottawa, ON.

Canadian Environmental Assessment Agency. 2013. News Release – Inuvik to Tuktoyaktuk Highway Project to Proceed (Released on April 5, 2013). Available at: http://www.ceaa-acee.gc.ca/050/document-eng.cfm?document=87491. Accessed in April 2013.

Chmelnitsky, E. G., and S. H. Ferguson. 2012. Beluga whale, *Delphinapterus leucas*, vocalizations from the Churchill River, MB, Canada. J. Acoust. Soc. Am. 13196. p. 4821-4835.

Clark, C. W., and J. H. Johnson. 1984. The sounds of the bowhead whale, *Baleana mysticetus*, during the spring migrations of 1979 and 1980. Can. J. Zool. 62(7):1436-1441.

Coachman, L. K., and C. A. Barnes. 1961. The contribution of Bering Sea water to the Arctic Ocean. Arctic 14(3).

Coad, B. W., and J. D. Reist. 2004. Annotated list of the Arctic marine fishes of Canada. Can. Manuscr. Rep. Fish. Aquat. Sci. 2674. 112 p.

Cobb, D., H. Fast, M. H. Papst, D. Rosenberg, R. Rutherford, and J. E. Sareault, editors. 2008. Beaufort Sea Large Ocean Management Area: Ecosystem Overview and Assessment Report. Can. Tech. Rep. Fish. Aquat. Sci. 2780. ix + 188 pp.

Community of Inuvik, Wildlife Management Advisory Council (NWT) (WMAC-NWT) and the Joint Secretariat. 2008. Inuvik Inuvialuit Community Conservation Plan (CCP). November 2008. 155 pp.

Community of Sachs Harbour, Wildlife Management Advisory Council (NWT) and Joint Secretariat. 2008. Sachs Harbour Community Conservation Plan. July 2008. 109 pp.

Community of Tuktoyaktuk, Wildlife Management Advisory Council, and Joint Secretariat. 2008. Tuktoyaktuk Community Conservation Plan. April 2008. 169 pp.

Conlan, K. E., A. Aitken, E. Hendrycks, C. McClelland, and H. Melling. 2008. Distribution patterns of Canadian Beaufort Shelf macrobenthos. Journal of Marine Systems. 74(3-4):864-886.

Copland, L., D. R. Mueller, and L. Weir. 2007. Rapid loss of the Ayles Ice Shelf, Ellesmere Island, Canada, Geophys. Res. Lett., 34, L21501, doi: 10.1029/2007GL031809.

Cornell University. 2011a. Ithaca, New York. Passive Acoustic Monitoring of Bowhead and Beluga Whales, Beaufort Sea, 16 August – 24 September 2010. Bioacoustics Research Program, Technical Report 11-12. Prepared for BP Exploration Operating Company Limited, Calgary, AB. Dated July 29, 2011. 57 pp.

Cornell University. 2011b. Ithaca, New York. Passive Acoustic Monitoring of Bowhead and Beluga Whales, Beaufort Sea, 16 August – 24 September 2010. Bioacoustics Research Program Technical Report 11-01. Prepared for BP Exploration Operating Company Limited, Calgary, AB.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). Annual Status Report. 1989. Government of Canada.

COSEWIC. 2004. COSEWIC assessment and update status report on the beluga whale *Delphinapterus leucas* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. ix + 70 pp.

COSEWIC. 2009. COSEWIC assessment and update status report on the Bowhead Whale *Balaena mysticetus*, Bering-Chukchi-Beaufort population and Eastern Canada-West Greenland population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, ON. vii + 49 pp.

COSEWIC. 2013. COSEWIC Species Database. Available at: http://www.cosewic.gc.ca/eng/sct1/searchdetail_e.cfm. Accessed on April 2, 2013.

Craig, P. C., and L. Haldorson. 1981. Beaufort Sea barrier island-lagoon ecological process studies: final report, Simpson Lagoon. Part 4, fish. P.384-678. In: Environ. Assess. Alaskan Cont. Shelf, Final Rep. Prin. Invest., Vol, February 1981. BLM/NOAA, OCSEAP, Boulder, Colo.

Craig, P. C., W. B. Griffiths, L. Haldorson, and H. McElderry. 1982. Ecological studies of Arctic cod (*Boreogadus saida*) in Beaufort Sea coastal waters, Alaska. Can. J. Fish. Aquat. Sci. 39:395-406.

Crawford, J. A., K. J. Frost, L. T. Quakenbush, and A. Whiting. 2012. Different habitat use strategies by subadult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. Polar Biol. 35:241-255.

Crawford, R. E., S. Vagle, and E. C. Carmack. 2012. Water mass and bathymetric characteristics of polar cod habitat along the continental shelf and slope of the Beaufort and Chukchi seas, Polar Biology, 35:179-190.

Crawford, R. L. 1981. Weather, migration and autumn bird kills at a north Florida TV tower. Wilson Bulletin 93:189-195.

Cummings, W. C., D. V. Holliday, and B. J. Lee. 1984. [publ. 1986]. Potential impacts of man-made noise on ringed seals: Vocalizations and reactions. Outer Cont. Shelf Environ. Assess. Program, Final Rep. Princ. Invest., NOAA, Anchorage, AK, USA. 37:95-230.

Cusson, M., P. Archambault, and A. Aitken. 2007. Biodiversity of benthic assemblages on the Arctic continental shelf: historical data from Canada. Marine Ecological Progress Series. 331:291-304.

Darnis, G., D. G. Barber, and L. Fortier. Sea Ice and the Onshore–Offshore Gradient in Pre-winter Zooplankton Assemblages in Southeastern Beaufort Sea. Journal of Marine Systems, 2008. Volume 74, Issues 3–4, December 1, 2008, pp. 994–1011.

Delarue, J., M. Laurinolli, and B. Martin. 2009. Bowhead whale (*Balaena mysticetus*) songs in the Chukchi Sea between October 2007 and May 2008. J. Acoust. Soc. Am. 126(6):3319-3328.

Demarchi, M. W., M. D. Bentley, and L. Sopuck. 2005. Best Management Practices for Raptor Conservation during Urban and Rural Land Development in British Columbia, MOE BMP Series (pp. 129). Prepared for: BC Ministry of Environment, Ecosystem Standards and Planning Biodiversity Branch.

Derocher, A. E., N. J. Lunn, and I. Stirling. 2004. Polar Bears in a Warming Climate. Integrative and Comparative Biology 44(2):163-176.

Devon (Devon Canada Corporation). 2004. Chemical Oceanography Study Report. Beaufort Sea Exploration Drilling Program. Devon Canada Corporation. Calgary, AB. 70 pp + Appendices.

DF Dickins Associates and ESL Environmental Sciences. 1987. Environmental Atlas for Beaufort Sea Oil Spill Response. Report to Environment Canada. Ottawa, ON.

DFO (Department of Fisheries and Oceans). 2008. Beaufort Sea Large Ocean Management Area: Ecosystem Overview and Assessment Report. Unpublished Report, DFO, Oceans Division, Winnipeg, MB. 199 pp.

Dickson, D. L., and H. G. Gilchrist. 2002. Status of marine birds of the southeastern Beaufort Sea. Arctic. 55 (Supp 1): 46-58.

Dome Petroleum Limited, Esso Resources Canada Limited, and Gulf Canada Resources Inc. 1982. Environmental Impact Statement. Hydrocarbon Development in the Beaufort Sea-Mackenzie Delta Region. Volume 3A: Beaufort Sea-Delta Setting.

Dumas, J., C. E. Carmack, and H. Melling. 2005. Climate Change Impacts on the Beaufort Shelf Landfast Ice. Cold Regions Science and Technology 42(1):41–51.

Dunbar, M. J., and D. M. Moore. 1980. Marine Life and Its Environment in the Canadian Eastern Arctic: a Biographic Study. Marine Sciences Manuscript No. 33, McGill University 1980, 119 pp.

Durner, G. M., S. C. Amstrup, and A. S. Fischbach. 2003. Habitat characteristics of polar bear terrestrial maternal den sites in northern Alaska. Arctic 56:55-62.

Duval, W. S. 1993. Proceedings of a workshop on Beaufort Sea beluga: February 3-6, 1992. Vancouver, BC.

Dyke, L. D., J. M. Aylsworth, M. M. Burgess, F. M. Nixon, and F. Wright. 1997. Permafrost in the Mackenzie Basin, its influence on land-altering processes, and its relationship to climate change. p. 111-116. In Mackenzie Basin Impact Study:

Final Report. Edited by S. J. Cohen. Environmental Adaptation Research Group, Environment Canada.

Edds-Walton, P. L. 1997. Acoustic communication signals of Mysticete whales. Bioacoustics. 8:47-60.

Emmerton, C. A., L. F. W. Lesack, and W. F. Vincent. 2008. Nutrient and organic matter patterns across the Mackenzie River, estuary and shelf during the seasonal recession of sea-ice. Journal of Marine Systems, 74, 741-755.

Energy Resources Conservation Board (ERCB). 2007. Directive 038: Noise Control. Issued February 27, 2007.

Environment Canada. 2013. Tuktoyaktuk A Monthly Meteorological Data. Accessed April 1, 2013 at: http://climate.weatheroffice.gc.ca/climateData/bulkdata_e.html?timeframe=3&Prov=XX&StationID=1700&Year=2007&Month=11&Day=1&format=csv.

Evans, P. G. H., and J. A. Raga. 2001. Marine Mammals: Biology and Conservation. Kluwer Academic/Plenum Publishers. New York.

Fay R. R., and A. N. Popper. 2000. Evolution of hearing in vertebrates: the inner ears and processing. Hear. Res. 149:1-10.

Fay, F. H., B. P. Kelly, P. H. Gehnrich, J. L. Sease, and A. A. Hoover. 1984. Modern populations, migrations, demography, trophics, and historical status of the Pacific walrus. In: Outer Continental Shelf Environmental Assessment Program: Final Rep 37. NOAA, US Department of Commerce, Washington, DC. 231−376.

Fay, R. R. 1988. Hearing in vertebrates: A psychophysics databook. Winnetka, IL. Hill-Fay Associates. vii 621 pp.

Feldhamer G. A., B. C. Thompson, and J. A. Chapman (Editors). 2003. Wild mammals of north America. Biology, management and Conservation. Second edition. The Johns Hopkins University press. Baltimore and London. 1187 pp.

Ferguson, S. H., I. Stirling, and P. McLoughlin. 2005. Climate change and Ringed Seal (*Phoca hispida*) recruitment in western Hudson Bay. Mar. Mamm. Sci. 21:121-135.

Ferguson, S. H., M. K. Taylor, and F. Messier. 1997. Space-use of Polar Bears in and Around Auyuittuq National Park, NT, during the Ice-free Period. Can. J. Zool. 75, 1585-1594.

Finley, K. J. 1979. Haul out behavior and densities of ringed seals (*Phoca hispida*) in the Barrow Strait area, NT. Can. J. Zool. 57(10):1985-1997.

Finley, K. J., G. W. Miller, R. A. Davis, and C. R. Greene. 1990. Reactions of belugas, *Delphinapterus leucas*, and narwhals, *Monodon monoceros*, to ice-breaking ships in the Canadian high arctic. Canadian Bulletin of Fisheries and Aquatic Sciences. 224:97-117.

Fischbach, A. S., S. C. Amstrup, and D. C. Douglas. 2007. Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. Polar Biology 30:1395-1405.

Fissel, D. B., and H. Melling. 1990. Interannual variability of oceanographic conditions in the southeastern Beaufort Sea. Arctic Sciences Ltd., Canadian Contractor Report of Hydrography and Ocean Sciences No. 35. 102 pp. (pls 6 microfiche).

Fissel, D. B., E. Ross, K. Borg, D. Billenness, A. Kanwar, A. Bard, D. Sadowy, and T. Mudge. 2012b. Improvements in the Detection of Hazardous Sea Ice Features Using Upward Looking Sonar Data, In Proceedings: Arctic Technology Conference. December 2012. Houston, TX, USA.

Fissel, D. B., J. R. Marko, and M. Martínez de Saavedra Álvarez. 2009. The changing met-ocean and ice conditions in the Beaufort Sea: Implications for Offshore Oil and Gas. Proc. the 19th Annual Meeting of the International Society of Offshore and Polar Engineers. Osaka, Japan. June 2009. 8 pp.

Fissel, D. B., J. R. Marko, M. Martínez de Saavedra Álvarez, N. Kulan, T. D. Mudge, and J. R. Marko. 2013. Long term changes in Metocean-Ice conditions in the Canadian Beaufort Sea. Proceedings of the Annual Meeting of the International Society of Offshore and Polar Engineers. Anchorage, AK, USA. June 30 – July 5, 2013. 8 pp.

Fissel, D. B., M. S. W. Bradstreet, and J. Moen. 1987. Water mass distributions in the Canadian Beaufort Sea. In: Proceedings IEEE, Oceans 87. Vol. 3, p. 910-916.

Fissel, D. B., N. Kulan, A. Kanwar, E. Ross, K. Borg, D. Billenness, and J. Reitsma. 2012c. Ajurak-Pokak Marine Physical Environment, Technical Data Report, Canadian Beaufort Sea, 2009-2011. Prepared for Imperial Oil Resource Ventures Ltd., ASL File: PR-791 (December 2012, Draft).

Fissel, D. B., H. Melling, D. Billenness, K. Borg, N. Kulan, M. Martinez de Saavedra Álvarez, and A. Slonimer. 2012a. The Changing Wave Climate over the Beaufort Sea Shelf, 2001-2010. Paper presented at the International Polar Year (IPY 2012) Conference, Montreal, QC. April 2012.

Forbes, D. L. 2005. Coastal Erosion. In: Encyclopedia of the Arctic. M. Nuttall (ed.). Routledge, New York and London, 1, 391–393 Government of Canada. 2009.

Forbes, D. L. 2011. 3.10: Polar Coasts. In: Treatise on Estuarine and Coastal Science. Estuarine and Coastal Geology and Geomorphology. Elsevier. p. 245-283.

Ford, J. K. B., J. C. Cubbage, and P. Norton. 1987. Distribution, abundance, and age segregation of bowhead whales in the southeast Beaufort Sea, August-September 1986. Environmental Studies Research Funds Report No. 089. Ottawa, ON. 93 p.

Forest, A., M. Sampei, M.-E. Rail, Y. Gratton, and L. Fortier. 2008. Winter pulses of Pacific-origin water and resuspension events along the Canadian Beaufort Slope revealed by a bottom-moored observatory. Proceedings of MTS/IEEE Oceans

2008: Oceans, Poles, and Climate - Technological Challenges. September 15-18, 2008. 8 pp. doi:10.1109/OCEANS.2008.5152010.

Fraker, M. A. 1979. Spring migration of bowhead (*Balaena mysticetus*) and white whales (*Delphinapterus leucas*) in the Beaufort Sea. Fisheries and Marine Service Technical Report 859.

Fraker, M. A., and J. R. Bockstoce. 1980. Summer distribution of bowhead whales in the eastern Beaufort Sea. Marine Fisheries Review (September-October): 57-64.

Fraker, M. A., and P. N. Fraker. 1979. The 1979 whale monitoring program/Mackenzie Estuary. Rep. from LGL Ltd., Sidney, BC, for Esso Resources Canada Ltd., Calgary, AB. 98 p.

Fraker, P.N, and M. A. Fraker. 1982. The 1981 white whale monitoring program, Mackenzie Estuary. Rep. from LGL Ltd. Sidney, BC. for Esso Resources Canada Ltd. (manager), Calgary, AB. 74 p.

Frame, G. W. 1973. Occurrence of birds in the Beaufort Sea, Summer 1969. Auk. 90:552-563.

Freeman M. M. R., and G. W. Wenzel. 2006. The Nature and Significance of Polar Bear Conservation Hunting in the Canadian Arctic. Arctic 59(1):21–30.

Frost, K. J., and L. F. Lowry. 1984. Trophic relationships of vertebrate consumers in the Alaskan Beaufort Sea. The Alaskan Beaufort Sea: Ecosystems and Environments, Academic Press, Orlando, FL, USA: 381-401.

Frost, K. J., L. F. Lowry, G. Pendleton, and H. R. Nute. 2004. Factors affecting the observed densities of ringed seals, *Phoca hispida*, in the Alaskan Beaufort Sea, 1996-99. Arctic. 57(2):115-128.

Fugro Jacques Geosurveys Inc. 2011. Geohazard assessment, BP 2010 Beaufort Field Data Collection, Lease Blocks EL 446 and 449, Western Beaufort Sea, Canada. Volume 1. Document no. 10014DT-001-RPT-006 rev 0. Prepared for: IMG-Golder Corporation, on behalf of BP Exploration Company. Calgary, AB.

Gallaway, B. J., W. B. Griffiths, P. C. Craig, W. T. Gazey, and J. W. Helmericks. 1983. An assessment of the Colville River delta stock of arctic cisco: migrants from Canada. Biol. Papers, Univ. Alaska 21: 4-23.

Galley, R. J. et al. 2012. Landfast Sea Ice Conditions in the Canadian Arctic, 1983-2009. Arctic, Vol. 65.

Gauthreaux Jr., S. A., and C. Belser. 2006. Effects of artificial night lighting on migrating birds. Ecological consequences of artificial night lighting, 67-93.

Geoffroy, M., A. Majewski, S. Rousseau, W. Walkusz, J. Reist, and L. Fortier. 2013. Active Acoustic Mapping of Fish: An Answer to the Mystery of the Missing Arctic Cod?. Presented at: Beaufort Regional Environmental Assessment (BREA) Results Forum. February 19-21, Inuvik, NT.

Geoffroy, M., D. Robert, G. Darnis, and L. Fortier. 2011. The Aggregation of Polar Cod (*Boreogadus saida*) in the Deep Atlantic Layer of Ice-covered *Amundsen* Gulf (Beaufort Sea) in winter. Polar Biology 34(12):1959-1971.

Geoffroy, M., S. Rousseau (ArcticNet), and C. Pyc (BP America). 2012. Beaufort Sea Active Acoustics Survey for Marine Mammal and Pelagic Fish Detection. Prepared for the Beaufort Regional Environmental Assessment (BREA).

George, J. C., C. Clark, G. M. Carroll, and W. T. Ellison. 1989. Observations on the ice breaking and ice navigation behaviour of migrating bowhead whales (*Balaena mysticetus*) near Point Barrow, AK, USA. Spring 1985. Arctic. 42(1):24-30.

Geraci, J. R., and D. J. St. Aubin. 1985. Study of the Effects of Oil on Cetaceans. Final Rep., Contract No. AA551-CT9-29. U.S. Dept. of the Interior, Bureau of Land Management, Washington, DC, USA.

Gleason J. S., and K. D. Rode. 2009. Polar bear distribution and habitat association reflect long-term changes in fall sea ice conditions in the Alaskan Beaufort Sea. Arctic 62(4):405-417.

GNWT (Government of the Northwest Territories). 2011a. Northwest Territories Air Quality Report 2011. Available at: www.enr.gov.nt.ca/_live/documents/content/2011_Air_Quality_Report.pdf.

GNWT. 2011b. NWT Species at Risk. NWT polar bear (*Ursus maritimus*): http://nwtspeciesatrisk.ca/tiki/tiki-index.php?page=PolarBear. Accessed in April 2013.

GNWT-ENR (Government of the Northwest Territories, Department of Environment and Natural resources). 2012. Northwest Territories General Status Ranking Program. Available at: http://nwtspeciesatrisk.ca/tiki/tiki-index.php?page=GenStatusRanking. Accessed on April 3, 2013.

GNWT-ENR. 2013. NWT Barren-Ground Caribou (*Rangifer taradus groenlandicus*). Accessed at: http://www.enr.gov.nt.ca/_live/pages/wpPages/caribou_information.aspx. Accessed on April 2, 2013.

Golder Associates Ltd. (Golder). 2011a. Tuktoyaktuk Interviews: Traditional Knowledge Collection Program. Report submitted to BP Exploration Operating Company Ltd.

Golder. 2011b. Inuvik Community Report: Traditional Knowledge Collection Program. Report submitted to BP Exploration Operating Company Ltd.

Golder. 2011c. Paulatuk Community Report: Traditional Knowledge Collection Program. Report submitted to BP Exploration Operating Company Ltd.

Golder. 2011d. Ulukhaktok Community Report: Traditional Knowledge Collection Program. Report submitted to BP Exploration Operating Company Ltd.

Golder. 2011e. Sachs Harbour Community Report: Traditional Knowledge Collection Program. Report submitted to BP Exploration Operating Company Ltd.

Golder. 2011f. Aklavik Community Report: Traditional Knowledge Collection Program. Report submitted to BP Exploration Operating Company Ltd.

Gosselin, M., M. Levasseur, P. A. Wheeler, R. A. Horner, and B. C. Booth. 1997. New measurements of phytoplankton and ice algal production in the Arctic Ocean. Deep Sea Res. Part II Top. Stud. Oceanogr. 44:1623.

Goudie, R. I., and I. L. Jones. 2004. Dose-response relationships of harlequin duck behaviour to noise from low-level military jet over-flights in central Labrador. Environmental Conservation 31(4):1-10.

Greene Jr., C. R. 1985. Characteristics of waterborne industrial noise, 1980-1984. P. 197-253. In W. J. Richardson (ed.), Behavior, disturbance responses and distribution of bowhead whales *Balaena Mysticetus* in the eastern Beaufort Sea, 1980-1984. OCS Study MMS 85-0034. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, USA, for US Minerals Management Service, Reston, VA, USA. 306 p. NTIS PB87-124376.

Greene Jr., C. R. 1987. Characteristics of oil industry dredge and drilling sounds in the Beaufort Sea. Journal of the Acoustical Society of America. 82(4):1315-1324.

Guay, C. K., and K. K. Falkner. 1997. Barium as a tracer of Arctic halocline and river waters, Deep-Sea Research II, 44(8), 1543-1569.

Gudmundsson, G. A., T. Alerstam, M. Green, and A. Hedenström. 2002. Radar observations of Arctic bird migrations at the Northwest Passage, Canada. Arctic. 55(1):21-43.

Haas, C., S. Howell, and C. Derksen. 2013. Airborne and Satellite Observations of the Distribution, Thickness, and Drift of Sea Ice Types and Extreme Ice Features in the Beaufort Sea. Presented at: Beaufort Regional Environmental Assessment (BREA) Results Forum. February 19-21, Inuvik, NT.

Hakkinen, S., A. Proshutinsky, and I. Ashik. 2008. Sea ice drift in the Arctic since the 1950s. Geophysical Research Letters, 35(19):L19704, doi: 10.1029/2008GL034791.

Hall, J. D., M. L. Gallagher, K. D. Brewer, P. R. Regos, and P. E. Isert. 1994. ARCO Alaska, Inc. 1993. Kuvlum exploration area site specific monitoring program/Final report. Rep. from Coastal and Offshore Pacific Corp., Walnut Creek, CA for ARCO Alaska Inc. Anchorage, AK, USA. 219 p. + Data Appendix vol. 1, 2.

Hammill, M. O., and T. G. Smith. 1991. The role of predation in the ecology of ringed seal in Barrow Strait, NT, Canada. Mar. Mamm. Sci. 7:123-135.

Hansen, D. J. 2004. Observations of Habitat Use by Polar Bears, *Ursus maritimus*, in the Alaskan Beaufort, Chukchi, and Northern Bering Seas. Canadian Field-Naturalist 118(3):395-399.

Harwood, L. A., and I. Stirling. 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Can. J. Zool. 70:891-900.

Harwood, L. A., and T. G. Smith. 2002. Whales of the Inuvialuit Settlement Region in Canada's Western Arctic: An Overview and Outlook. Arctic, Vol. 55, Supplement 1: The Beaufort Sea Conference 2000 on the Renewable Marine Resources of the Canadian Beaufort Sea. 2002. pp. 77-93.

Harwood, L. A., F. McLaughlin, R. M. Allen, J. Illasiak Jr., and J. Alikamik. 2005. First-ever marine mammal and bird observations in the deep Canada Basin and Beaufort/Chukchi seas: expeditions during 2002. Polar Biol. 28:250-253.

Harwood, L. A., J. Aul, A. Joynt, and S. E. Moore. 2010. Distribution of bowhead whales in the SE Beaufort Sea during late summer, 2007-2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/111.

Harwood, L. A., S. Innes, P. Norton, and M. C. S. Kingsley. 1996. Distribution and abundance of beluga whales in the Mackenzie estuary, southeast Beaufort Sea, and west Amundsen Gulf during late July 1992. Can. J. Fish. Aquat. Sci. 53:2262-2273.

Harwood, L. A., T. G. Smith, and J. C. Auld. 2012. Fall migration of ringed seals (*Phoca hispida*) through the Beaufort and Chukchi seas, 2001-2002. Arctic 65(1):35-44.

Health Canada. 2010. Useful Information for Environmental Assessments. H128-1/10-599E.

Hegseth, E. N. 1998. Primary production in the northern Barents Sea: Polar Research. 17:113-123.

Henry, R. F., and N. S. Heaps. 1976. Storm surges in the southern Beaufort Sea. J. Fish. Res. Brd. Canada. 33(10), 2362-2376.

Hill, P. R., S. M. Blasco, J. R. Harper, and D. B. Fissel. 1991. Sedimentation on the Canadian Beaufort Shelf. Cont. Shelf Res. 11. p. 821-842.

Hirst, S. M., M. Miles, S. P. Blachut, L. A. Goulet, and R. E. Taylor. 1987. Quantitative synthesis of the Mackenzie Delta ecosystems. Applied Ecology Ltd., North Vancouver, BC. Inland Waters Directorate, Environment Canada.

Holmes, R. M., J. W. McClelland, B. J. Petersen, S. E. Tank, E. Bulygina, T. I. Eglington, V. V. Gordeev, T. Y. Gurtovaya, P. A. Raymond, D. J. Repeta, R. Staples, R. G. Striegl, A. V. Zhulidov, and S. A. Zimov. 2012. Seasonal and Annual Fluxes of Nutrients and Organic Matter from Large Rivers to the Arctic Ocean and Surrounding Seas. Estuaries and Coasts. 35, 369-382.

Hopky, G. E., M. J. Lawrence, and D. B. Chiperzak. 1994. NOGAP B2; data on the meio- and macrobenthos, and related bottom sediment from Tuktoyaktuk Harbour and Mason Bay, N.W.T., March, 1985 to 1988. Canadian Data Report of Fisheries and Aquatic Sciences, No. 939: 297 p.

Hsiao, S. I. C. 1976. Biological Productivity of the Southern Beaufort Sea: Phytoplankton and Seaweed Studies. Arctic Biological Station. Fisheries and Marine Service. Environment Canada. Beaufort Sea Technical Report #12C. March 1976.

Hudak, D. R., and M. C. Young. 2002. Storm Climatology of the Southern Beaufort Sea. Atmosphere-Ocean 40(2):145–148.

IEG. 2002. Vegetation Classification and Wildlife Habitat suitability Modeling in the Mackenzie Delta Region. Prepared for the Operators and the Wildlife Management Advisory Council in the Mackenzie Delta Region, NT. February 2002. 66 pp (plus appendices).

International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM), adopted in 2004, (subject to its full ratification by 2016) available at: http://www.imo.org/About/Conventions/listofconventions/pages/international-convention-for-the-control-and-management-of-ships'-ballast-water-and-sediments-(bwm).aspx.

International Finance Corporation (IFC). 2007. Environmental, Health, and Safety Guidelines – Noise Management. Issued April 30, 2007.

Inuvik (The Community of Inuvik, the Wildlife Management Advisory Council (NWT) and the Joint Secretariat). 2008. Inuvik Inuvialuit Community Conservation Plan: A plan to provide guidance regarding the conservation and management of renewable resources and lands within the Inuvialuit Settlement Region in the vicinity of Inuvik, NT. November 2008.

Jackson, J. M., E. C. Carmack, F. A. McLaughlin, S. E. Allen, and R. G. Ingram. 2010. Identification, characterization and change of the near-surface temperature maximum in the Canada Basin, Arctic Ocean, 1993-2008, Journal of Geophysical Research, 115, C05021, doi: 10.1029/2009JC005265.

James, T. S., K. M. Simon, D. L. Forbes, A. S. Dyke, S. Carriérre, and D. J. Mate. 2011. Projections of relative sea-level change for the Northwest Territories and Nunavut. NWT Cumulative Impact Monitoring Program Annual Monitoring Results. Abstracts volume. Yellowknife Geoscience Forum. Yellowknife, NT. 96 pp.

JASCO (JASCO Research Ltd., Victoria, BC). 2009. Acoustic Modelling of Underwater Noise, BP Exploration Company Limited's 2009 Pokak 3D Seismic Program. Prepared for BP Exploration Operating Company Limited, Calgary, AB. Version 2, dated February 11, 2009. 30 pp.

Jensen, A. S., and G. K. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-ORP. 37 pp.

Johnson, S. R., and J. W. Richardson. 1982. Waterbird migration near the Yukon and Alaskan coast of the Beaufort Sea: II. Moult migration of seaducks in summer. Arctic. 35(2):291-301.

Johnston, M. 2013. "Measuring the Thickness and Strength of Hummocked Multi-year Ice". Presented at: Beaufort Regional Environmental Assessment (BREA) Results Forum. February 19-21, Inuvik, NT.

JRP (Joint Review Panel for the Mackenzie Gas Project). 2009. Foundation for a Sustainable Northern Future. Volume I Chapters 1 to 10. December 2009. 327 pp.

Kapel, F. O. 1979. Exploitation of large whales in West Greenland in the twentieth century. Rep. Int. Whal. Comm. 29:197-214.

Karasiuk, D. J., G. J. Birch, T. L. Slaney, and J. D. McPhail. 1993. Chapter 7: Aquatic resources of Northern Yukon national park. 222 p. In Canadian Parks Service, Northern Yukon national park resource description and analysis. Natural Resource Conservation Section, Canadian Parks Service, Prairie and Northern Region, Winnipeg, MB.

Karlsen, J. D., A. Bisther, C. Lydersen, T. Haug, and K. M. Kovacs. 2002. Summer vocalizations of adult male white whales (*Delphinapterus leucas*) in Svalbard, Norway. Polar Biol. 25:808-817.

Kavik Axys 2008. Biophysical research requirements for Beaufort Sea hydrocarbon development : final/prepared for Environmental Studies Research Fund[s] ; prepared by Kavik-AXYS Inc. in association with FMA Heritage Resources Consultants Inc.

Kavik-AXYS Inc. 2008. Ajurak Exploration License 446. Beaufort Sea 3-D Seismic Program Project Description. Imperial Oil Resources Ventures Limited. Submitted to the Environmental Impact Screening Committee, Inuvialuit Settlement Region. February 2008.

Kavik-AXYS Inc. 2009. BP Exploration Pokak 3D Seismic Program Project Description. BP Exploration Company Limited. Submitted to the Environmental Impact Screening Committee, Inuvialuit Settlement Region. February 2009. 1032914.

Kavik-Stantec, Inc. and SL Ross Environmental Research. 2013. BREA Study on Inuvialuit Community Spill Response Training in the Beaufort Region: Current Capacity, Projected Need, Realistic Roles and Gap Identification. Report to AANDC, Project No. 123510832. Yellowknife, NT. 197 pp.

Ketten, D. R. 1992a. The marine mammal ear: specializations for aquatic audition and echolocation. Chapter 35. In: the Evolutionary Biology of Hearing (D. B. Webster, R. R. Fay, and A. N. Popper [eds.]). Springer-Verlag. pp 717-750.

Ketten, D. R. 1992b. The cetacean ear: form, frequency and evolution. In: Marine Mammal Sensory Systems (J. Thomas et al. [eds.]). Plenum Press. pp 53-75.

Kirchman, D. L., X. A. Moran, and H. Ducklow. 2009. Microbial growth in the polar oceans - role of temperature and potential impact of climate change. Nat Rev Microbiol. 7, 451-9.

Kite-Powell, H. L., A. Knowlton, and M. Brown. 2007. Modeling the effect of vessel speed on Right Whale ship strike risk. NA04NMF47202394. National Oceanic and Atmospheric Administration and National Marine Fisheries Service. 8 pp.

Klishin, V. O., V. V. Popov, and A. Y. Supin. 2000. Hearing capabilities of a beluga whale, *Delphinapterus leucas*. Aquatic Mammals. 26.3:212-228.

Kokelj, S., T. Lantz, S. Solomon, M. Pisaric, D. Keith, P. Morse, J. Thienpont, J. Smol, and D. Esagok. 2012. Using Multiple Sources of Knowledge to Investigate Northern Environmental Change: Regional Ecological Impacts of a Storm Surge in the Outer Mackenzie Delta, NT. ARCTIC 65(3). p 257-272.

Koski, W. R., and G. W. Miller. 2009. Habitat use by different size classes of bowhead whales in the central Beaufort Sea during late summer and autumn. Arctic. 62(2):137-150.

Kovacs, A., and M. Mellor. 1974. Sea ice morphology and ice as geological agent in the southern Beaufort Sea. In: The Coast and Shelf of the Beaufort Sea, 113-161. Proceedings of a Symposium on Beaufort Sea and Shelf Research. J. C. Reed, and J. A. Sater, (Eds.). The Arctic Institute of North America: Virginia.

Kulikov, E. A., A. B. Rabinovich, and E. Carmack. 2004. Barotropic and baroclinic tidal currents on the Mackenzie shelf break in the southeastern Beaufort Sea. Journal of Geophysical Research. 109.

Kwok, R., and D. A. Rothrock. 2009. Decline in Arctic sea ice thickness from submarine and ICES at records: 1958 2008, Geophys. Res. Lett., 36, L15501, doi: 10.1029/2009GL039035.

Ladich, F and A. N. Popper. 2004. Evolution of the Vertebrate Auditory Parallel Evolution in Fish Hearing Organs. System Springer Handbook of Auditory Research, 2004, Volume 22, 95-127.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17(1):35-75.

Lansard, B., A. Mucci, L. A. Miller, R. W. Macdonald, and Y. Gratton. 2012. Seasonal variability of water mass distribution in the southeastern Beaufort Sea determined by total alkalinity and d18O, J. Geophys. Res., 117, C03003, doi: 10.1029/2011JC007299.

Larsen, E., J. M. Azerrad, and N. Nordstrom (Eds.). 2004. Management Recommendations for Washington's Priority Species, Volume IV: Birds. Olympia.

Latour, P. B., J. Leger, J. E. Hines, M. L. Mallory, D. L. Mulders, H. G. Gilchrist, P. A. Smith, and D. L. Dickson. 2008. Key migratory bird terrestrial habitat sites in the

Northwest Territories and Nunavut. Canadian Wildlife Service. Occasional Paper Number 114.

Lawrence, M. J., G. Lacho, and S. Davies. 1984. A survey of the coastal fishes of the southeastern Beaufort Sea. Can. Tech. Rep. Fish. Aquat. Sci. 1220: x + 178 p.

Legendre, L., S. Ackley, and S. F. Dieckmann. 1992. Ecology of sea ice biota. 2. Global significance. Polar Biology. 12:429.

Legendre, L., S. F. Ackley, G. S. Dieckmann, B. Guuiksen, R. Horner, T. Hoshiai, I. A. Melnikov, W. S. Reeburgh, M. Spindler, and C. W. Sullivan. 1992. Ecology of Sea Ice Biota. Polar Biology, 12, 429-444.

LGL and Greenridge. 1986. Reactions of beluga whales and narwhals to ship traffic and ice-breaking along ice edges in the eastern Canadian High Arctic: 1982-1984. Environmental Study 37. Indian and Northern Affairs Canada, Ottawa, ON. 301 p.

LGL and Greenridge. 1987. Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, USA, for Shell Western E&P Inc., Anchorage, AK, USA. 371 p.

LGL and Greenridge. 1996. Northstar marine mammal monitoring program, 1995: Baseline surveys and retrospective analyses of marine mammal and ambient noise data from the central Alaskan Beaufort Sea. LGL Rep. 2101-2. Rep. from WLLtd., King City, ON, and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK, USA. 104 p.

LGL Ecological Research Associates, Inc. 1982. Food Web and Nutrient Dynamics in Nearshore Alaska Beaufort Sea Waters. Prepared by: D. M. Schell, P. J. Ziemann, D. M. Parrish, K. H. Dunton, and E. J. Brown. pp. 369-415.

LGL Limited. 2005. Husky Delineation/Exploration Drilling Program for Jeanne D’Arc Basin Area Environmental Assessment. LGL Rep. SA845. Rep. by LGL Limited, St. John’s, NL, Oceans Limited, St. Johns, NL, Canning and Pitt Associates, Inc., St. John’s Limited, and PAL Environmental Services, St. John’s, NL, for Husky Oil Operations Ltd., St. John’s, NL. 340 p.

Li, W. K. W., F. A. Mclaughlin, Y. C. Lovejo, and E. C. Carmack. 2009. Smallest Algae Thrive as the Arctic Ocean Freshens. Science, 326, 539.

Lissner, A. L., G. L. Taghon, D. R. Diener, S. C. Schroeter, and J. D. Dixon. 1991. Recolonization of deep-water hard-substrate communities: Potential impacts from oil and gas development. Ecological Applications, 1(3):258-267.

Liu, Y., J. R. Key, Z. Liu, X. Wang, and S. J. Vavrus. 2012. A cloudier Arctic expected with diminished sea ice, Geophys. Res. Lett., 39, L05705, doi: 10.1029/2012GL051251.

Ljungblad, D. K., P. O. Thompson, and S. E. Moore. 1982. Underwater sounds recorded from migratory bowhead whales, *Balaena mysticetus*, in 1979. J. Acoust. Soc. Am. 71(2):477-482.

Loseto, L., T. Wazny, H. Cleator, B. Ayles, D. Cobb, L. Harwood, C. Michel, O. Nielsen, J. Paulic, L. Postma, P. Ramlal, J. Reist, P. Richard, P. S. Ross, S. Solomon, W. Walkusz, L. Weilgart, and B. Williams. 2010. Canadian Science Advisory Secretariat Research Document 2010/094. Information in Support of Indicator Selection for Monitoring the Tarium Niryutait Marine Protected Area (TNMPA).

Lukovich, J. V., and D. G. Barber. 2006. Atmospheric controls on sea ice motion in the southern Beaufort Sea. Journal of Geophysical Research. 111, D18103. 12 p.

Lukovich, J. V., M. G. Asplin, and D. G. Barber. 2009. Atmospheric forcing of the Beaufort Sea gyre: Surface-stratosphere coupling. Journal of Geophysical Research. 114, C00A03. 14 p.

Mabile, N. 2012. Controlled in-Situ Burning: Transition from Alternative Technology to Conventional Spill Response Option. Proceedings of the Thirty-fifth Technical Seminar on Environmental Contamination and Response. Environment Canada, Ottawa, ON. 2012.

Macdonald, R. W., and Y. Yu. 2006. The Mackenzie Estuary of the Arctic Ocean. Hdb. Env. Chem. Vol. 5H. p 91-120.

Macdonald, R. W., E. C. Carmack, F. A. Mclaughlin, K. Iseki, D. M. Macdonald, and M. O. O'Brien. 1989. Composition and modification of water masses in the Mackenzie Shelf Estuary. Journal of Geophysical Research 94:18057–18070.

Macdonald, R. W., E. C. Carmack, F. A. Mclaughlin, K. K. Falkner, and J. H. Swift. 1999. Connections among ice, runoff and atmospheric forcing in the Beaufort Gyre. Geophys. Res. Lett. 26, 2223–2226.

Macdonald, R. W., F. A. McLaughlin, and E. C. Carmack. 2002. Fresh water and its sources during the SEHBA drift in the Canada Basin of the Arctic Ocean. Deep Sea Res.I. 49, 1769-1785.

Majewski, A., on Behalf of Project Participants. 2013. "Marine Fishing Program: Integrated Knowledge of Canadian Beaufort Sea Fisheries & Their Ecosystems". Presented at: Beaufort Regional Environmental Assessment (BREA) Results Forum. February 19-21. Inuvik, NT.

Manci, K. M., D. N. Gladwin, R. Villella, and M. G. Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: A literature synthesis (No. NERC-88/29). National Ecology Research Center, Fort Collins, CO, USA. 97 p.

Manson, G. K., and S. M. Solomon. 2007. Past and Future Forcing of the Beaufort Sea Coastal Change. Atmosphere-Ocean. 45(2):107–122.

Martínez de Saavedra Álvarez, M., D. B. Fissel, N. Kulan, and T. D. Mudge. 2011. Long-terms trends in the physical environment along the Northwest Passage shipping route. Presented at the 45th CMOS Congress. June 5-9, 2011, Victoria, BC.

Mate, B. R., G. K. Krutzikowsky, and M. H. Winsor. 2000. Satellite-monitored movements of radio-tagged bowhead whales in the Beaufort and Chukchi seas during the late summer feeding season and fall migration. Can. J. Zool. 78:1168-1181.

McClelland, J. W., R. M. Holmes, K. H. Dunton, and R. W. Macdonald. 2012. The Arctic Ocean Estuary. Estuaries and Coasts, 35, 353-368.

McFarlin, K., M. B. Leigh, and R. Perkins. 2011. Indigenous Microorganisms Degrade Oil in Arctic Seawater. International Oil Spill Conference Proceedings: March 2011, Vol. 2011, No. 1, pp. abs 132.

McLaren, I. A. 1958. The biology of the ringed seal (*Phoca hispida Schreber*) in the eastern Canadian Arctic. Bulletin of the Fisheries Research Board of Canada No. 118.

McLaren, P. L., and R. A. Davis. 1985. The distribution of bowhead whales in the southeast Beaufort Sea, August-September 1983. Environmental Studies Revolving Funds Report, No. 001. Ottawa, ON. 62 p.

McLaughlin, F. A., and E. C. Carmack. 2010. Deepening of the nutricline and chlorophyll maximum in the Canada Basin interior, 2003–2009. Geophys. Res. Lett.37. L24602, doi: 10.1029/2010GL045459.

McLoughlin, P. D., F. Messier, R. L. Case, R. J. Gau, R. Mulders, and H. D. Cluff. 1999. The Spatial Organization and Habitat Selection Patterns of Barren-Ground Grizzly Bears (*Ursus arctos*) in the Northwest Territories and Nunavut: Final Report to the West Kitikmeot/Slave Study. 55 pp (plus appendices).

Melling, H. 2012. Comments and Presentation at the Beaufort Regional Environmental Assessment (BREA) Climate Change Workshop, Inuvik, NT. November 19-21, 2012. Pers. Comm.

Miller, F. L. 1995. Inter-Island Water Crossings by Peary Caribou, South-Central Queen Elizabeth Islands Arctic, Vol. 48, No. 1. March 1995. pp. 8-12.

Milne, A. R. 1967. Sound propagation and ambient noise under sea ice. Underwater Acoustics, Vol. 2. Plenum Press, New York.

Mitson, R. B., (ed.). 1995. Underwater noise of research vessels - Review and recommendations. Cooperative Research Report. 209. ACOUSTEC, prepared for the International Council for the Exploration of the Sea. Copenhagen, Denmark.

Mohl, B. 1968. Auditory sensitivity of the common seal in air and water. J. Aud. Res. 8(1):27-38.

Montevecchi, W. A. 2006. Influences of artificial light on marine birds. Ecological consequences of artificial night lighting, 94-113.

Montevecchi, W. A., F. K. Wiese, G. Davoren, A. W. Diamond, F. Huettmann, and J. Linke. 1999. Seabird Attraction to Offshore Platforms and Seabird Monitoring from Offshore Support Vessels and Other Ships. Literature Review and Monitoring Designs. Prepared for the Canadian Association of Petroleum Producers. St. John's, NL.

Moore, G. W. K., and R. S. Pickart. 2012. The Wrangel Island Polynya in early summer: Trends and relationship to other polynyas and the Beaufort Sea High. Geophysical Research Letters, 39, L05503, 5 p.

Moore, S. E. 2000. Variability of cetacean distribution and habitat selection in the Alaskan Arctic, Autumn 1982–91. Arctic 53(4):448-460.

Moore, S. E., and J. T. Clarke. 1991. Estimates of bowhead whale (*Balaena mysticetus*) numbers in the Beaufort Sea during late summer. Arctic. 44(1):43-46.

Moore, S. E., D. P. DeMaster, and P. K. Dayton. 2000. Cetacean habitat selection in the Alaskan Arctic during summer and autumn. Arctic 53:432-447.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkalehto. 2002. Cetacean distribution and relative abundance on the central-eastern and the southeastern Bering Sea shelf with reference to oceanographic domains. Progress in Oceanography 55:249–261.

Morata, N., P. E. Renaud, S. Brugel, K. A. Hobson, and B. J. Johnson. 2008. Spatial and seasonal variations in the pelagic-benthic coupling of the southeastern Beaufort Sea revealed by sedimentary biomarkers. Marine Ecology Progress Series, 371:47-63.

Moulton, V. D., and J. W. Lawon. 2002. Seals, 2001. In: W. J. Richardson, ed., Marine mammal and acoustical monitoring of WesternGeco's open water seismic program in the Alaskan Beaufort Sea, 2001. Rep. from LGL Ltd., King City, ON, and Greeneridge Sciences Inc., Santa Barbara, CA, for WesternGeco, Houston, TX, USA, and Nat. Mar. Fish. Serv., Anchorage, AK, USA, and Silver Spring, MD, USA. LGL Rep. TA2564-4.

Moulton, V. D., J. W. Richardson, T. L. McDonald, R. E. Elliott, and M. T. Williams. 2002. Factors influencing local abundance and haulout behavior of ringed seals (*Phoca hispida*) on landfast ice of the Alaskan Beaufort Sea, Can. J. Zool. 80:1900-1917.

Mundy, C. J. et al. 2009. Contribution of under-ice primary production to an ice-edge upwelling phytoplankton bloom in the Canadian Beaufort Sea. Geophys. Res. Lett. 36:L17601.

Murty, T. S., S. Venkatesh, M. B. Danard, and M. I. El-Sabh. 1995. Storm surges in Canadian Waters. Atmosphere-Ocean. 33(2), 359-387.

Nachtigall, P. E., A. Y. Supin, and M. Amundin. 2007. Polar Bear *Ursus maritimus* Hearing Measured with Auditory Evoked Potentials. Journal of Experimental Biology. Vol: 210 Issue: 7, pp. 1116-1122.

Nagy, J. A., W. H. Wright, T. M. Slack, and A. M. Veitch. 2005. Seasonal Ranges of the Cape Bathurst, Bluenose-West, and Bluenose-East Barren-Ground Caribou Herds. Manuscript Report No. 167. Government of the Northwest Territories, Yellowknife, NT. 44 pp.

NEB (National Energy Board Canada) Offshore Waste Treatment Guidelines. Available at: http://www.neb-one.gc.ca/clf-nsi/rpblctn/ctsndrgltn/rgltnsndgdlnsprsnttthrct/ffshrwsttrtmntgdln2010/ffshrwsttrtmntgdln2010-eng.html#s2_6. Accessed on April 1, 2013.

NEB Offshore Chemical Selection Guidelines for Drilling and Production Activities on Frontier Lands, 2009. Available at: www.cnlopb.nl.ca/pdfs/guidelines/ocsg.pdf. Accessed on April 9, 2013.

Nicolaus, M., S. Gerland, S. R. Hudson, S. Hanson, J. Haapala, and D. K. Perovich. 2010. Seasonality of spectral albedo and transmittance as observed in the Arctic Transpolar Drift in 2007. Journal of Geophysical Research. 115 (No. C11).

Niemi, A., J. Johnson, A. Majewski, H. Melling, J. Reist, and W. Williams. 2012. State of the Ocean Report for the Beaufort Sea Large Ocean Management Area. Can Manu Rep Hydrogr Oc Sci No 2977, 57 pp. Fs97-4/2977E.

Nishi, J. S., and A. Gunn. 2004. An Estimate of Herd Size for the Migratory Dolphin and Union Caribou Herd During the Rut (October 17–22, 1997). File report No. 131. Government of the Northwest Territories, Department of Resources, Wildlife and Economic Development. Yellowknife, NT. 62 pp.

North/South Consultants Inc. 2003. Ecological Assessment of the Beaufort Sea Beluga Management Plan – Zone 1(a) as a Marine Protected Area. Prepared for the Beaufort Sea Integrated Management Planning Initiative (BSIMPI) Working Group.

Norton, P., and L. A. Harwood. 1986. Distribution, abundance and behaviour of white whales in the Mackenzie estuary. Environmental Studies Revolving Funds, Report No. 036. Ottawa, ON. 73 p.

NSDIC (National Snow and Ice Data Center). 2013. Factors Affecting Arctic Weather and Climate: http://nsidc.org/cryosphere/arctic-meteorology/factors_affecting_climate_weather.html. Accessed in April 2013.

NWTBS (Northwest Territories Bureau of Statistics). 2012a. 2011 NWT Socio-Economic Scan. Available at: http://www.statsnwt.ca/publications/socio-economic_scan/StatSup(2011).xlsx. Accessed in April 2013.

NWTBS. 2012b. Summary of NWT Community Statistics. Available at: http://www.statsnwt.ca/community-data/Summary%20of%20NWT%20Statistics%202012.pdf. Accessed in April 2013.

NWTBS. 2013b. Community Population by Ethnicity, 2001-2012. Available at: http://www.statsnwt.ca/population/population-estimates/commethnicity.xlsx. Accessed in March 2013.

NWTBS. 2013c. Community Population by Ethnicity, 2001-2012. Available at: http://www.statsnwt.ca/population/population-estimates/commethnicity.xlsx. Accessed in March 2013.

NWTBS. 2013d. NWT Labour Force Activity – February 2013. Available at: http://www.statsnwt.ca/labour-income/labour-force-activity/Monthly/Feb13NewStatsLF.pdf. Accessed in March 2013.

NWTBS. 2013e. Labour Market Activity Monthly: rates. Available at: http://www.statsnwt.ca/indicators/employment_unemployment. Accessed in April 2013.

NWTBS. 2013f. Table V2091177 – Unemployment rate – Seasonally Unadjusted. Available at: http://www.statsnwt.ca/TSR/series.php?seriesid=V2091177. Accessed in April 2013.

Osborne, P. D., D. Fissel, T. Mudge, M. G. Lowings, J. Hawkins, N. Darlow, Y. Gratton, C. Pyć, D. Driver, M. Fortier, and K. Lévesque. 2012. Observations of currents, salinity, and temperature in the Ajurak and Pokak exploration license areas of the Canadian Beaufort Sea, July 2009 to September 2012. Abstract and poster presentation, United States – Canada Northern Oil and Gas Research Forum, November 13-15, 2012, Anchorage, AK, USA.

Overland, J. E. 1990. Prediction of vessel icing for near-freezing sea temperatures. Weather and Climate, 5, 62-77.

Overland, J. E. 2009. Meteorology of the Beaufort Sea. Journal of Geophysical Research, 114. doi: 10.1029/2008jc004861.

Overland, J. E., C. H. Pease, R. W. Preisendorfer, and A. L. Comiskey. 1986. Prediction of vessel icing. Journal of Climate and Applied Meteorology, 25, 1793-1806.

Overland, J. E., J. Key, B. E. Kim, S. J. Liu, J. Walsh, M. Wang, and U. Bhatt. 2012. Air temperature, atmospheric circulation and clouds. In Arctic Report Card 2012: http://www.arctic.noaa.gov/reportcard/.

Owens, C. K., and R. S. Belore, 2004. Dispersant Effectiveness Testing in Cold Water and Brash Ice, In the Proceedings of the 27th Arctic and Marine Oil Spill Program (AMOP Technical Seminar. Environment Canada, Ottawa, ON. pp. 855-878.

Paetkau, D., I. Stirling, W. Calvert, and C. Strobeck. 1995. Microsatellite analysis of population structure in Canadian polar bears. Molecular Ecology 4(3):347-354.

Panova, E. M., R. A. Belikov, A. V. Agafonov, and V. M. Bel'kovich. 2012. The relationship between the behavioural activity and the underwater vocalizations of the beluga whale (*Delphinapterus leucas*). Oceanology. 52(1):79-87.

Paulatuk (The Community of Paulatuk, the Wildlife Management Advisory Council (NWT) and the Joint Secretariat). 2008. Paulatuk Community Conservation Plan: A plan for the conservation and management of renewable resources and lands within the Inuvialuit Settlement Region in the vicinity of Paulatuk, NT. November 2008.

Percy, R., B. Smiley, and T. Mullen. 1985. Fishes, Invertebrates and Marine Plants. Beaufort Sea Project. 167 p.

Pickart, R. S, L. M. Schulze, G. W. K. Moore, M. A. Charette, K. Arrigo, G. van Dijken, and S. Danielson. 2013. Long–term Trends of Upwelling and Impacts on Primary Productivity in the Alaskan Beaufort Sea. Deep-Sea Research I, accepted for publication.

Pickart, R. S., M. A. Spall, G. W. K. Moore, T. J. Weingartner, R. A. Woodgate, K. Aagaard, and K. Shimada. 2011. Upwelling in the Alaskan Beaufort Sea: Atmospheric forcing and local versus on-local response, Progress in Oceanography, 88, 78–100.

Popper, A. N., and M. C. Hastings. 2009. Effects of Anthropogenic Sources of Sound on Fishes. J. Fish Biol. 75:455-498.

Popper, A. N., and R. R. Fay. 1973. Sound detection and processing by teleost fishes: A critical review. Journal of the Acoustical Society of America, 53:1515-1529.

Popper, A. N., and R. R. Fay. 1999. The auditory periphery in fishes. In: R. R. Fay, and A. N. Popper, editors. Comparative Hearing: Fish and Amphibians. New York, NY, USA: Springer-Verlag. p 43 -100.

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. MacGillivray, M. E. Austin, and D. A. Mann. 2005. Effects of exposure to seismic air gun use on hearing of three fish species. Journal of Acoustical Society of America 117(6):3958-3971.

Popper, A. N., R. R. Fay, C. Platt, and O. Sand. 2003. Sound detection mechanisms and capabilities of teleost fishes. In: S. P. Collin, and N. J. Marshall, editors. Sensory Processing in Aquatic Environments. New York, NY, USA: Springer-Verlag. p 3-38.

Popper, A. N., T. J. Carlson, A. D. Hawkins, B. L. Southall, and R. L. Gentry. 2006. Interim criteria for injury of fish exposed to pile driving operations: A white paper.

Popper, A. N. and R. R. Fay. 1993. Sound Detection and Processing by Fish: Critical Review and Major Research Questions (Part 1 of 2). Brain Behav Evol 1993. 41:14-25.

Proshutinsky, A., M. L. Timmermans, I. Ashik, A. Beszczynska-Moeller, E. Carmack, J. Eert, I. Frolov, M. Itoh, T. Kikuchi, R. Krishfield, F. McLaughlin, B. Rabe, U. Schauer, K. Shimada, V. Sokolov, M. Steele, J. Toole, W. Williams, R. Woodgate, and S. Zimmermann. 2011. Ocean. In: Arctic Report Card 2011. Accessed March 2012 at: http://www.arctic.noaa.gov/reportcard.

Prowse, T., C. Furgal, B. Bonsal, H. Melling, D. Peters, and S. Smith. 2009. Implication of changing climate for northern Canada: Energy, Resource, and Transportation Sectors. Ambio 38:272–281. BioOne.

Rabe, B., M. Karcher, U. Schauer, J. M. Toole, R. A. Krishfield, S. Pisarevc, F. Kauker, R. Gerdes, and T. Kikuchi. 2011. An assessment of Arctic Ocean freshwater content changes from the 1990s to the 2006–2008 period. Deep Sea Research. 58(5):173–185.

Raddatz, R. L., R. J. Galley, and D. G. Barber. 2011. Linking the atmospheric boundary layer to the Amundsen Gulf sea ice cover: a mesoscale to synoptic-scale perspective from winter to summer 2008. Boundary Layer Meteorology. doi: 10.1007/s10546-011-9669-2.

Rainville, L., and R. A. Woodgate. 2009. Observations of internal wave generation in the seasonally ice-free Arctic. Geophys. Res. Lett. 36: L23604. doi: 10.1029/2009GL041291.

Rampal, P., J. Weiss, and D. Marsan. 2009. Positive trend in the mean speed and deformation rate of Arctic sea ice, 1979–2007, J. Geophys. Res., 114, C05013, doi: 10.1029/2008JC005066.

Regehr, E. V., C. M. Hunter, H. Caswell, S. C. Amstrup, and I. Stirling. 2007. Polar Bears in the Southern Beaufort Sea I: Survival and Breeding in Relation to Sea Ice Conditions, 2001-2006. U.S. Geological Survey, Alaska Science Center, Administrative Report. 45 pp.

Regehr, E. V., S. C. Amstrup, and I. Stirling. 2006. Polar Bear Population Status in the Southern Beaufort Sea: U.S. Geological Survey Open-File Report 2006-1337. 20 p.

Regulations for the Prevention of Pollution from Ships and for Dangerous Chemicals (SOR/2007-86) last amended on March 30, 2012. Available at: http://laws-lois.justice.gc.ca/eng/regulations/SOR-2007-86/20110503/P1TT3xt3.html#h-137. Accessed on April 4, 2013.

Reimers, E., and J. E. Colman. 2003. Reindeer and Caribou Response Towards Human Activity. Rangifer (26, 2):55-71.

Renaud, P. E., A. Riedel, C. Michel, N. Morata, M. Gosselin, T. Juul-Pedersen, and A. Chiuchiolo. 2007. Seasonal variation in benthic community oxygen demand: A response to an ice algal bloom in the Beaufort Sea, Canadian Arctic? Journal of Marine Systems, 67:1-12.

Review of Tuktoyaktuk Harbour as a Base for Offshore Oil and Gas Exploration and Development. Environment Research Funds Report No. 179, August 2010.

Richard, P. R., A. R. Martin, and J. R. Orr. 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. Arctic. 54(3):223-236.

Richard, P. R., M. P. Heide-Jorgensen, J. R. Orr, R. Dietz, and T. G. Smith. 2001. Summer and autumn movements and habitat use by belugas in the Canadian high arctic and adjacent areas. Arctic 54: 207-222.

Richardson, J. W., and S. R. Johnson. 1981. Waterbird migration near the Yukon and Alaskan coast of the Beaufort Sea: I. Timing, routes and numbers in spring. Arctic. 34(2):108-121.

Richardson, J. W., R. A. Davis, R. C. Evans, D. K. Ljungblad, and P. Norton. 1987. Summer distribution of bowhead whales, *Balaeana mysticetus*, relative to oil industry activities in the Canadian Beaufort Sea, 1980-1984. Arctic. 40(2):93-104.

Richardson, W. J., B. Wurig, and C. R. Greene Jr. 1990. Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. Marine Environmental Research. 29(2):135-160.

Richardson, W. J., K. J. Finley, G. W. Miller, R. A. Davis, and W. R. Koski. 1995. Feeding, Social and Migration Behavior of Bowhead Whales, *Balaena mysticetus*, in Baffin Bay vs. the Beaufort Sea-Regions with Different Amounts of Human Activity. Mar. Mamm. Sci. 11, 1–45.

Richerol, T., A. Rochon, S. Blasco, D. B. Scott, T. M. Schell, R. Bennett. 2008. Evolution of paleo sea-surface condition over the last 600 years in the Mackenzie Trough, Beaufort Sea (Canada). Marine Micropaleontology. 68, 6-20.

Robert, D., M. Levesque, and J. Gagnon. 2009. Ajurak 2009: Data from the environment and marine resources assessment of the Ajurak Exploration License Area (EL446), Beaufort Sea, in July 2009. Quebec, QC. 70 pp.

Robert, D., M. Levesque, and J. Gagnon. 2010. Ajurak 2009: Data from the environment and marine resources assessment of the Imperial Oil/BP Exploration License Areas 446, 449 and 451 (Beaufort Sea), in the summers of 2009 and 2010. Quebec, QC. 70 p.

Robinson, S. P., P. D. Theobald, G. Hayman, L. S. Wang, P. A. Lepper, V. Humphrey, and S. Mumford. 2011. Measurement of noise arising from marine aggregate dredging operations. Marine Aggregate Levy Sustainability Fund (MALSF), (MEPF Reference number 09/P108), ISBN 978(0907545), 57 p.

Rowlett, R. A., M. A. Smultea, J. Brueggeman, G. A. Green, C. C. Swanson, R. A. Grotefendt, D. P. Volsen, and J. J. Burns. 1993. Polar bear reactions to ice-breaker operations associated with offshore drilling explorations. p. 94. In: Abstracts of the 10th Biennial Conference of Biology of Marine Mammals. Galveston, TX, USA. November 1993. 130 p.

Sachs Harbour (The Community of Sachs Harbour, Wildlife Management Advisory Council (NWT) and Joint Secretariat). 2008. Sachs Harbour Community Conservation Plan: A plan for the conservation and management of renewable resources and lands within the Inuvialuit Settlement Region and in the vicinity of Banksland, NT. July 2008.

Sage, B. 1979. Flare up over North Sea birds. New Scientist 82:464-466.

Salter, R. E., M. A. Gollop, S. R. Johnson, W. R. Koski, and C. E. Tull. 1980. Distribution and abundance of birds on the Arctic Coastal Plain of northern Yukon and adjacent Northwest Territories, 1971-1976. Can. Field-Nat. 94(3):219-238.

Sandstrom, S. 1995. The effect of overwintering site temperature on energy allocation and life history characteristics of anadromous female Dolly Varden (*Salvelinus malma*), from the Yukon and Northwest Territory North Slope, Canada. MSc. thesis, University of Manitoba. 161 p. (Upun-LGL 2013).

SARA (Species at Risk Act). 2012. Species at risk public registry: A to Z species index. Available at: Government of Canada. Ottawa, ON: http://www.sararegistry.gc.ca/sar/index/default_e.cfm. Accessed March 26, 2013.

Schliebe, S., K. Rode, J. Gleason, J. Wilder, K. Proffitt, T. Evans, and S. Miller. 2008. Effects of sea ice extent and food availability on spatial and temporal distribution of polar bears during the fall open-water period in the Southern Beaufort Sea. Polar Biology (31)8:999-1010.

Schliebe, S., T. Evans, K. Johnson, M. Roy, S. Miller, C. Hamilton, R. Meehan, and S. Jarhsdoerfer. 2006. Range-wide Status Review of the Polar Bear (*Ursus maritimus*). U.S. Fish and Wildlife Service. Anchorage, AK, USA. December 21, 2006.

Schulze, L. M., and R. S. Pickart. 2012. Seasonal variation of upwelling in the Alaskan Beaufort Sea: Impact of sea ice cover. J. Geophys. Res., 117, C06022, doi: 10.1029/2012JC007985.

Scott, D. B., T. Schell, A. Rochon, S. Basco. 2008. Benthic formaminfera in the surface sediments of the Beaufort Shelf and slope, Beaufort Sea, Canada: Applications and implications for past sea-ice conditions. Journal of Marine Systems. V.74, Issue 3-4, 840-863.

Serreze, M. C., and R. G. Barry. 2011. Processes and impacts of Arctic amplification: A research synthesis. Global and Planetary Change. 77:85-96.

Shaw, G. E. 1995. The Arctic Haze Phenomenon. Bull Am. Met. Soc 76(12):2403-2413.

Siferd, T. D. 2001. Sachs Harbour benthic community survey: Summary of results 1999-2000. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2366: 47 p.

SINTEF. 2010. Joint Industry Program on Oil Spill Contingency for Arctic and Ice-Covered Waters. Report No. 32. 39 p.

Sjare, B. L., and T. G. Smith. 1986. The vocal repertoire of white whales, *Delphinapterus leucas*, summering at Cunningham Inlet, Northwest Territories. Can. J. Zool. 64(2):407-415.

SL Ross Environmental Research Ltd. 2011. Spill Response Gap Study for the Canadian Beaufort Sea and the Canadian Davis Strait. Report to National Energy Board, Contract 11027, Calgary, AB. 37 pp.

Solomon and Forbes. 1994.

Statistics Canada. 2012a. CANSIM Table 384-0038 (Gross domestic product, expenditure-based, by province and territory). Available at: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ15-eng.htm. Accessed in April, 2013.

Statistics Canada. 2012b. CANSIM Table 051-0001 (Population by sex and age group, by province and territory). Available at: http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/demo31a-eng.htm. Accessed in April, 2013.

Steele, M., J. Morison, W. Ermold, I. Rigor, M. Ortmeyer, and K. Shimada. 2004. Circulation of summer Pacific halocline water in the Arctic Ocean, J. Geophys. Res., 109, C02027, doi: 10.1029/2003JC002009.

Steidl, R. J., and R. G. Anthony. 2000. Experimental effects of human activity on breeding bald eagles. Ecological Applications 10(1):258-268.

Stewart, D. B., and W. L. Lockhart. 2005. An overview of the Hudson Bay marine ecosystem. Canadian Technical Report of Fisheries and Aquatic Sciences. Report No. 2586. 487 pp.

Stirling, I. 1973. Vocalization in the ringed seal (*Phoca hispida*). J. Fish. Res. Board Can. 30(10):1592-1594.

Stirling, I. 1988. Attraction of polar bears, *Ursus maritimus,* to offshore drilling sites in the eastern Beaufort Sea. Polar Rec. 24(148):1-8.

Stirling, I., T. L. McDonald, E. S. Richardson, E. V. Regehr, and S. C. Amstrup. 2011. Polar bear population status in the northern Beaufort Sea, Canada, 1971–2006. Ecological Applications 21:859–876.

Suydam, R. S., D. L. Dickson, J. B. Fadely, and L. T. Quakenbush. 2000. Population declines of King and Common Eiders of the Beaufort Sea. Condor. 102:219-222.

Swail, V. R., V. J. Cardonne, B. Callahan, M. Ferguson, D. J. Gummer, and A. T. Cox. 2007. The MSC Beaufort Wind and Wave Reanalysis. Proceedings, 10th International Conference on Wave Forecasting and Hindcasting, Hawaii, USA. November 2007.

Terhune J. M., and K. Ronald. 1975. Underwater hearing sensitivity of two ringed seals (*Pusa hispida*). Can. J. Zool. 53(3):227-231.

Terhune, J. M. 1981. Influence of loud vessel noises on marine mammal hearing and vocal communication. In: N. M. Peterson, editor. The question of sound from icebreaker operations: The proceedings of a workshop. Arctic Pilot Proj., Petro-Canada, Calgary, AB. p. 270-286.

Terhune, J. M., and K. Ronald. 1972. The harp seal, *Pagophilus groenlandicus,* (Erxleben, 1777). III. The underwater audiogram. Can. J. Zool. 50(5):565-569.

Terhune, J. M., and W. C. Verboom. 1999. Right whales and ship noise. Marine Mammal Science 15(1):256-258.

Thode, A., K. H. Kim, C. R. Greene, and E. Roth. 2010. Long range transmission loss of broadband seismic pulses in the Arctic under ice-free conditions. J. Acoust. Soc. Am. 128(4), October 2010, EL181-EL187. WMAC-NWT (Community of Inuvik, Wildlife Management Advisory Council [NWT] and the Joint Secretariat). 2008. Inuvik Inuvialuit Community Conservation Plan (CCP). November 2008. 155 pp.

Thomas, J. A., S. Leatherwood, W. E. Evan, J. R. Jehl Jr., and F. T. Awbrey. 1981. Ross Sea killer whale distribution, behavior, color pattern, and vocalizations. Antarct. J.U.S. 16:157-158.

Thomson, D. H., D. B. Fissel, J. R. Marko, R. A. Davis, and G. A. Borstad. 1986. Distribution of bowhead whales in relation to hydrometeorological events in the Beaufort Sea. Environmental Studies Revolving Funds Report No. 028. Ottawa, ON. 119 p.

Törnqvist, T. E., S. R. Wortman, Z. R. P. Mateo, G. A. Miline, and J. B. Swenson. 2006. Did the last sea level lowstand always lead to cross-shelf valley formation and source-to-sink sediment flux? J. Geophys. Res.111, F04002, doi: 1029/2005JF000425, 13 p.

Treacy, S. D., J. S. Gleason, and C. J. Cowles. 2006. Offshore distances of bowhead whales (*Baleana mysticetus*) observed during fall in the Beaufort Sea, 1982-2000: An alternative interpretation. Arctic. 59(1):83-90.

Tremblay, J. E., and J. Gagnon. 2009. In Influence of Climate Change on the Arctic and Subarctic Conditions, J. C. J. Nihoul, A. G. Kostianoy (Eds.). Springer Science Business Media B.V., Dordrecht, Netherlands, 2009: pp. 73–93.

Tuktoyaktuk (The Community of Tuktoyaktuk, the Wildlife Management Advisory Council (NWT) and the Joint Secretariat). 2008. Tuktoyaktuk Community Conservation Plan: A Plan for the conservation and management of natural resources and lands within the Inuvialuit Settlement Region in the vicinity of Tuktoyaktuk, NT. April 2008.

Turner, M., J. Skinner, J. Roberts, R. Harvey, and S. L Ross. Environmental Research Ltd. 2010. Review of Offshore Oil-spill Prevention and Remediation

Requirements and Practices in Newfoundland and Labrador. St. John's: Government of Newfoundland and Labrador.

Ulukhaktok (The Community of Ulukhaktok, the Wildlife Management Advisory Council (NWT) and the Joint Secretariat). 2008. Olokhaktomiut Community Conservation Plan: A plan for the conservation and management of renewable resources and lands within the Inuvialuit Settlement Region in the vicinity of Ulukhaktok, NT. July 2008.

Urick, R. J. 1975. Rician Distribution and the Amplitude Fluctuation of Transmitted Signals in the Sea. The Journal of the Acoustical Society of America 57.s1 S59-S60. American Institute of Physics.

US EPA. 2009. Regulatory Announcement: EPA Finalizes More Stringent Standards for Control of Emissions from New Marine Compression-Ignition Engines at or Above 30 Litres per Cylinder. Office of Transportation and Air Quality. EPA-420-F-09-069. December 2009.

Vanderlaan, A. S. M., and C. T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Society for Marine Mammalogy 23(1):144-156.

Wacasey, J. W. 1975. Biological productivity of the southern Beaufort Sea: Zoobenthic studies. Beaufort Sea Project Study Technical Report. Environment Canada. No. 12B.

Wacasey, J. W., E. G. Atkinson, L. Derick, and A. Weinstein. 1977. Zoobenthos data from the southern Beaufort Sea, 1971-1975. Fisheries Marine Services Data Report, 41: 187 pp.

Wadhams, P. 2000. Ice in the Ocean. Gordon and Breach Science Publishers, Amsterdam, 351 p.

Ward, D. H., and R. A. Stehn. 1989. Response of brant and other geese to aircraft disturbances at Izembek Lagoon, AK. MMS-90/0046 Final Report to Minerals Management Service. 14-12-0001-30332. U.S. Fish Wildlife Service. Anchorage, AK. 265 pp.

Wassmann, P. et al. 2006. Food web and carbon flux in the Barents Sea. Prog. Oceanogr. 71:232.

Wassmann, P., D. Slagstad, and I. H. Ellingsen. 2010. Primary production and climatic variability in the European sector of the Arctic Ocean prior to 2007: Preliminary results. Polar Biol. 33:1641-1650.

Welch, D. M. 1993. Geomorphology of the Northern Yukon National Park. Northern Yukon National Park Resources Description and Analysis: Resource Management Report 93-01/INP, Natural Resource Conservation Section, Prairie and Northern Region, Canadian Parks Service. Winnipeg, MB.

Whittles, M. 2005. Economic development as if culture matters: Inuvialuit wild game harvesting, community-based economic development, and cultural maintenance in the western Arctic. The Journal of Aboriginal Economic Development 4:129-140.

Wiese, F., W. Montevecchi, G. Davoren, F. Huettman, A. Diamond, and J. Linke. 2001. Seabirds at Risk Around Oil Platforms. Mar. Pollut. Bull. p 42.

Williams, W. J., and E. C. Carmack. 2008. Combined effect of wind-forcing and isobath divergence on upwelling at Cape Bathurst, Beaufort Sea. Journal of Marine Research. 66:645–663.

Williams, W. J., E. C. Carmack, K. Shimada, H. Melling, K. Aagaard, R. W. Macdonald, and R. G. Ingram. 2006. Joint Effects of Wind and Ice Motion in Forcing Upwelling in Mackenzie Trough, Beaufort Sea, Continental Shelf Research, 26, 2352-2366.

WMAC (Wildlife Management Advisory Council). 2000a. Aklavik Inuvialuit Community Conservation Plan. 166 pp.

WMAC. 2000b. Inuvik Inuvialuit Community Conservation Plan. 160 pp.

WMAC. 2000c. Tuktoyaktuk Inuvialuit Community Conservation Plan. 168 pp.

Wong, P.-L. 2000. A summary and synthesis of benthic literature from southeastern Beaufort Sea. Unpublished report for the Department of Fisheries and Oceans. Winnipeg, MB. 30 p.

Wood, D. 1999. Hibernia, Air Canada EnRoute. 48-57.

Working Group on General Status of NWT Species. 2011. NWT Species 2011-2015 – General Status Ranks of Wild Species in the Northwest Territories, Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT. 172 pp.

Wursig, B., E. M. Dorsey, M. A. Fraker, R. S. Payne, and J. W. Richardson. 1985. Behaviour of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: A description. Fishery Bulletin 83(3):357-377.

Yamamoto-Kawai, M., F. A. McLaughlin, E. C. Carmack, S. Nishino, K. Shimada, and N. Kurita. 2009. Surface freshening of the Canada Basin, 2003-2007: River runoff versus sea ice meltwater. Journal of Geophysical Research, 114, doi: 10.1029/2008JC005000.

Yunker, M. B., L. R. Snowden, R. W. Macdonald, J. N. Smith, M. G. Fowler, D. N. Scibo, F. A. McLaughlin, A. I. Danyushevskay, V. I. Petrova, and G. I. Ivanov. 1996. Polycyclic aromatic hydrocarbon composition and potential sources for sediment samples from the Beaufort and Barents Seas. Env. Sc. Tech. 30(4):1310-1320.

Yunker, M. B., R. W. Macdonald, W. J Cretney, B. R. Fowler, and F. A. McLaughlin. 1993. Alkane, terpene, and polycyclic aromatic hydrocarbon geochemistry of the Mackenzie River and Mackenzie Shelf: Riverine contributions to Beaufort Sea coastal sediment. Geochim Cosmochim Acta. 57:3041-3061.

Zeh, J. E., and A. E. Punt. 2005. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. J. Cetacean Res. Manage. 7(2):169-175.

Zelick, R., D. Mann, and A. N. Popper. 1999. Acoustic communication in fishes and frogs. In: R. R. Fay, A. N. Popper, editors. Comparative Hearing: Fish and Amphibians. New York, NY, USA: Springer-Verlag. p. 363-411.

Zhang, J., R. Lindsay, A. Schweiger, and M. Steele. 2013. The Impact of an Intense Summer Cyclone on 2012 Arctic Sea Ice Retreat. Geophys. Res. Lett. 40(4). p. 720–726. doi: 10.1002/grl.50190.

Zhange, J., Y. H. Spitz, M. Steele, C. Ashjian, R. Campbell, L. Berline, and P. Matrai. 2010. Modeling the impact of declining sea ice on the Arctic marine planktonic ecosystem. Journal of Geophysical Research. 115:C10015.

GLOSSARY

°C	The metric symbol for degrees Celsius.
°F	The metric symbol for degrees Fahrenheit.
%	The abbreviation for percent.
‰	The abbreviation for parts per thousand.
>	The symbol for greater than.
±	The symbol for plus or minus.
μmol	The symbol for micromole.
μPa	The symbol for micropascal (pressure).
2-D	The abbreviation for two dimensional.
3-D	The abbreviation for three dimensional.
AANDC	The abbreviation for Aboriginal Affairs and Northern Development Canada (formerly INAC).
AODR	The abbreviation for the NEB's Arctic Offshore Drilling Review.
Atlantic water	The abbreviation for Atlantic Ocean water.
bbl	The abbreviation for barrel.
BOP	The abbreviation for blowout preventer.
BP	The abbreviation for BP Exploration Operating Company Limited.
BREA	The abbreviation for Beaufort Regional Environmental Assessment program.
BSEE	The abbreviation for Bureau of Safety and Environmental Enforcement.
CAC	The abbreviation for criteria air contaminant.
CCG	The abbreviation for Canadian Coast Guard.

CCGS	The abbreviation for Canadian Coast Guard Ship.
CCP	The abbreviation for community conservation plan.
CEAA, 2012	The abbreviation for *Canadian Environmental Assessment Act, 2012*.
cm	The metric symbol for centimetre.
cm/s	The metric symbol for centimetres per second.
CO	The chemical formula for carbon monoxide.
CO_2	The chemical formula for carbon dioxide.
COGOA	The abbreviation for *Canada Oil and Gas Operations Act*.
COSEWIC	The abbreviation for the Committee on the Status of Endangered Wildlife in Canada.
CWS	The abbreviation for Canadian Wildlife Service.
dB	The abbreviation for decibels.
dB re 1 µPa-m	The theoretical sound pressure level under water within 1 m of the source.
DFO	The abbreviation for Fisheries and Oceans Canada.
DP	The abbreviation for dynamic positioning.
EC	The abbreviation for Environment Canada.
EIRB	The abbreviation for Environmental Impact Review Board.
EIS	The abbreviation for Environmental Impact Assessment.
EISC	The abbreviation for Inuvialuit Environmental Impact Screening Committee.
EL	The abbreviation for exploration licence.
EMDC	The abbreviation for ExxonMobil Development Company.
EPP	The abbreviation for Environmental Protection Plan.
ERCB	The abbreviation for Alberta Energy Resources Conservation Board.
ERP	The abbreviation for Emergency Response Plan.
ExxonMobil	The abbreviation for ExxonMobil Canada Ltd.

FDCP	The abbreviation for field data collection program.
FJMC	The abbreviation for Fisheries Joint Management Committee.
ft	The abbreviation for foot.
GHG	The abbreviation for greenhouse gas.
GNWT	The abbreviation for Government of the Northwest Territories.
GNWT-ENR	The abbreviation for the Government of the Northwest Territories Department of Environment and Natural Resources.
H_2S	The chemical symbol for hydrogen sulphide.
hp	The abbreviation for horsepower.
HTC	The abbreviation for Hunters and Trappers Committee.
Hz	The abbreviation for hertz.
IACS	The abbreviation for International Association of Classification Societies Ltd.
IFA	The abbreviation for Inuvialuit Final Agreement.
IFC	The abbreviation for International Finance Corporation.
IGC	The abbreviation for Inuvialuit Game Council.
ILA	The abbreviation for Inuvialuit Land Administration.
IMO	The abbreviation for the International Maritime Organization.
IMP	The abbreviation for Ice Management Plan.
Imperial	The abbreviation for Imperial Oil Resources Ventures Limited.
IRC	The abbreviation for the Inuvialuit Regional Corporation.
ISR	The abbreviation for Inuvialuit Settlement Region.
JRP	The abbreviation for Joint Review Panel.
kHz	The abbreviation for kilohertz.
km	The metric symbol for kilometre.
km^2	The metric symbol for square kilometres.

km^3	The metric symbol for cubic kilometres.
KOPRI	The abbreviation for the Korea Polar Research Institute.
kPa	The metric symbol for kilopascal.
L	The metric symbol for litre.
LOMA	The abbreviation for large ocean management area.
LSA	The abbreviation for local study area.
m	The metric symbol for metres.
m^3	The metric symbol for cubic metres.
m/s	The metric symbol for metres per second.
m/yr	The metric symbol for metres per year.
m^3/s	The metric symbol for cubic metres per second.
MARPOL 73/78	The abbreviation for the International Convention for the Prevention of Pollution from Ships.
MBARI	The abbreviation for the Monterey Bay Aquarium Research Institute.
MEPC	The abbreviation for the Marine Environment Protection Committee.
mg	The metric symbol for milligrams.
mm	The metric symbol for millimetres.
mm/yr	The metric symbol for millimetres per year.
MMMP	The abbreviation for Marine Mammal Management Plan.
MMO	The abbreviation for marine mammal observer.
MPA	The abbreviation for marine protected area.
NADF	The abbreviation for nonaqueous drilling fluid.
NEB	The abbreviation for National Energy Board.
NEBA	The abbreviation for net environmental benefit analysis.
NO	The chemical formula for nitric oxide.
NO_2	The chemical formula for nitrogen dioxide.

NO_x	The chemical formula for oxides of nitrogen.
NRCan	The abbreviation for Natural Resources Canada.
NWT	The abbreviation for Northwest Territories.
NWTBS	The abbreviation for Northwest Territories Bureau of Statistics.
O_3	The chemical formula for ozone.
OA	The abbreviation for operations authorization.
OEM	The abbreviation for original equipment manufacturer.
OIMS	The abbreviation for Operations Integrity Management System.
OSRP	The abbreviation for Oil Spill Response Plan.
Pacific water	The abbreviation for Pacific Ocean water.
PAH	The abbreviation for polycyclic aromatic hydrocarbons.
PD	The abbreviation for Project Description.
PEMT	The abbreviation for Petroleum and Environmental Management Tool.
PIP	The abbreviation for Preliminary Information Package.
$PM_{2.5}$	The abbreviation for particulate matter 2.5 microns or less.
PM_{10}	The abbreviation for particulate matter 10 microns or less.
ppm	The abbreviation for parts per million.
program or exploration program	The abbreviation for the Beaufort Sea Exploration Joint Venture Drilling Program.
psi	The abbreviation for pounds per square inch.
R&D	The abbreviation for research and development.
RSA	The abbreviation for regional study area.
SARA	The abbreviation for *Species at Risk Act*.
SDL	The abbreviation for significant discovery licence.
SO_2	The chemical formula for sulphur dioxide.
SO_x	The chemical formula for oxides of sulphur.

SSA	The abbreviation for site study area.
SSHE	The abbreviation for safety, security, health and environment.
SSRW	The abbreviation for same season relief well.
TC	The abbreviation for Transport Canada.
US	The abbreviation for United States.
US EPA	The abbreviation for United States Environmental Protection Agency.
USGS	The abbreviation for United States Geological Survey.
VEC	The abbreviation for valued ecosystem component.
VOC	The abbreviation for volatile organic compound.
VSP	The abbreviation for vertical seismic profiling.
WA	The abbreviation for well approval.
WMAC NS	The abbreviation for Wildlife Management Advisory Council – North Slope.
WMAC NWT	The abbreviation for Wildlife Management Advisory Council of the Northwest Territories.
WMP	The abbreviation for Waste Management Plan.
yr	The abbreviation for year.