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MAIL ROOM
SALLE DE COURIER
2011 MAY -3 A 11:04
NEB/ONE

April 29, 2011

Christy Wickenheiser
Environmental Specialist
National Energy Board
444 Seventh Avenue SW
Calgary, Alberta
T2P 0X8

Dear Sir/Madame:

RE: 2D Seismic Survey offshore Baffin Bay/Davis Strait 2011.

TGS-NOPEC Geophysical Company ASA (hereinafter referred to as TGS) & Multi Klient Invest AS (hereinafter referred to as KMI or the Operator) a company associated with Petroleum GeoServices (herein referred to as PGS) have entered into a joint venture to conduct a regional marine 2D (two-dimensional) seismic reflection survey offshore Baffin Bay, Davis Strait within the regulatory jurisdiction of the National Energy Board (NEB).

As you are aware, Federal coordination was initiated for this project in the spring of 2010, however the project was suspended until 2011 and the project area has since expanded and Federal coordination initiated for 2011 program.

Under section 5 of the Canadian Environmental Assessment Act, an Environmental Assessment is required because the National Energy Board may take action in relation to paragraph 5 (1) (b) of the Canada Oil and Gas Operations Act for the purpose of enabling the project to be carried out in whole or in part.

Attached you will find three hard copies of the Environmental Assessment and three electronic copies.

If you require anything further, please donot hesitate to contact me.

Regards,

Darlene Davis

Darlene Davis
Project Manager
RPS Energy
Tel: (902) 492-0281
Cell☹902) 790-1212

ENVIRONMENTAL IMPACT ASSESSMENT FOR MARINE 2D SEISMIC REFLECTION SURVEY BAFFIN BAY AND DAVIS STRAIT OFFSHORE EASTERN CANADA BY MULTI KLIENT INVEST AS

Report No. HOPH417(B)

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Date of Issue April 28, 2011

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NON TECHNICAL SUMMARY

TGS-NOPEC Geophysical Company ASA (hereinafter referred to as TGS) & Multi Klient Invest AS (hereinafter referred to as KMI or the Operator) a company associated with Petroleum GeoServices (herein referred to as PGS) have entered into a joint venture to conduct a regional marine 2D (two-dimensional) seismic reflection survey offshore Baffin Bay, Davis Strait within the regulatory jurisdiction of the National Energy Board (NEB).

This Environmental Assessment prepared by RPS Energy assesses potential impacts from the proposed operations on the surrounding environment.

The main sensitivities and environmental constraints identified in this area include marine mammal and fish species, benthic and pelagic habitats, and resident breeding and migrant bird species.

An appreciation of the traditional knowledge was obtained by consulting two major studies: The Nunavut Wildlife Harvest Study (Nunavut Wildlife Management Board, August 2004), and the Final Report of the Inuit Bowhead Knowledge Study (Nunavut Wildlife Management Board, March 2000).

The operator will use mitigation measures to minimize the impacts on the marine environment, in particular "The Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment." (Appendix A).

Contractors must have in place Shipboard Oil Pollution Emergency Plans (SOPEP) to combat any spills and ensure adequate training for all crew members. For port spills Port Oil Contingency Plan must be adhered to.

It must be ensured that waste segregation, handling and disposal are carried out in line with existing company and contractor environmental policies and standards. Any hazardous wastes produced throughout the course of operations should be disposed of with great care and in conformity with environmental aims, objectives, and Canada legislation.

The environmental performance of any project is dependent largely on the commitment of the contractors involved. MKI must employ best practice in pollution prevention programmes to effectively protect the environment. They must also ensure that contractors employ best environmental practice in their waste disposal programmes and spill contingency planning.

To this end, an Operational Project Plan incorporating the measures specified in the Environmental Protection Plan will be implemented to ensure operations are completed in full compliance of the company's stated environmental aims and objectives. This will facilitate the final planning, implementation, and follow-up activities associated with the operations.

MKI representatives need to monitor contractors and measure their practices through active programmes that are reviewed at regular intervals. This will help ensure that operations are carried out in an environmentally acceptable manner.

1. INTRODUCTION

In accordance with the Canadian Environmental Assessment Act (CEAA) and based on the information presented in the project description “Project Description for 2D Marine Seismic Survey Offshore Baffin Bay, Davis Strait (MKI December 2010). This document is a screening level environmental assessment (EA) as defined by the Canadian Environmental Assessment Act (CEAA) for a multi-year seismic program (2011-2015) proposed for Baffin Bay/Davis Strait by MKI.

In early January, representatives of RPS Energy and Environmental Manager for PGS travelled to Iqaluit for consultation meetings with several Federal and territorial groups for in person meetings to explain the potential project and seek information which could be used in this assessment and project planning.

They included:

- Department of Economic Development
- Department of Environment
- Fisheries and Sealing’s
- Manager of Mineral Resources
- Resources Development Advisor
- Department of Fisheries
- Indian Northern Affairs Canada
- Nunavut Development Corporation
- Nunavut Research Institute
- Quikiqtani Inuit Association (QIA)

It was determined in these meetings that based on the previous years concerns re: Lancaster Sound, that there were many concerns and questions with regards to seismic activity in Baffin Bay with the local communities.

In mid February RPS representatives on behalf of MKI travelled to several Inuit communities to share information and seek assistance in the preparation of the program. A representative of INAC (Petroleum Advisor) travelled along with our group. The Petroleum Advisor attended the meetings to advise the communities that INAC would be returning to speak with them on a future date concerning the possibility of opening lease blocks in Baffin Bay. A member of QIA also was invited and attended our meeting in Pond Inlet. (QIA/ Nigel Qaumariaq).

We had tried to schedule a meeting in Pangnirtung with no success. The manager of their Hunters and Trappers Association had left the position and they were in the process of seeking a replacement.

The Meetings were held in the following communities:

- Clyde River
- Pond Inlet
- Qikiqtarjuaq
- Iqaluit

A brief meeting was held in Iqaluit with the Manager of the HTO group, to briefly explain the project.

In addition to the above meetings, direct email contact was made with the following stakeholders;

- Parks Canada
- WWF-Canada
- Nunavut Planning Commission
- NIRB
- Baffin Fisheries Coalition
- Nunavut Wildlife Management Board
- Nunavut Tunngavik Inc.

You can find the minutes of the meetings in (Appendix B).

The meetings were held with Hunters and Trappers Association members in each community listed here. It was asked that we return for a public meeting in the communities.

Time didn't seem to allow for these meetings between our return and end March. As I understand it; INAC and NEB were also scheduling meetings in March month. In April a notice was sent around advising the communities of our intention to conduct public meetings from May 1-6th in Iqaluit, Clyde River, Pond Inlet, Quik and Pang. However, these meetings were cancelled at the last minute due to negative feedback with regards to public meetings during election week.

Best efforts are now being made for public meetings prior to the end of May 2011.

This EA has been based on the information available, which we believe is adequate to complete this assessment.

2. REGULATORY REQUIREMENTS AND JURISDICTION

Authorizations to Conduct a Geophysical Program will be required from the National Energy Board (NEB). As the federal authority that received the project description, the NEB will distribute to the other federal authorities, which may also have a responsibility or interest and need to be notified. The NEB has been appointed Federal Environmental Assessment Coordinator (FEAC) under the CEAA for this project, and in this role is responsible for coordinating the review activities of the federal and provincial authorities participating as expert departments in the environmental assessment.

Geophysical programs (seismic surveys) in the area proposed for this project require authorization from the National Energy Board (NEB). The Canadian Environmental Assessment Act (CEAA) requires federal authorities to conduct environmental assessments (EA) before issuing regulatory permits for certain projects (Section 5(1) d).

Legislation that is relevant to the environmental aspects of this Project is provided
Table 1

Table 1. Summary of Authorizing Agencies

Instrument and Legislation	Agency	Activities	Remarks
• Canada Environmental Assessment Act (CEAA) • Canada Environmental Protection Act (CEPA) • Oceans Act • Fisheries Act • Navigable Waters Act • Canada Shipping Act • Migratory bird Convention Act • Species at Risk Act (SARA) • Canada Oil and Gas Operations Act	National Energy Board (NEB)	Geophysical Operation Authorization	Screening required pursuant to CEAA. EA submission herein.

3. PROJECT DESCRIPTION

MKI proposes to conduct an offshore two-dimensional (2D) seismic reflection survey within Baffin Bay and Davis Strait over the next 5 years scheduled to start sometime after mid-end July as weather and ice conditions allow.

All proposed program activities will occur seaward of Canada’s 12 nautical mile boundary, to the east of the land-fast ice limit. No Geophysical data will be recorded within the Land Fast Ice Zone. The survey is approximately 180km from the mouth into Lancaster Sound. The majority of the survey lines to be collected are in deep water. MKI requests approval of all lines in the program in order to allow flexibility in the collection of the data in 2011.

3.1 PURPOSE

The proposed project is a regional survey designed to provide a better understanding of the offshore geology in Baffin Bay and Davis Strait and to use this information to introduce new exploration opportunities to the industry. This information will be used to determine the regional extent of geological formations. This program is being used to develop geological concepts and is not the basis of an exploration drilling program, as the survey line spacing is much too coarse for that purpose.

3.2 LOCATION

Figure 1 shows the location of the entire multiyear survey area. Subsequent years will include infill lines within the same assessed area.

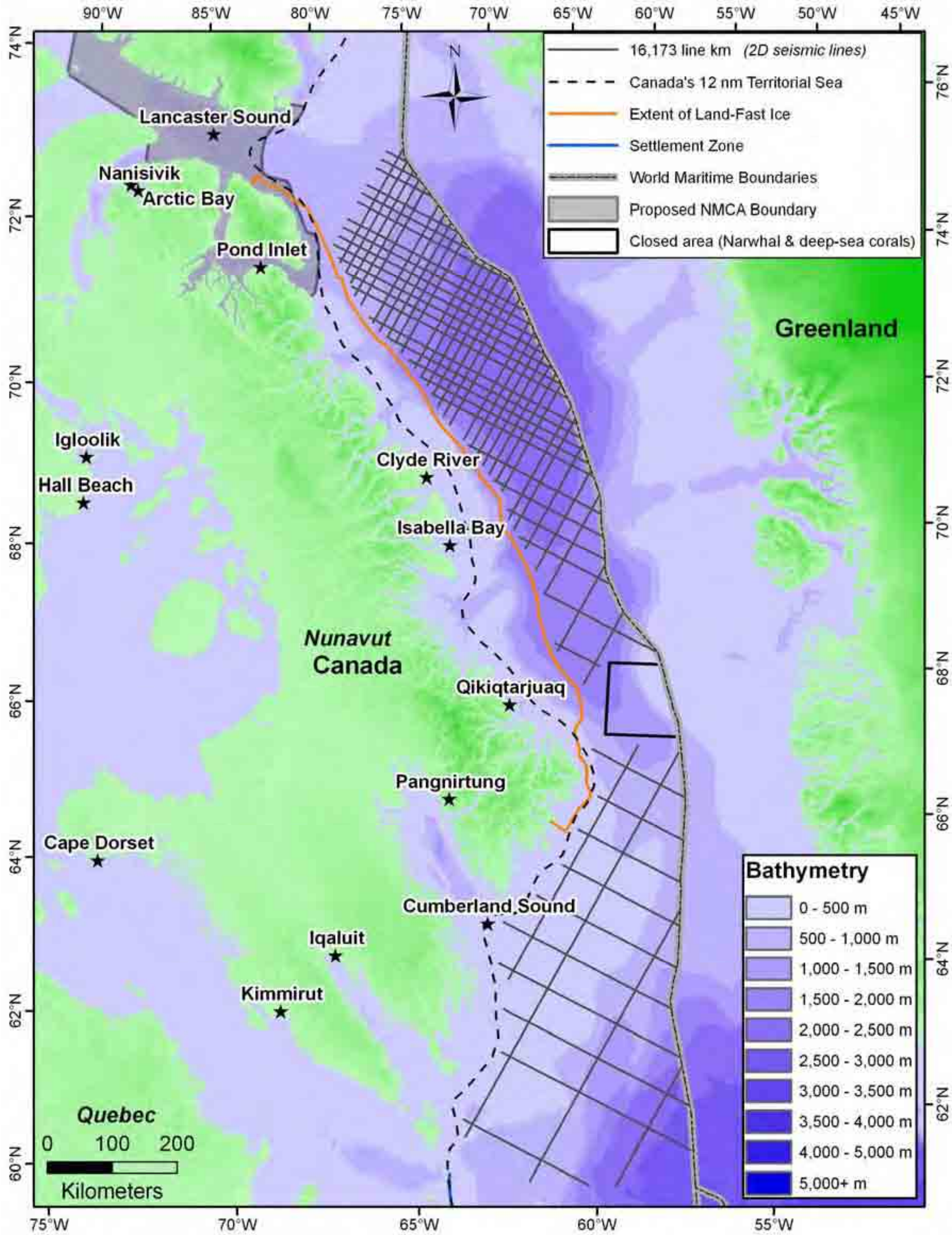

Figure 1. Location of Survey

3.3 SITE HISTORY

Marine geophysical data has been acquired over the Baffin Bay / Davis Strait area since 1969. Figure 2 illustrates these data as documented by the Geological Survey of Canada – Atlantic (GSC-A) BASIN database (http://basin.gsca.nrcan.gc.ca/index_e.php). BASIN is a federal government archive of geological, geophysical, and engineering information (including seismic data) acquired during the many years of petroleum exploration offshore northern and eastern Canada.

A full listing of these geophysical projects is provided in Appendix C, and consists of approximately two hundred (200) seismic reflection surveys (2D and 3D), seismic refraction surveys, and shallow seismic / seabed surveys, and five (5) aeromagnetic surveys. The most recent program in the area of the proposed 2010 survey was acquired by Husky Oil in the Davis Strait / southern Baffin Bay in 2008. TGS's most recent exploration program in the area was also in 2008, with fairly continuous work completed in the Davis Strait through the 1990's.

The proposed project represents a small program relative to the historic totals. The acquisition of a high-quality modern regional dataset is required to compliment this vintage data. Advances in seismic technology, in particular advances in longer receiver arrays (streamers) and recording systems, have allowed geophysicists to use advanced signal processing and image the subsurface geology with much greater accuracy, and to much greater depth below the seafloor, than was previously possible.

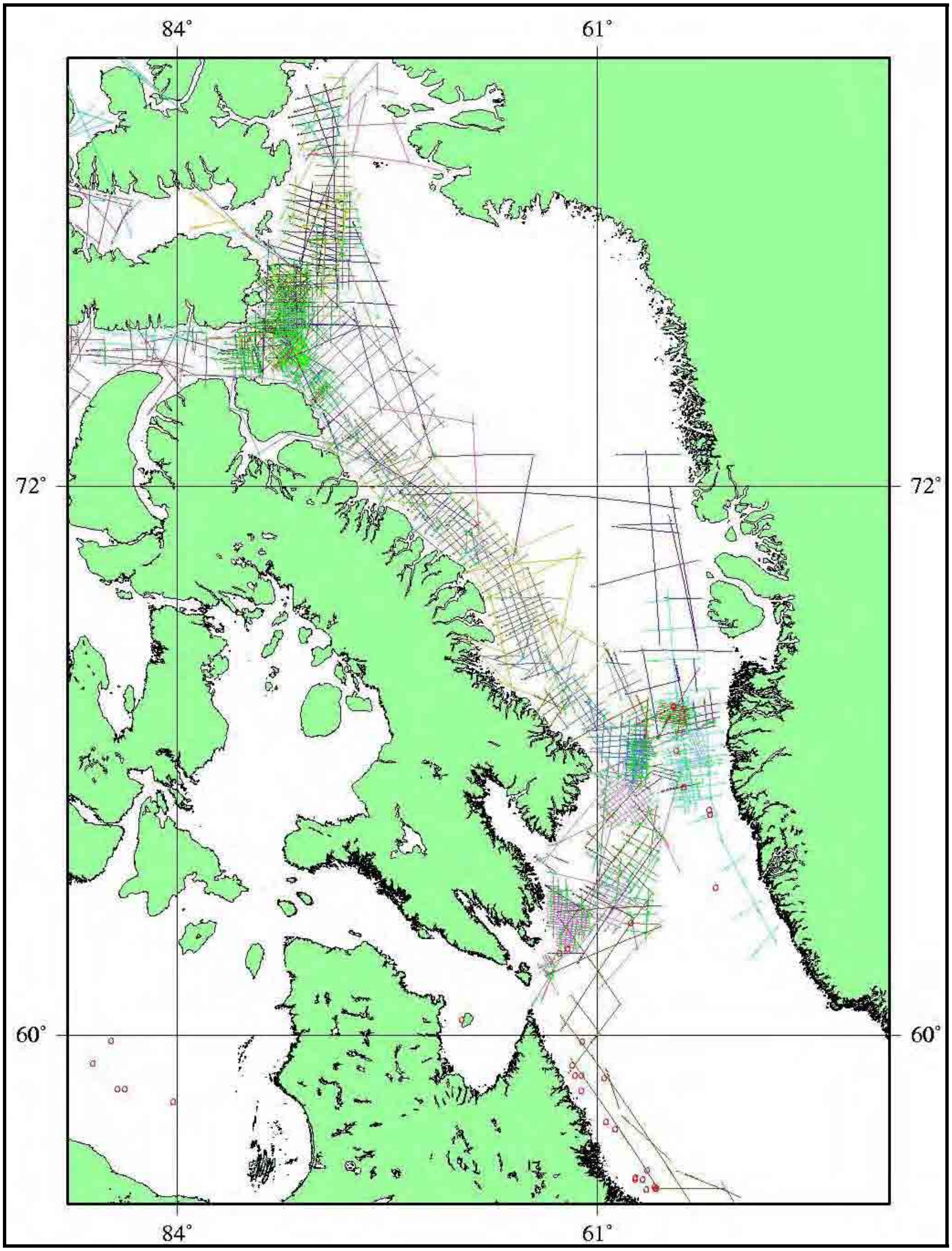

Figure 2. Exploration History within the Project Area
(BASIN, 2007)

3.4 SCHEDULE

The proposed survey season is end July through mid November 2011, depending on the location, weather conditions, and vessel availability. Based on previous work in Davis Strait/Baffin Bay weather usually allows productive recording until approximately mid October. It is possible that work might be able to continue as late in the year as November. The proposed survey lines (Figure 1) represent the proposed program for 2011. Infill lines will be acquired in subsequent seasons.

Although the proposed survey vessel is an ice-class vessel (1A1 Ice C) data will not be acquired in areas of pack ice. The survey data will be acquired such that ice-free areas are surveyed first (i.e. the southern portion of the survey area) then, as the season progresses, the vessel will move north.

It is possible that there may be transects in pack ice waters; however, the sound source will not be active during these periods and the vessel will merely be transiting through. Marine mammal observations will still be made during these transects, which will serve to enhance the database of observations that will be obtained during the project. Due to the seasonal nature of offshore marine conditions, it is hoped that work will also take place in future years, as the area is mapped.

The vessel will be at sea and operate continuously (i.e. 24-hour operations) during survey operations. Seismic vessels typically operate on a 5/6-week crew change schedule, which will be maintained for this project.

3.5 OFFSHORE SEISMIC SURVEY

The follow is an introduction to seismic surveying.

“A marine seismic survey is a method of determining geological features below the seafloor, by sending acoustic sound waves into the various buried rock layers beneath the seafloor and then recording the time it takes for each wave to bounce back as well as measuring the strength of each returning wave. It is the most reliable form of initial exploration for oil and gas and is essential in identifying geological features that may contain oil or gas deposits.

Seismic surveys generally take place over a few weeks in a given area. Once geophysicists have studied the subsurface “picture”, they may ask for some parts of the area to be surveyed again to provide greater detail. This extra data helps them to map potential prospects more accurately and to decide the best place to drill exploration wells. Shallow seabed surveys can also be used to detect changes in the sub-surface rock layers that may present a safety hazard during drilling operations.

A marine seismic survey is conducted using purpose-built ships, towing a number of air guns as the acoustic energy source at depths of 6-10 metres below the sea surface. The sound (or seismic) waves are generated by the rapid release of compressed air from an underwater piston. These seismic waves are directed down toward the seabed. They are reflected back to the surface by the layers of different rock types under the seafloor. The returning sound waves are detected and recorded by hydrophones that are spaced out along "streamers" that are typically 6 – 10 kilometres in length, towed behind the survey vessel (Figure 3). For regional surveys (often referred to as 2D surveys) the seismic vessel sails up and down gridlines which can be 5 to 100 kilometres apart.

Seismic waves travel through different rock types at different speeds, so it is possible to calculate the depth and the shape of the rock layers by measurements such as the two-way travel time taken for the reflected seismic waves to reach the hydrophones and the strength of each returning wave. In 2D surveys the resultant picture is a general view because the cross sections are far apart.

As further background on marine seismic surveys, Appendix D contains the International Association of Geophysical Contractors (IAGC) overview document *Marine Seismic Operations – An Overview*, which provides a thorough introduction to all aspects of marine seismic operations, including the underlying principles of seismic data acquisition, methodology, and equipment. This document is also available on the Canadian Association of Geophysical Contractors (CAGC) website (IAGC, 2002). The reader is also referred to *Seismic and the Marine Environment* (APPEA, 2004).

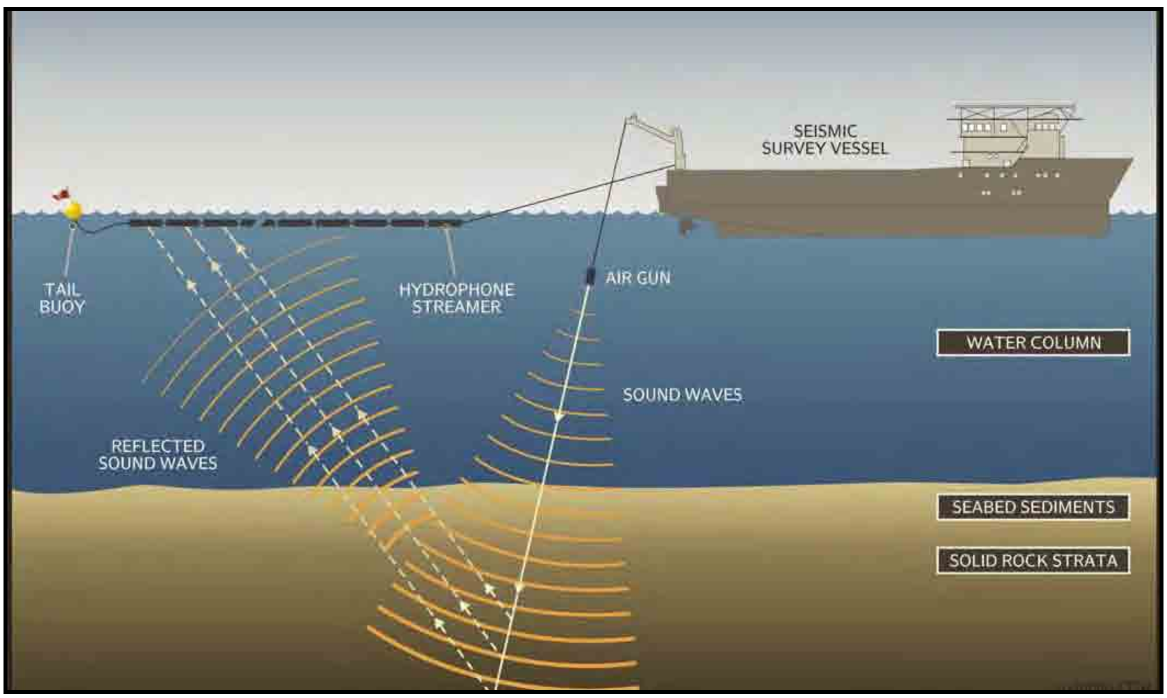

Figure 3. Seismic Acquisition using Seismic Reflection Method (Sikumuit 2008)

A 2D marine seismic survey will be conducted within the proposed project areas. The field acquisition program will consist of the following four activities:

- Mobilization to the survey area
- Deployment and calibration of the seismic gear
- Data acquisition, and
- Seismic gear retrieval and demobilization.

3.6 SEISMIC EQUIPMENT

3.6.1 Survey Vessel

The M/V Sanco Spirit is the dedicated research vessel that has been chosen to conduct this project. The vessel is a new build in 2009 with state of the art technology and equipment. The vessel has a total of 47 berths, and a dedicated hospital. The vessel has all equipment, systems, and protocols in place for prevention of pollution by oil, sewage, and garbage in accordance with international standards and certification authorities, specifically the Arctic Shipping Pollution Prevention Act (ASPPA) and Arctic Shipping Pollution Prevention Regulations (ASPPR). Regulations require that the survey vessel possess an Arctic Pollution Prevention Certificate. The vessel will be subject to pre-survey audits by the operator in the port of mobilization prior to survey commencement. Transport Canada will conduct a Safety Inspection of the vessel in accordance with the issuing of the Coasting Trade License to operate in Canada.

The survey vessel will comply with all applicable regulations concerning management of waste and discharges of materials into the marine environment. The vessel has a ballast water management plan. The International Maritime Organization (IMO; http://www.imo.org/) is the United Nations specialized agency with responsibility for the safety of shipping and the prevention of marine pollution by ships. Canada became a member of the IMO in 1948. Full specifications of the vessel M/V Sanco Spirit are shown in Appendix E.

Figure 4. Survey Vessel Sanco Spirit

3.6.2 Supply Vessel

The primary function of the supply vessel is to provide supplies for the seismic vessel and to assist in emergency situations (including oil spills). At least one support vessel will be utilized for the proposed seismic survey.

Seismic vessels are recognized as having a restricted manoeuvrability and, in this respect, under marine sailing directions, they have priority over vessels that are not similarly restricted. In areas where poor charting, or the presence of other vessels, may pose a potential problem to the survey operation, the chase boats will ensure that other vessels do not cross over, or otherwise interfere with, the towed equipment. The supply boat may also check that the way ahead of the survey vessel is clear of obstructions, such as uncharted shallow water and fishing equipment. Fishing nets are a particular problem to seismic operations as they can become entangled around the survey equipment and force operations to stop. It is likely that the FLO and one of the two MMO's will travel onboard the supply vessel, ahead of the research vessel.

3.6.3 Energy Source

Manufacturer and type	Sercel – G Gun 2
Effective volume of standard array(s)	4135 ci
Maximum number of sub-arrays	6
Standard array depth(s)	7 M
Position of depth transducers	Front and tail of sub-array
Working pressure	2000 psi psi
Type of firing sensors	Pressure activated
Position of firing sensors	Mounted directly on the gun.
Type of firing synchroniser unit	RTS BigShot
Timing resolution	0.1ms ms
Timing accuracy	+/- 1.0ms
Position of near field phones	1 mounted on each gun hang frame.
Air compressors capacity	Neuman & Esser, 2200 cfm each
Number of air compressors	2

3.6.4 Streamer

Manufacture and type	PGS GeoStreamer® Solid
Skin material	Polyurethane
Outside diameter	62mm cm
Length of each group	12.5m m
Streamer set-up	Typical 1 x 10050m
Manufacture and type of hydrophones	Hydrophones: Teledyne T-2BX or equivalent, Velocity Sensors: PGS

	confidential (MarkIII)
Type of array (e.g. linear, binomial)	Linear
Number of hydrophones per group/distance apart	Hydrophones: 12 per 12.5m, Velocity Sensors: PGS confidential
Coupling between phones and pre-amp	Capacitive
Sensitivity of near group at 1/P to recorder	20V/Bar
Sensitivity of far group at 1/P to recorder	20V/Bar
Bandwidth over which above sensitivities apply	Specified at 100Hz
Availability of shore-side spares if required	Pool system
Manufacturer and type of depth controller	ION DigiCourse 5011
Manufacturer and type of compass	ION DigiCourse 5011

3.7 PROJECT ALTERNATIVES

Alternatives to survey method:

No method for surveying deep marine geology has been developed that is more accurate, time efficient, or has fewer environmental impacts than the use of a towed airgun array and hydrophones contained in a long streamer. Prior to the development of airguns, dynamite was used for marine seismic surveying, but that survey method was abandoned over 30 years ago by the exploration industry.

Alternatives to survey parameters:

The main survey parameters such as line position, line length, line spacing, shot-point interval, and streamer length are determined by geophysicists considering the objectives of the survey. With regard to location, proposed survey lines are carefully selected based on a current understanding of the geological conditions of the study area and are intended to test geological concepts at those specific locations. The survey lines tie into the grid established offshore Greenland. Extensive geophysical survey work, over the past 10 years, of the same nature proposed here, has been taking place.

Parameters such as airgun array and streamer tow depths may be adjusted at the start of the survey to optimize data quality. Gun types, array configurations, and streamer type are limited to what equipment is available on the vessel and, therefore, cannot be easily changed.

Alternatives to program timing:

Specific timing of the program will depend on a variety of factors, including ice conditions, weather conditions, timing, and sensitivities associated with biological and socio-economic constraints. For example, mitigation options to minimize potential impacts can potentially include modification of the operations schedule within specific areas, and the survey plan has been developed on this basis.

Because there are no viable alternatives that can be genuinely considered from an environmental viewpoint (as described above), the two alternatives may simply be proceeding or not proceeding (i.e. no-go alternative).

No-go alternative

In the case that the project does not proceed, the mitigated impacts of seismic operations on the environment will of course not occur, however, the environment will not necessarily maintain its current baseline condition as impacts from fishing and vessel activity (i.e. ice breakers, cargo vessels, cruise ships, and other research vessels), waste materials, sedimentation, fall-out of atmospheric pollutants, discharge of ballast waters, etc. will still take place.

The 'no-go alternative' would also mean that the renewed interest in exploration in this area would cease, or at least be significantly set back, as geologists would not have the information required to map the sub-surface in this area. This would consequently mean that the potential to assess the hydrocarbon potential of this area would not proceed, along with the assessment of opportunity for further subsurface exploration and drilling programs. Ultimately, the project not proceeding in this case would effectively preclude the potential to evaluate the area's offshore hydrocarbon resources. This would result in the removal of future potential business, royalty, and tax revenue sources and the data would not exist for future knowledge and research.

It would also lead to significant reduction in direct employment opportunities on the vessel and the opportunity to collect biological observation information.

3.8 PHYSICAL SETTING

The north seismic survey area is proposed to take place in portions of Davis Strait, and Baffin Bay (Figure 1). Davis Strait is situated between Baffin Island and Greenland and is the entrance to Baffin Bay from the North Atlantic. This large body of water is over 950 kilometres across at its greatest width and never less than 300 kilometres wide.

3.9 CLIMATE

The Davis Strait is within the Arctic Climatic Region with mean air temperatures below 10° C annually. The coldest month is February and the warmest is August (July in coastal regions). In summer air temperatures will be similar to those of the surface water. Freezing temperatures may occur over sea ice. In winter, very low air temperatures occur over snow covered pack ice. Over open water, air temperatures are generally below those of the sea surface. Coastal regions may experience summer temperatures as high as 15° C. Visibility within this region is mainly reduced by fog (visibility < 1 km). Fog is primarily a summer phenomenon, with increasing frequency during May and peak occurrences in June / July. It is uncommon by late August. In winter, advection fog may form as a result of mixing of warm moist masses advected from the south. Sea smoke is often very local in occurrence and is formed from cold air flowing from pack ice or from cold land over open water.

Most precipitation falls in late summer or early autumn. In winter, it will be in the form of snow. In summer, light snow or freezing rain may fall over pack ice or open water with surface temperatures near the freezing point. Generally, the months of June and October are the rain / snow transition months in the north, with May and November the transition months in the south. Freezing rain often occurs with the advection of warm air from the south in the winter. It is unlikely to occur over a sea with surface temperatures greater than 5° C.

Freezing fog is typically a summer event occurring over vast ice fields. It is not likely to occur over open waters with surface temperatures above 1° C. Freezing spray may be frequent from November to April but rare in October and May.

Wind in the northern part of the region, north of 65° N, has an annual speed of 5-6 metres/second that increases south of 65° N to 7-8 metres/second. In the north the maximum wind speed occurs as early as October / November but elsewhere in midsummer. The minimum wind speed is in midsummer throughout the region (MacLaren, 1978a).

3.9.1 Sea-Ice Climate

In June, the ice in the North Water Polynya of Northern Baffin Bay disintegrates, and then clearing extends southward across the approach to Lancaster Sound. Since pack deteriorates more quickly around the eastern shores (i.e. Greenland) than it does in the centre of the bay, by the beginning of August ice remains near the coast from Cape Dyer to Clyde River and in central parts of the Bay northward to near latitude 74° N. The pack is finally reduced to offshore isolated patches between Cape Dyer and Home Bay late in August. Clearing occurs on the average by September.

Historically the north-flowing current along the Greenland coast is relatively warm, and the south-flowing current along eastern Baffin Island is relatively cold. Consequently, ice formation along the west side of the bay (Canadian side) begins earlier than on the Greenland side. In September, new ice begins to form in the north western reaches of Baffin Bay. By the end of the September a fringe of new ice forms all along the Baffin Island coast. Ice formation accelerates through October, such that first-year ice becomes predominant north of Cape Dyer. On average, the southern extent of sea ice achieves equilibrium near a line from the Greenland Coast near latitude 68° N generally southwest-ward to a point some 200 kilometres off Resolution Island.

In general, Baffin Bay and Davis Strait have cleared of all sea ice as early as mid-August. Freeze-up in north western Baffin Bay has developed as early as the last week of August and been delayed until the middle of October. In Frobisher Bay, new ice formation has begun as early as mid-October, and as late as the second week of November.

The typical retreat of the sea ice cover from the late winter to late summer is shown in Figure 5 below. Melting of sea ice begins in spring in the Gulf of St. Lawrence and East Newfoundland, retreating northward towards the Labrador coast. In June openings appear in Baffin Bay and the Beaufort Sea, while clearing is already underway in Hudson Bay. Break-up continues throughout the summer months, reaching a minimum extent around mid-September.

With the changes seen in the ice this past year, it is anticipated that work may start sooner and end later.

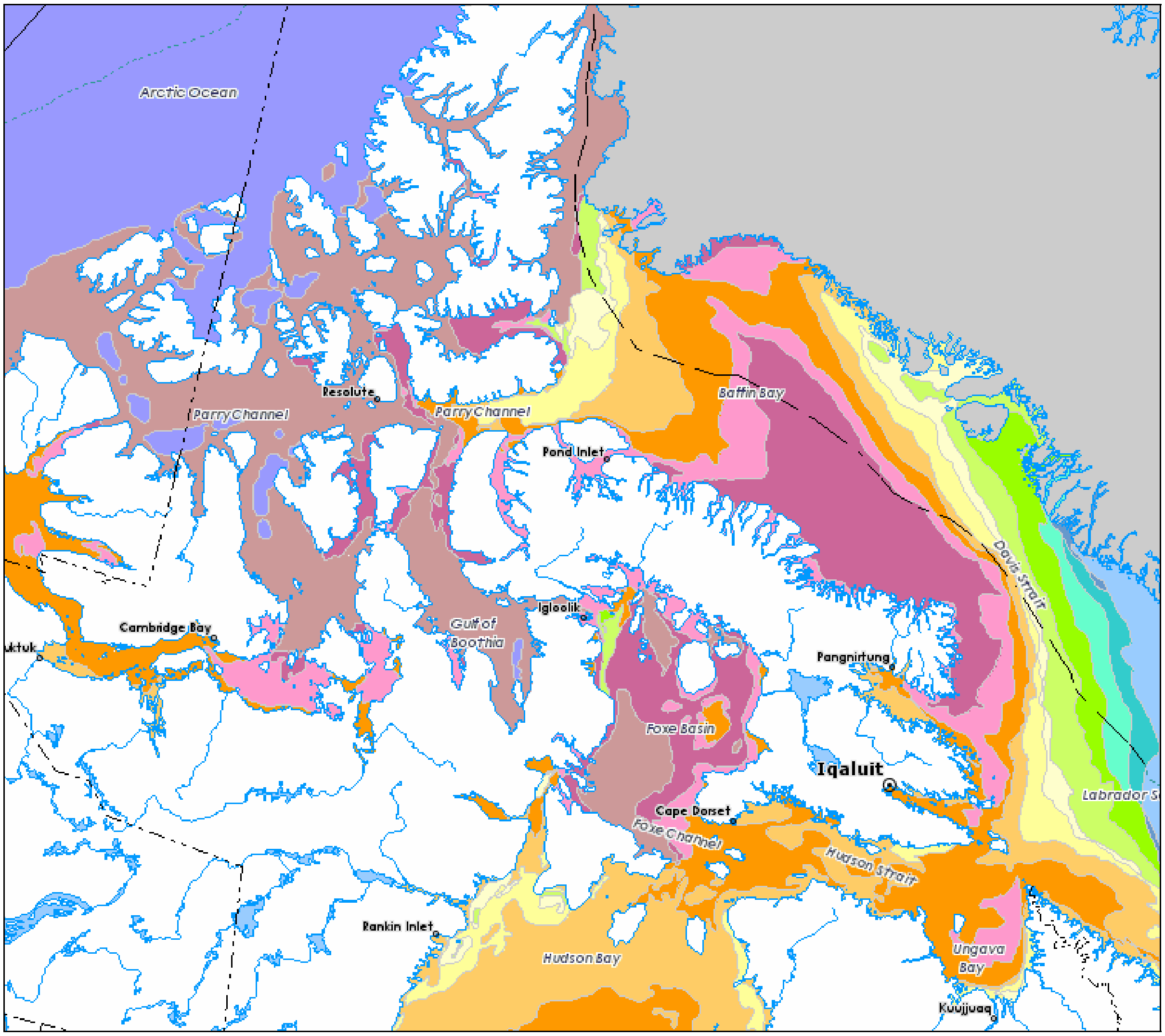

Figure 5. Break up of Sea Ice NRCAN 2007

3.10 OCEANOGRAPHY

The physical oceanographic environment of the eastern Davis Strait and north-eastern Labrador Sea has been well documented and an excellent overview is provided in a Mineral Resources Administration for Greenland (Nazareth and Steensboe, 1998) publication. uch of this overview includes the survey area and it indicates that there are no physical oceanographic environmental conditions that can significantly affect the proposed seismic program within the scheduled period (Nazareth and Steensboe, 1998).

The surface water circulation in Davis Strait is strongly affected by counter-clockwise flowing currents.

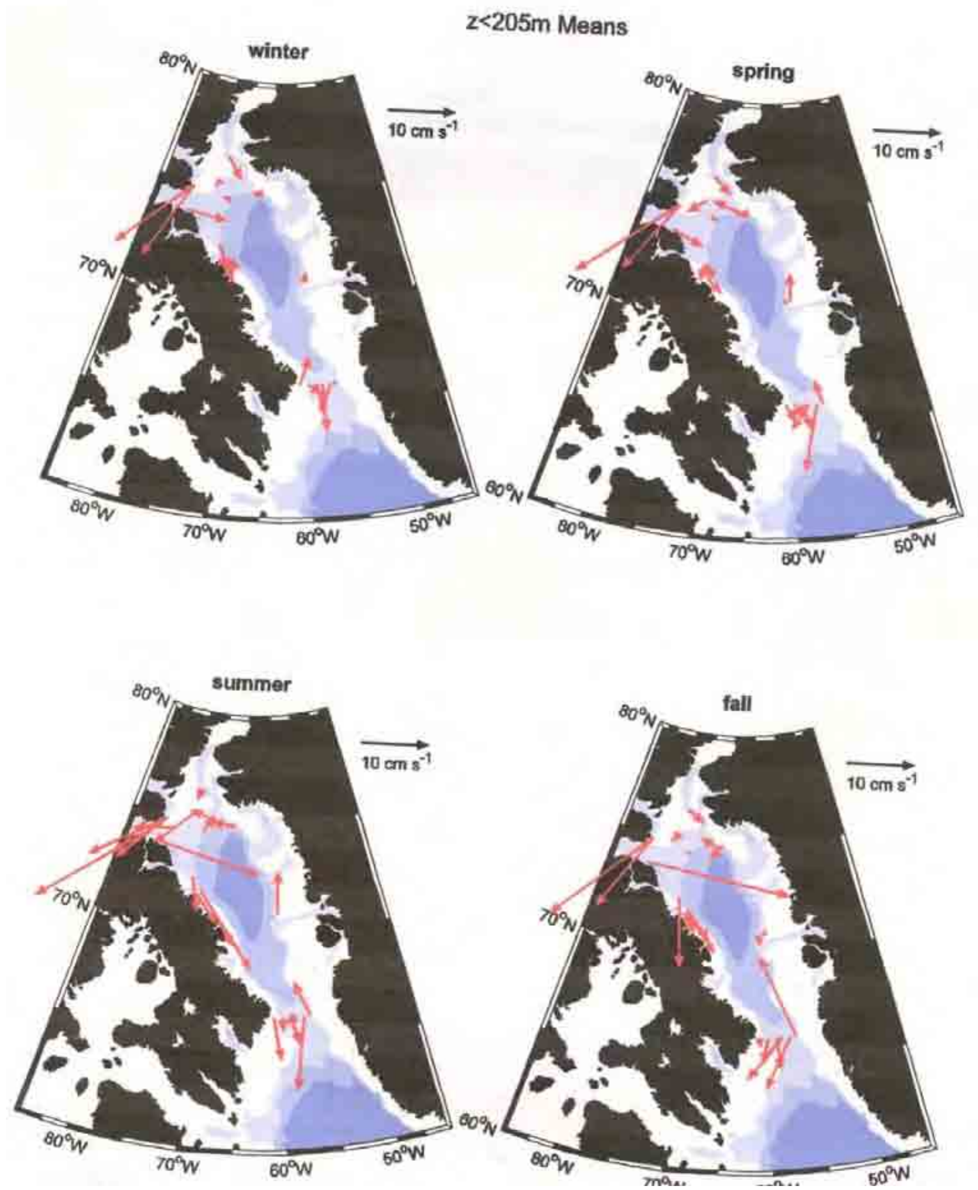

Figure 6. Circulation, within Baffin Bay (Tang et al. 2004)

3.11 BATHYMETRY

Its submarine topography includes an undersea ridge that is the continuation of the mid-Labrador ridge. This ridge extends from the coast of Baffin Island to Greenland. The shallowest waters in Davis Strait occur along this sill and extend from 350 to 500 metres depth before dropping down to the abyssal basins on either side. In the southern end of Davis Strait, some of the greatest depths on the eastern Arctic are reached (3,660 metres).

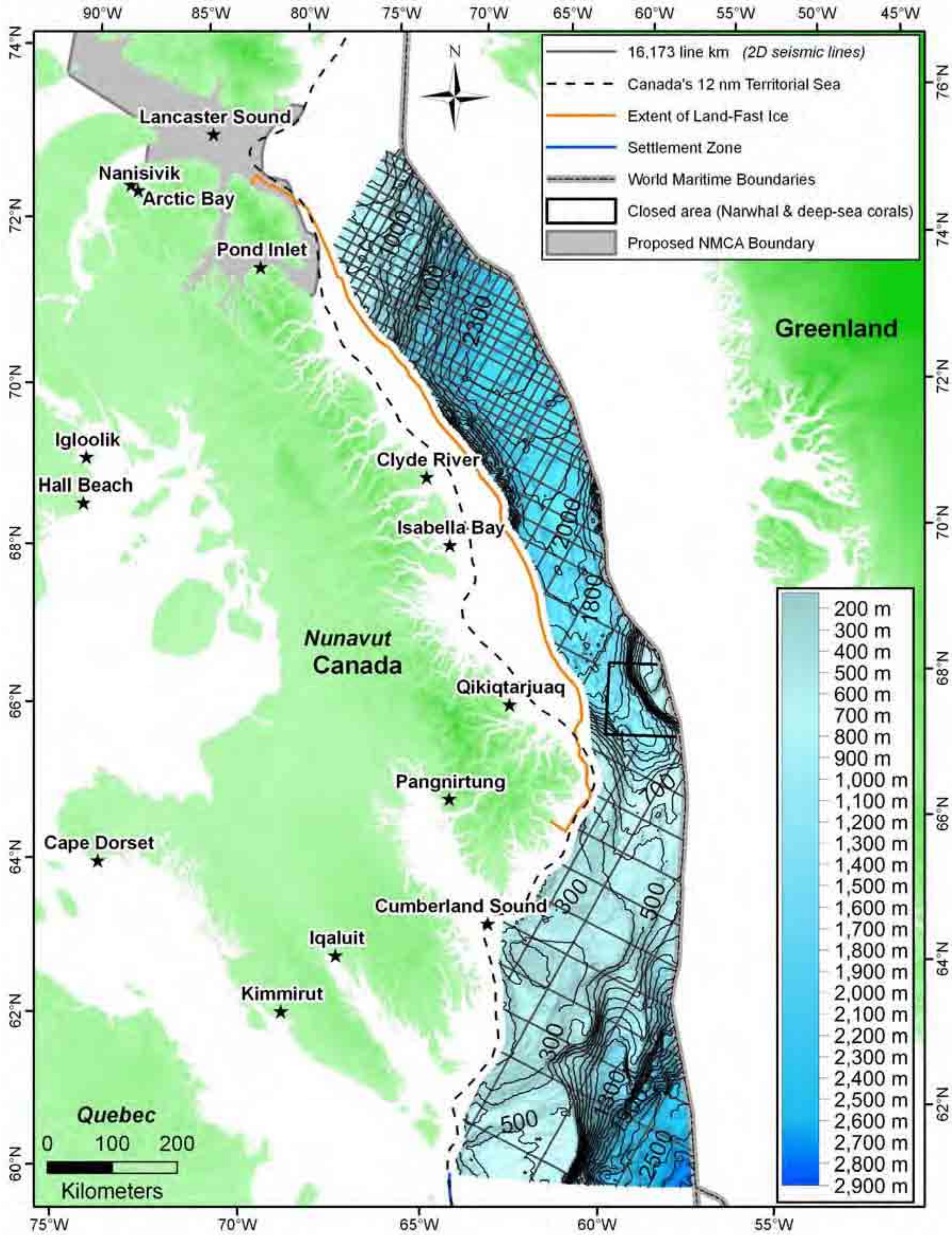

Figure 7. Bathymetry Baffin Bay

3.12 GEOLOGY

Baffin Bay is the north western extension and terminus of the North Atlantic-Labrador Sea rift system. The progressive northward stepping of sea floor spreading in the North Atlantic resulted in graben development in the incipient Baffin Bay area in the Early Cretaceous. Oceanic crust began to form in Baffin Bay in the Paleocene but sea-floor spreading appears to have ceased in the Oligocene. Baffin Bay is bounded to the north by Nares Strait, a probable transform fault, and to the south by the Ungava transform underlying Davis Strait. Sedimentary strata are thickest along the narrow east Baffin shelf and the opposing and much broader west Greenland shelf. A major depocentre is present at the northern end of the Baffin shelf opposite the mouth of Lancaster Sound. Sedimentation has been characterized by the influx of coarse elastic material across the rifted and rapidly foundering margin of Baffin Island. The sediments were derived from the surrounding highlands of the Baffin coast and by clastics brought from the lower Paleozoichinterland of the Canadian Arctic Islands by major rift controlled drainage systems (MacLean et al.1990).

3.13 EXPLORATION HISTORY

No wells have been drilled in Baffin Bay, with the exception of ODP site 645. In 1976-77, five wells were drilled in Davis Strait, at the southern entrance to Baffin Bay. These dry and abandoned wells are in Danish waters on the west Greenland Shelf. The Geological Survey of Greenland suggests that they failed to test prospective pre-Tertiary sequences indicated by seismic. Seismic exploration of the north-eastern Baffin shelf has been limited. The few reconnaissance program shot are insufficient to delineate drilling prospects (Rice and Shade, 1982).

3.14 STRATIGRAPHY

The Mesozoic sediments of Baffin Bay are probably underlain by Proterozoic rocks comparable to those now exposed on Baffin Island. Ordovician to Silurian rocks may be preserved in the offshore, but there is no seismic evidence to suggest that this is the case.

4. BIOLOGICAL ENVIRONMENT

4.1 PRIMARY PRODUCTION

Arctic climatic conditions impose a variety of conditions on the open water annual cycle phytoplankton production. The presence of ice inhibits light penetration, and the annual growth cycle of free living (non-ice algae) may be more compressed in high latitudes such as is experienced in the Davis Strait Region. Nonetheless, a considerable contribution to the overall plant production is attributed to ice algae that develops prior to and independent of the phytoplankton.

The spring phytoplankton bloom in the western Davis Strait begins in May and June with *Fragilaria oceanica* playing an important role (Gran, 1929) along with *Thalassiosira* sp. and *Leptocylindrus danicus* by July and August. In contrast, the waters of the western side of Davis Strait experienced different phytoplanktonic species assemblages. Here the species include the dinoflagellate *Ceratium arcticum* and various diatoms (*Chaetoceros*, *Asteromphalus*, and *Coscinodiscus*) (MacLaren, 1978a, 1978b). Ice flora in the western Arctic consist primarily of diatoms (*Nitzchia* sp., *Amphipora hyperborean*, *Nitzchia coterie*, *Pleurosigma stuxbergii*, *Gomphonema exiguuem arctica*, *Navicula* sp., and dinoflagellates *Peridinium* sp.) and flagellates (*Dimema litorale*, *Eutreptiella* sp. and *Platymonas* sp.) (Horner and Alexander, 1972; MacLaren, 1978a, 1978b). Jensen et al. (1999) have studied phytoplankton biomass distribution and productivity in the Davis Strait region and determined that overall primary phytoplankton production is in the range of 67-3,207 mgC m^2 $d^{1,}$ which is within the range of the few results published for eastern Canadian Arctic and West Greenland waters. Hsaio and Pinkewycz (1987) conducted a detailed survey of the area. A list of species recorded from their investigations is presented for the region in Appendix F. Additional information on the phytoplankton species composition within the area of study may be gained through review of Dunbar and Moore (1980).

4.2 ZOOPLANKTON

Zooplankton species, found in north-eastern Baffin Bay, Davis Strait area are common to Arctic regions in eastern Canada (LGL 1983, Granger 1965, Dunbar and Moore 1980). Like other Arctic regions, copepods are the most important group of zooplankton, both in terms of numbers and biomass (LGL 1983). Species of Calanus (C. finmarchicus, C. hyperboreus and C.glacialis) along with Oithona similis, Pseudocalanus minutus, Microcalanus spp. and Metridia longa are the most common (LGL 1983, Granger 1965 and Dunbar and Moore 1980). Other important groups include: chaetognaths, amphipods, gastropods ctenophores and hydrozoans (LGL 1983). A tabulated list of marine zooplankton occupying the study area may be reviewed by consulting Appendix G (Kennedy 2005).

Here in the Davis Strait region, the marine arctic zooplankton planktonic ecosystem is characterized by a brief summer period of intense productivity following the spring phytoplankton bloom. Young zooplankton stages feed in the surface waters (Grainger,

1959) and there may be spatial and temporal variation in zooplankton reproduction that varies from year to year (Grainger, 1959).

Specifically in the Davis Strait region, the *calanoid copepods Calanus finmarchicus, Calanus glacialis, and Calanus hyperboreus* and *the cyclopoid copepod Oithona similis* are the most numerically abundant species (Bainbridge and Corlett, 1968; MacLaren, 1978a, 1978b). In more coastal realms the *calanoids Acartic longiremis* and *Pseudocalanus minutus* may also be numerically important (Grainger, 1961). According to Grainger (1961, 1963), *Calanus glacialis* and *Calanus hyperboreus* are thought to be indicators of cold arctic waters while Calanus finmarchius indicates a boreal watermass. The zooplankton found in eastern Davis Strait by Bainbridge and Corlett (1968) is similar to that seen in the North Atlantic (Matthews, 1969), and is dominated by Calanus finmarchicus. Bainbridge and Corlett (1968) found that the second most abundant species were the *euphausiids* specifically *Thysanoessa inermis, Thysanoessa rashii, and Thysanoessa longicaudata.*

The Northern shrimp (*Pandalus borealis*) is the most important commercial invertebrate species within the project area. They are generally found in deep depressions and captured using trawl nets. Northern shrimp spawn during late summer and fall, with the eggs remaining attached to the female until spring. Females with eggs move inshore in late autumn and winter to release the eggs (Parsons, 1993).

Table 2 lists the major zooplankton species occurring in the Davis Strait (MacLaren, 1978a, 1978b).

Table 2. Major Zooplankton Species Occurring in the Davis Strait

Acartia longiremis	*Euchaeta norvegica*	*Parathemisto gaudichaudi*
Aglantha digitale	*Gaidius tenuispinus*	*Pseudocalanus minutus*
Beroe cucumis	*Limacina helicoids*	*Sagitta elegans*
Calanus finmarchicus	*Limacina retroversa*	*Sagitta maxima*
Calanus glacialis	*Metrida longa*	*Scolecithricella minor*
Calanus hyperboreus	*Microcalanus pygmaeus*	*Thysanoessa inermis*
Cochoecia obtusata	*Oikopleura labradorienis*	*Thysanoessa rashii*
Conchoecia elegans	*Oithona similis*	*Thysanoessa longicaudata*
Euchaeta norvegica	*Pandulas borealis*	

4.2.1 Marine Benthos

Investigations of the marine benthic community of the region of concern have focused primarily on bivalves. Dunbar and Moore (1980) list 51 species of bivalve (their chart 20) occurring in the Eastern Canadian Arctic. They also record 3 crab species (their chart 19), none of these listed species are of commercial importance to the area. An extensive list of marine plants, benthic invertebrates, and other bivalve mollusks and decapods crustacean collected in the Eastern Canadian Arctic is provided also in Dunbar and Moore (1980). Further to the region, Lubinsky (1980) has published a definitive monograph on the faunal composition and zoogeography of marine bivalve mollusks of the Canadian Central and Eastern Arctic.

Specific to the Davis Strait and Western Baffin Bay Region, LGL (1983) presents information on the *infaunal, epibenthic* and *epifaunal* species. None of these species are commercially harvested. Thompson (1982) has described the marine benthic community of Lancaster Sound and northern and central Baffin Bay. More recently, Mohammed (2001), in a study of the energy flow within Lancaster Sound, found that the benthic species *Mya truncata, Hiatella artica, Serripes groelandicus* and *Macoma calcarea* were key players in the energy transformation within the benthic community. Other important groups included echinoderms (sea cumbers, brittle stars), annelids, terebellid polychaetes and small crustacea.

4.3 MARINE FISH

Dunbar and Moore (1980) in a biogeographic study of marine life in the Canadian eastern Arctic, indicated, for that period, that the state of knowledge of the fishes occurring in the eastern Canadian Arctic was rudimentary. In their report, they list only 13 species of marine fish of which only five species could be attributed to the study area. The five species included: *Boreogadus saida* (Arctic cod), *Moxocephalus scorpius* (Arctic sculpin), *Gymnelis viridis* (fish doctor), *Icelus bicornic* (two horn sculpin) *Coryphaenoides repestris* (rock grenadier) and *Oncocottus quadricornus* (now called Triglopsis quadricornis, fourhorn sculpin). Since then, there has been considerable more information revealed on the species of marine fish that inhabit the region of Lancaster Sound, Jones Sound and Baffin Bay. LGL (1983) in a study of the biological environment of eastern Lancaster Sound and western Baffin Bay recorded 28 species of marine fish (see their Table 2.6.1 for a listing of species). More recently, Coad and Reist (2004) have expanded our knowledge of the species of marine fish that inhabit the Canadian Arctic. In their comprehensive study of Canadian Arctic Ecozones many more species of marine fish have been identified. Here, for the region three Ecozones are represented. These zones are: Baffin Bay-Davis Strait near shore, Lancaster Sound region (including Jones Sound) and Baffin Bay-Davis Strait Offshore. For these three Ecozones combined, a total of 183 species of marine fish have been recorded. This list is presented in Appendix H.

In particular, Davis Strait region of the proposed seismic survey supports a wide variety of fish species. In excess of 80 species from Otter trawls taken between 400 and 1,500 metres have been identified (Treble et al., 2001; Table 3). Earlier studies sampling shallower waters and the benthic environment for fish found several other species (MacLaren, 1978a, 1978b; Table 4). The seasonal distribution of eggs and larvae of several of the more commercially abundant species is documented below for this area of the Davis Strait.

Table 3. Fish Species within the Davis Strait Region

Alepocephalus agassizii	*Coryphaenoides rupestris*	*Malacosteus niger*
Alepocephalidae	*Cyclopterus*	*Myctophidae*
Alleposomus copei	*Gadus morhua*	*Myxiniformes*
Amblyraja hyperborean	*Gaidropsarus argentatus*	*Nemichthyidae*

Amblyraja radiate	*Gaidropsarus ensis*	*Nemichthys scolopaceus*
Anarhichas denticulatus	*Gaidropsarus sp.*	*Nezumia bairdi*
Anarhichas minor	*Glyptocephalus cynoglosslls*	*Nezumia sp.*
Anoplogaster cornula	*Gonostoma bathyphilum*	*Notacanthus chemnitzi*
Antimora rostrata	*Gonostoma sp.*	*Notoscopelus kroeyeri*
Arctozenus rissoi	*Hippoglossoides platessoides*	*Octopodidae*
Artediellus atlanticus	*Hippoglossus hippoglossus*	*Oneirodes sp.*
Astronesthes sp.	*Holtbyrnia sp.*	*Paraliparis copei*
Bajacalifornia megalops	*Lampanyctus macdonaldi*	*Paralepididae*
Bathylagus euryops	*Leptagonus decagon*	*Paralepis coregonoides*
Bathylagus sp.	*Liparidae*	*Raja fyllae*
Bathyraja spinicauda	*Liparis fabricii*	*Raja sp.*
Bathytroctes sp.	*Lophiformies*	*Reinhardtius hippoglossoides*
Benthosema glaciale	*Lycenchelys muraena*	*Saccopharynx ampullaceus*
Boreogadus saida	*Lycodes esmarki*	*Scopelosaurus sp.*
Borostomias antarcticus	*Lycodes eudipleuroslictus*	*Sebastes marinus*
Bythites fuscus	*Lycodes pallidus*	*Sebastes mentella*
Careproctlls reinhardti	*Lycodes sp.*	*Serrivomer beani*
Caristius sp.	*Lycodes terraenovae*	*Stephanoberyciformes*
Centroscyllium fabricii	*Lycodes vahlii*	*Stomias boa*
Chauliodus sloani	*Lycodonus mirabilis*	*Stomias boa ferox*
Chiasmodon niger	*Macdonaldia rostrata*	*Stomiatidae*
Conttunculls microps	*Macrouridae*	*Synaphobranchus kaupi*
Conttunculls thompsoni	*Macrouriformes*	*Triglops nybelini*
Coryphaenoides brevibarbis	*Macrourus berglax*	*Xenodermichthys*
Coryphaenoides guentheri	*Malacosteidae*	

Table 4. Shallow Water Benthic Fish Species within the Davis Strait Region

Ammodytes sp.	*Gymnelis viridis*	*Myoxocephalus scorpius*
Benthosema glaciale	*Gymnocanthus tricuspis*	*Myoxocephalus sp.*
Boreogadus saida	*Liparis liparis*	*Paralepis coregonoides borealis*
Cyclopterus lumpus	*Macrourus rupestris*	*Salmo salar*
Eurnicrotremus spinous	*Myoxocephalus quadricornis*	*Salvelinus alpinus*
Gadus ogac	*Myoxocephalus scorpioides*	

Greenland halibut is a commercially important species that spawn in deep waters (600 to 1,000 metres) in the Davis Strait in the winter or early spring and produce bathypelagic eggs that rise to the surface where larvae are released. These larvae are in the water column during the months of March to June (Smidt, 1968; MacLaren, 1978a, 1978b). Recently however, Morgan and Treble (2006) suggest from gonad development studies that Greenland halibut spawning takes place in the winter or early spring in Davis Strait. The only recognized major nursery area is near the northern end of its distribution, west of Disko Bay, approximately 69° N.

The roundnose grenadier is thought to spawn all year round in this area (Parsons, 1976), while redfish larvae are found from May to August (Dunbar, 1970). Atlantic cod (COSEWIC, 2003) and Greenland cod have similar spawning periods, February to April (Postolaky, 1969; Dunbar, 1970). In general, the eggs and larvae of the major commercial species are not in the water column nor is there significant spawning activity when project-related seismic activity is proposed.

Commercial fisheries within the Davis Strait region are discussed in Section 4.9 of this document.

4.4 MARINE ASSOCIATED BIRDS

There are many species of seabirds and related bird species that can be found associated with the waters of Davis Strait. Not all are breeding populations and may only contact water or the shore area for brief period in the summer (Mallory and Fontain 2004). Both food and nesting site availability affect seabird distribution locally and seasonally and many variations in the summer habitat and feeding areas will occur each season. A list of seabirds associated with Davis Strait is presented below and adapted from MacLaren (1978a, 1978b) Table 5. There are no endangered or threatened species within the seismic survey area according to the latest information on the Species at Risk (SARA) Registry. The Ivory Gull is however a species of special concern (COSEWIC, 2006).

Table 5. Major Seabirds within the Davis Strait Region

Thick-billed Murr (*Uria lomvia)*	Greenland Mallard (*Anas platyrhynchos conboschas)*
Dovekie *(Alle alle)*	Common Mallard (*Anas platyrhynchos platyrhynchos)*
Atlantic Puffin (*Fratercula arctica)*	Brant *(Branta bernicla)*
Black-legged Kittiwake *(Rissa tridactyla)*	Lesser Snow Goose *(Anser Caerulescens)*
Icelandic Gull *(Larus glaucoides)*	Northern Fulmar *(Fulmarus glacialis)*
Herring Gull *(Larus argentatus)*	Greater Sherewater *(Puffinus grabis)*
Glaucous Gull *(Larus hyperboreus)*	Red Phalarope *(Phalaropus fulicarius)*

Great Black-backed Gull *(Larus marinus)*	Parasitic Jaeger *(Stercorarius parasiticus)*
Arctic Tern *(Sterna paradisaea)*	Pomarine Jaeger *(Stercorarius pomarinus)*
Northern Eider (*Somateria mollissima borealis)*	Long-tailed Jaeger *(Stercorarius lonicaudus)*
King Eider *(Somateria spectabilis)*	Skua *(Catharacta shus)*
Oldsquaw *(Clangula hyemalis)*	Redthroated Loon *(Gavia stellata)*
Harlequin Duck *(Histrionicus histrionicus)*	Common Loon *(Gavia immer)*
Red-Breasted Merganser *(Mergus serrator)*	Arctic Loon *(Gavia arctica)*
Barrow's Goldeneye *(Bucephala islandica)*	Ivory Gull *(Pagophilia eburnea)*

According to Dr. M. Mallory of the Canadian Wildlife Service (Nunavut) the following list of seabirds may be encountered, to a greater or lesser degree (Table 6). In addition, the distribution and abundance of some of these seabirds has been studied for the region by D. Fiefield (Canadian Wildlife Service, St. Johns Newfoundland).

Table 6. Likelihood of encounter of major seabird species within the northern study region

Species	Likely hood of encounter
Thick-billed Murr (*Uria lomvia)*	Certain
Dovekie *(Alle alle)*	Certain
Atlantic Puffin (*Fratercula arctica)*	Possible
Black-legged Kittiwake *(Rissa tridactyla)*	Certain
Icelandic Gull *(Larus glaucoides)*	Certain
Common Eider (*Somateria mollissima)*	Certain
Glaucous Gull *(Larus hyperboreus)*	Certain
Northern Fulmar *(Fulmarus glacialis)*	Certain
Arctic Tern *(Sterna paradisaea)*	Probable
Parasitic Jaeger *(Stercorarius parasiticus)*	Probable

King Eider *(Somateria spectabilis)*	Certain
Long-tailed Jaeger *(Stercorarius lonicaudus)*	Probable
Thayer's Gull (*Larus thayeri*)	Certain
Long-tailed Duck (*Clangula hyemalis*)	Probable
Sabine's Gull (Xema sabini)	Possible
Black Guillemot (*Cepphus grylle)*	Certain
Ivory Gull *(Pagophilia eburnea)*	Possible
Pomarine Jaeger *(Stercorarius pomarinus)*	Possible
Ross's Gull (*Rhodostethia rosea)*	Doubtful

(Dr. M. Mallory CWS, Nunavut)

It is not expected that seismic activity will measurably impact seabirds within the study area for the period of August through September (Lacroix et al 2003, Evans et al.1993, Stemp 1985, Huettmann and Diamond 2000). The surveys will begin far offshore and mitigation measures such as "ramping-up" the airgun array will aide in the dispersion of any concentration of seabirds that may be within the immediate area being studied. Nevertheless there are several seabird and related species that merit closer attention including the Thick-billed Murre, Black-legged Kittiwake, King Eider, Northern Fulmar and Ivory Gull; they are discussed below.

4.4.1 Thick-billed murres

Thick-billed murres are the most abundant colonial seabird in eastern Canada (Orr and Ward 1982, Gaston 1980, Figure 8). They breed along the Labrador coast and the northern islands between May and August (McLaren 1982, McLaren and McLaren 1982). At this time flightless birds (adults and chicks) from both western and eastern arctic colonies utilize surface water currents and travel rapidly through Hudson Strait, Davis Strait and the Labrador Sea (Orr and Ward 1982). During this period, August to October, sever hundred thousand flightless adults and chicks will be migrating. However as Figure 8 indicate these birds may be encountered during seismic activity.

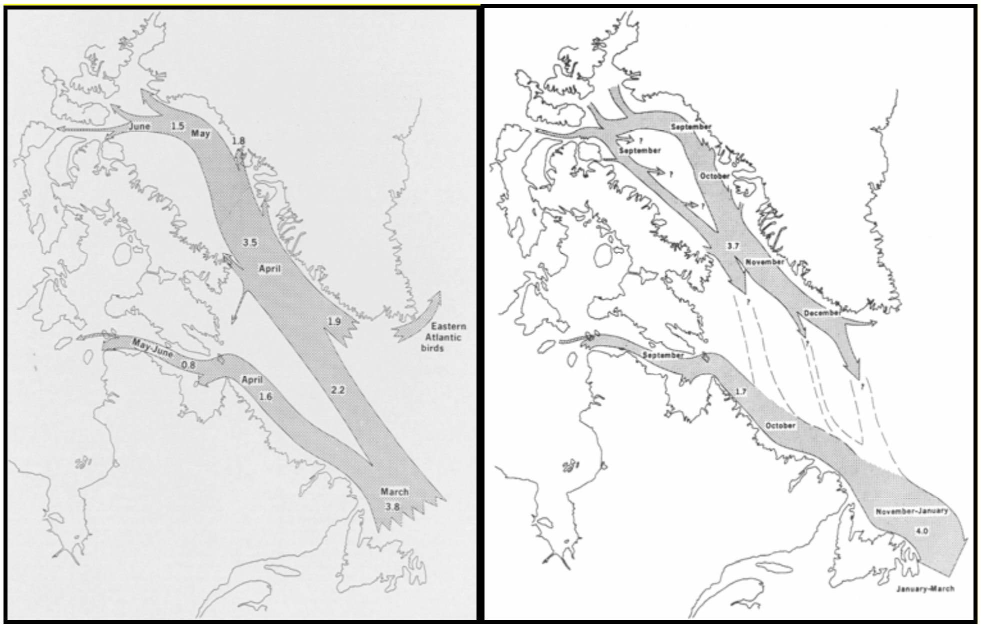

Figure 8. Thick-billed Murre seasonal distribution (Gaston 1980)

Common and Thick-billed Murres are divers and may be affected by seismic activity. This is also true for *Alcidae* that breed in Newfoundland and Labrador including Razorbill and Atlantic Puffin. The largest colony of Razorbill in North America is at the Gannet Islands in southern Labrador. Shearwaters also dive for their food and may be susceptible to seismic interactions. Although diving birds may be susceptible to seismic interactions studies by Lacroix et al (2003) found no measurable impact of seismic activity on diving ducks (*Clangula hyemalis*), see also McLaren and McLaren 1982.). Stemp (1985).

4.4.2 Northern Fulmars

Northern Fulmars that reside in the Canadian Arctic in summer, winter in offshore open water areas in southern Baffin Bay, Davis Strait and the Labrador Sea (McLaren 1982). From May to June, prior to nesting, Fulmars generally occur in similar densities on coastal and ice edge habitats.

4.4.3 Black-legged Kittiwakes

Black-legged Kittiwakes that summer in the eastern Canadian Arctic winter pelagically in open waters of the Labrador Sea and North Atlantic (McLaren 1982). During the spring and early summer their densities were found to be higher along coastal areas than along fast ice edges and both higher than in offshore areas (McLaren 1982).

4.4.4 King Eiders

King Eiders, according to Mosbech and Boertmann (1999) will not be in the survey area during the period scheduled for this seismic activity (Figure 9).

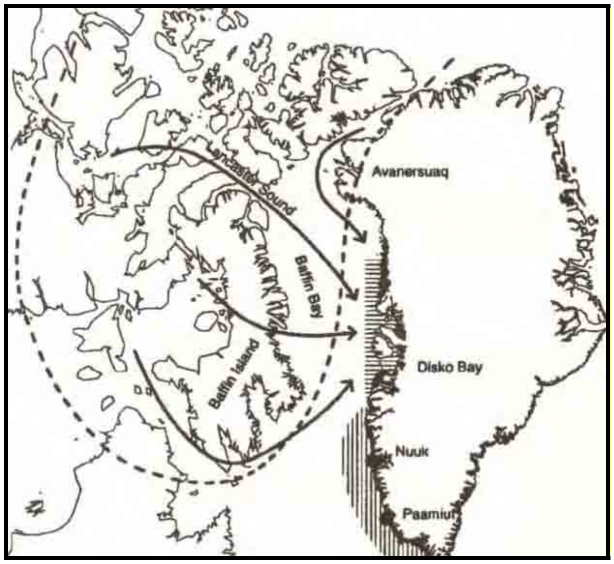

Figure 9. Molt migration of King Eiders and main molting area off Greenland (Mosbech and Boertmann 1999)

Most recently, D. Fiefield, CWS (Newfoundland) has compiled the latest abundance and distribution of several bird species within the region of concern. The distribution and estimated abundance for some of the above mentioned species from July through September over the period 2006 to 2009 is presented in the following figures (Figure 10 to Figure 14). Graphic distribution and abundance for the period of the northern field program in the eastern Arctic for some of these species is presented below. (We gratefully acknowledge the assistance of C. Gjerdrum CWS, Dartmouth, Nova Scotia for these figures.) Additional information on regional seabirds may be acquired through review of Mallory and Fontaine (2004).

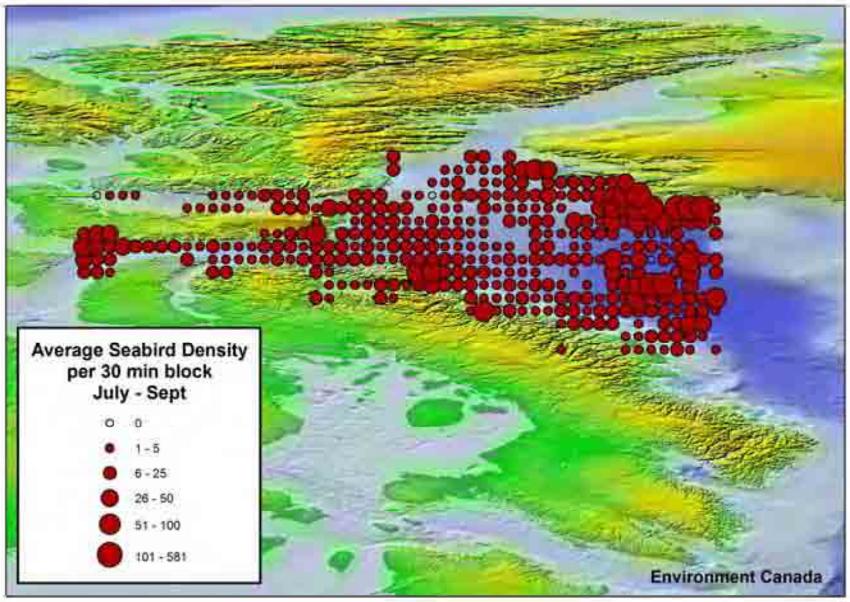

Figure 10. Average seabird distribution and abundance (all seabirds) for the period of July to September

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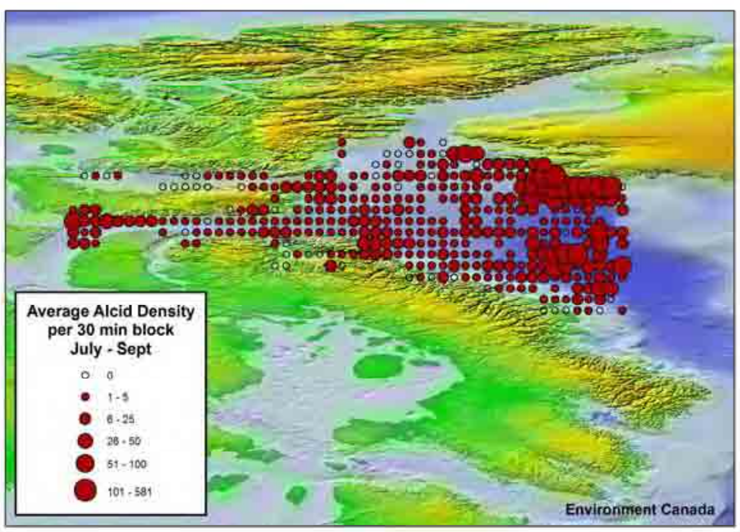

Figure 11. Average *Alcid* seabird distribution and abundance (Razorbills, Auklets, Puffins and Murres) for the period of July to September

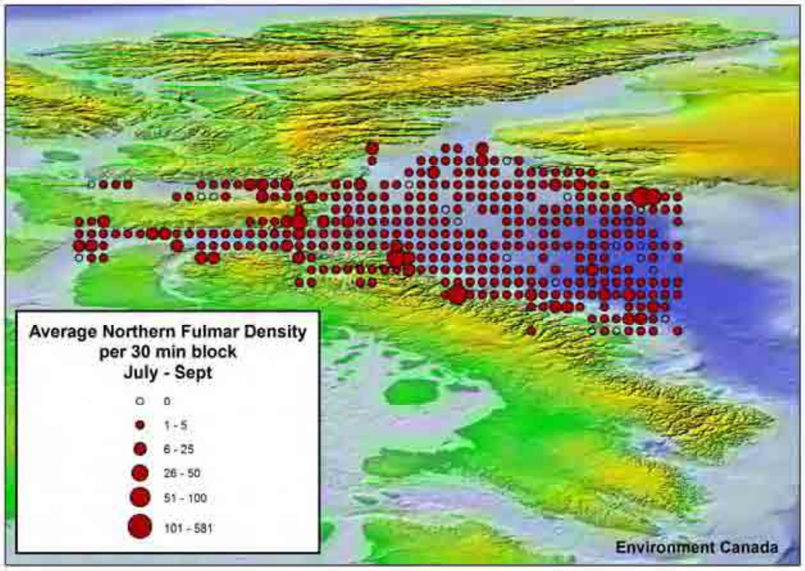

Figure 12. Average distribution and abundance of Northern Fulmars for the period of July to September

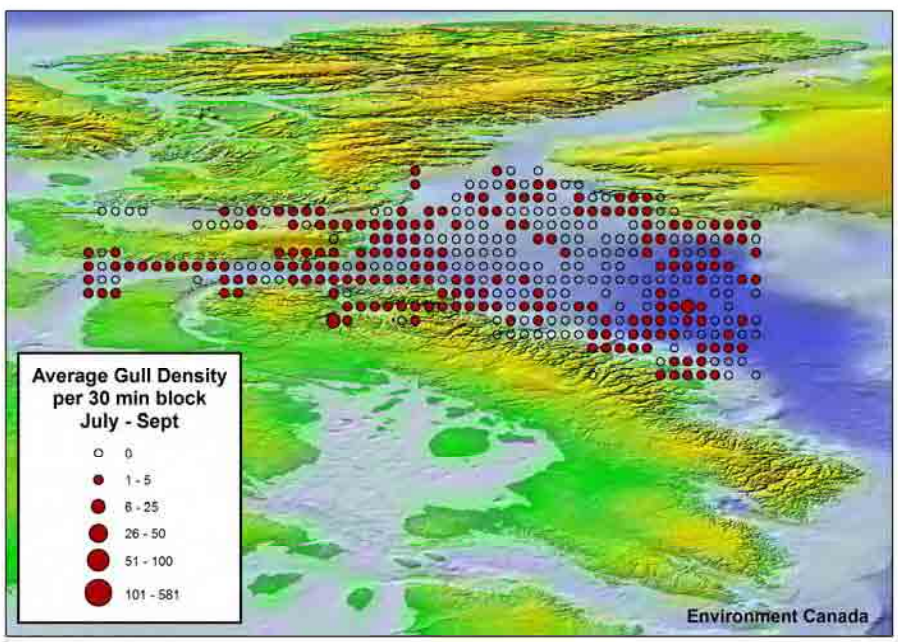

Figure 13. Average Gull distribution and abundance for the period of July to September

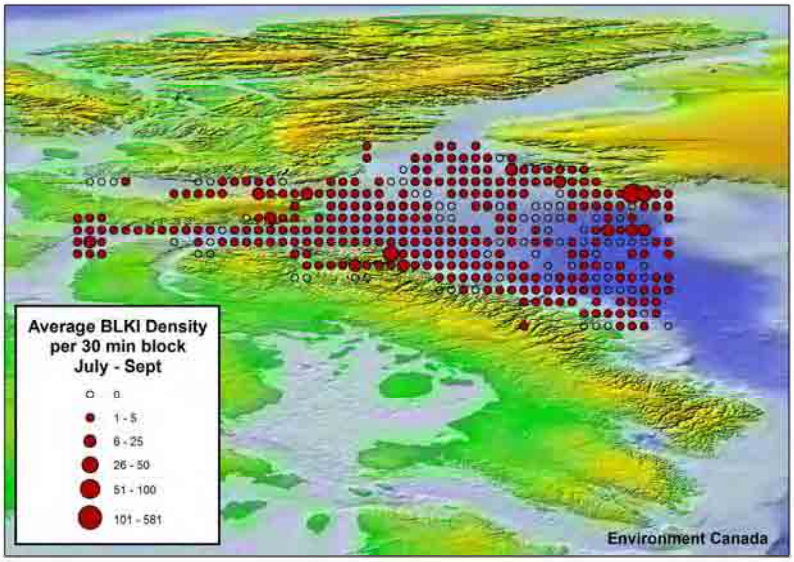

Figure 14. Average Black-Legged Kittiwake distribution and abundance for the period of July to September

4.4.5 Ivory Gull

Although the east coast of northern Baffin Island, Lancaster Sound and Jones Sound support many seabird colonies only one species has been identified as at risk by SARA and COSEWIC 2006. The Ivory Gull was assigned as an endangered species by COSEWIC (2006c) and SARA due to decline in their distribution and abundance (Gilchrist and Mallory 2005). Although the historic winter range (Figure 15) shows that the species may frequent areas of the proposed seismic survey in the late fall the seismic survey will be completed by the end of September. Consequently, these birds that may frequent the most southern regions of the seismic survey area for wintering (November) are less likely to be exposed to measurable influences related to human activity undertaken in the summer.

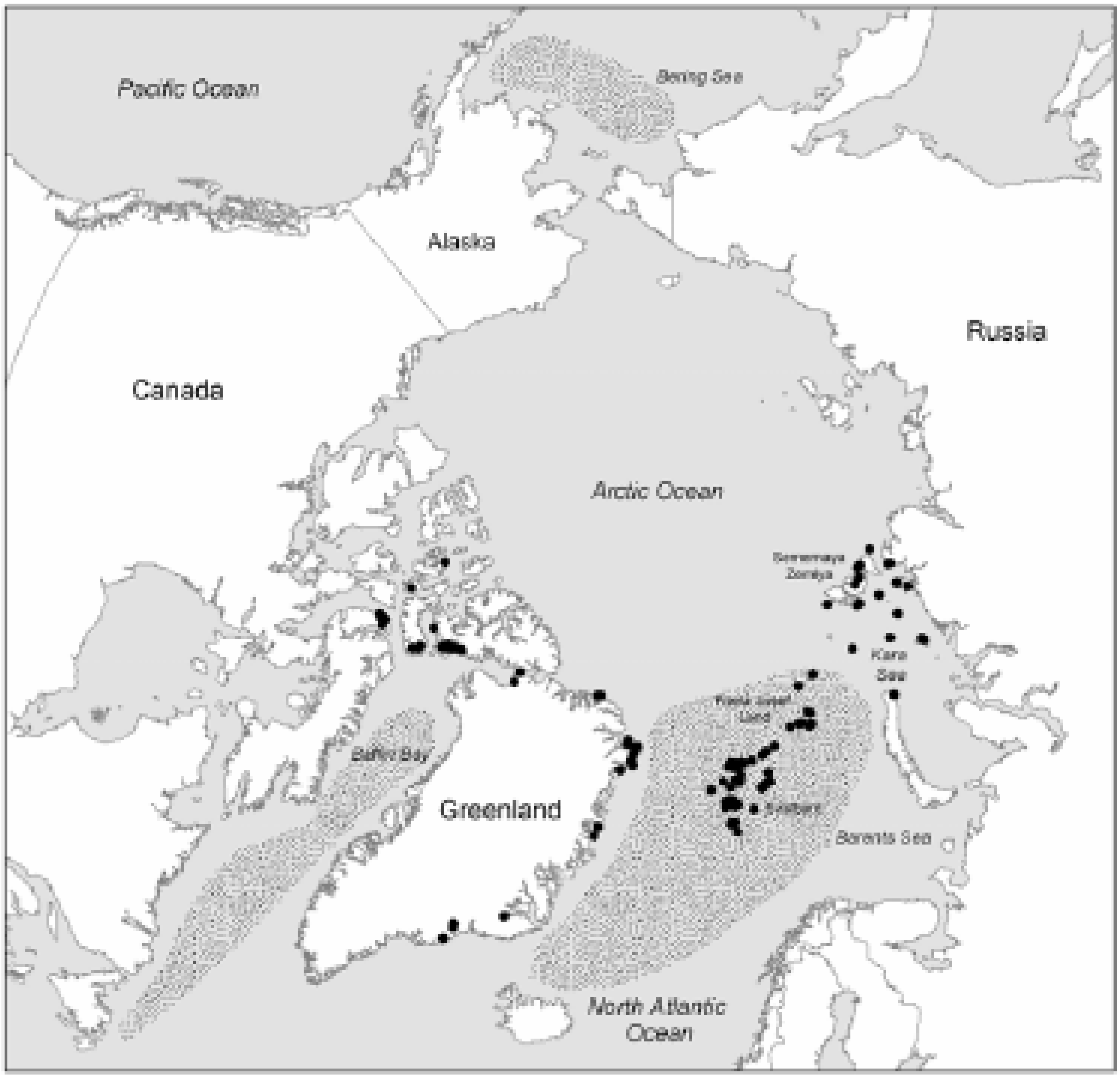

Figure 15. Distribution of ivory gull, stippled indicates winter range, dots identified colonies (active and inactive, COSEWIC 2006c).

4.4.6 Dovekies

Dovekies (*Little Auks*) breed in northwest Greenland and migrate through Davis Strait during the latter part of April and early May (Renaud et al., 1982). The number of dovekies wintering in North American waters and breeding colonies in northwest Greenland has been estimated to be in the tens of millions (Montevecchi and Stenhouse, 2002). The only known breeding area in the Canadian Arctic is in Home Bay on eastern Baffin Island (Montevecchi and Stenhouse, 2002). This species winters in low arctic waters of the Labrador Sea, Grand Banks, and coastal Newfoundland (Montevecchi and Stenhouse, 2002). Colonies are abandoned by late August and birds start to leave northern Baffin Bay through to October, where they remain at the edge of pack-ice in southern Baffin Bay and Davis Strait. Here, in these offshore habitats, dovekies generally occur in higher densities associated with moderate to heavy pack-ice. Ice-free areas or areas with total ice cover are generally avoided (Renaud et al., 1982). Because ice-free areas are the only areas where seismic activity will take place, it is unlikely that significant numbers of dovekies will be encountered during the survey period. Nevertheless, mitigation measures will be adopted to reduce potential interaction of seismic activity on dovekies.

4.4.7 Long-tailed Ducks

Long-tailed ducks (*formerly Oldsquaws*) may occur in large numbers along coastal areas and shore-ice areas of eastern Lancaster Sound and northern Baffin Bay from May to July (McLaren and McLaren, 1982); however, they are rarely seen greater than 1 kilometre from the coast or shore-fast ice. Although densities may peak in September, by mid-October only a few individuals remained when surveys were undertaken in Lancaster Sound (McLaren and McLaren, 1982). Since these ducks are rarely seen out as far as 1 kilometre from the shore, it is unlikely that the seismic survey will encounter this species.

4.4.8 Black Guillemots

Black Guillemots within Baffin Bay and eastern Lancaster Sound, during the spring and early summer, have densities that are higher along fast ice edges than along coasts, and densities offshore were lower than along interfaces (McLaren and McLaren, 1982). Their distribution in the most northern areas during early to mid-summer. Like Murres, Guillemot densities were highest in light to heavy pack-ice and lowest in ice-free areas and areas with total ice cover. Since the proposed seismic activity will take place in ice-free waters, the potential for interaction with this species is significantly reduced. Nevertheless mitigation measures to reduce the potential for interaction will be in place

4.5 MARINE MAMMALS

Marine mammal occupation of this region of eastern Canadian high Arctic may include up to 22 species: 5 seal, 1 walrus, 6 species of baleen whale, 6 species of toothed whale, 3 porpoises, and the polar bear (MacLaren Atlantic Limited, 1978, McLaren et al.1982). The proposed study area forms the northern most range extent for several species and the likelihood of their presence here is therefore less understood during the proposed period of seismic activity in this area of the high Arctic. Most notably, the marine mammal species that could be encountered during this portion of the northern survey include: ring, harbour, bearded and harp seals, possibly hooded seals; the walrus, polar bear as well as beluga, narwhal and bowhead whales and possibly killer whales (LGL 1983, Dunbar and Moore 1980).

Pinnipeds

4.5.1 Ringed seal (*Phoca hispida*)

The Ring seal, (*Phoca hispida*), has a circumpolar distribution (DF0 2009) and they are generally closely associated with the distribution of land fast ice. They are the most common seal within Nunavut (MacLaren, 1958, LGL 1983, Dunbar Moore 1980). Immature ringed seals may move offshore during open water season, but adults remain around islands and within the bays and fiords (MacLaren, 1958, LGL 1983, Dunbar Moore 1980). Consequently, they are unlikely to be encountered during the seismic survey that will take place in the summer. There is no evidence of large scale migrations. The native harvest within Nunavut takes place throughout the year (Priest and Usher 2004, Table 7. Their general distribution/range is shown in Figure 16

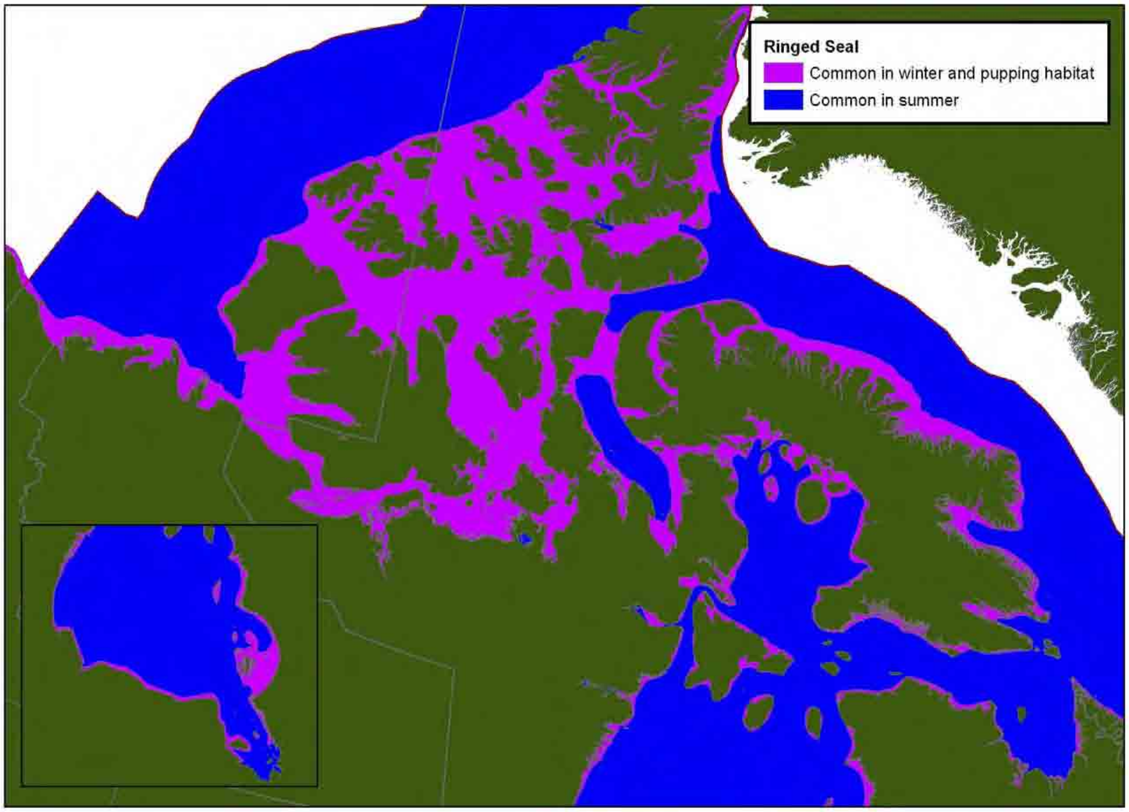

Figure 16. Distribution of Ringed Seal (*Pusa hispida*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

Table 7. Month with Species captured in Nunavut (Priest and Usher 2004).

	June	July	August	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May
Seals												
(unspecified)												
Ringed												
Bearded												
Harp												
Harbour												
Hooded												
Walrus												
Whales												
Narwhal												
Beluga												
Bowhead												
Polar Bear												

4.5.2 Bearded Seal (*Erignathus barbatus*)

The Bearded seal, *Erignathus barbatus*, is sparsely distributed throughout the Canadian Arctic and restricted in distribution by the extent of pack ice and shallow water (MacLaren, 1958, LGL 1983, Dunbar Moore 1980, CNLOPB 2008). Unlike many of the other seal species occurring in the Canadian Arctic, this species has not been well investigated (Stephenson and Hartwig 2010). Studies of their general distribution have lead to adopt the 250 m benthic contour interval as a measure to delineate the area in which Bearded Seals are commonly seen (Stephenson and Hartwig 2010). Their general distribution/range is shown in Figure 17. Note that they are absent from the central portion of Baffin Bay and Davis Strait where the northern portion of the survey will take place and they generally occur near shore. Bearded seals are harvested throughout the year by native populations (Priest and Usher 2004).

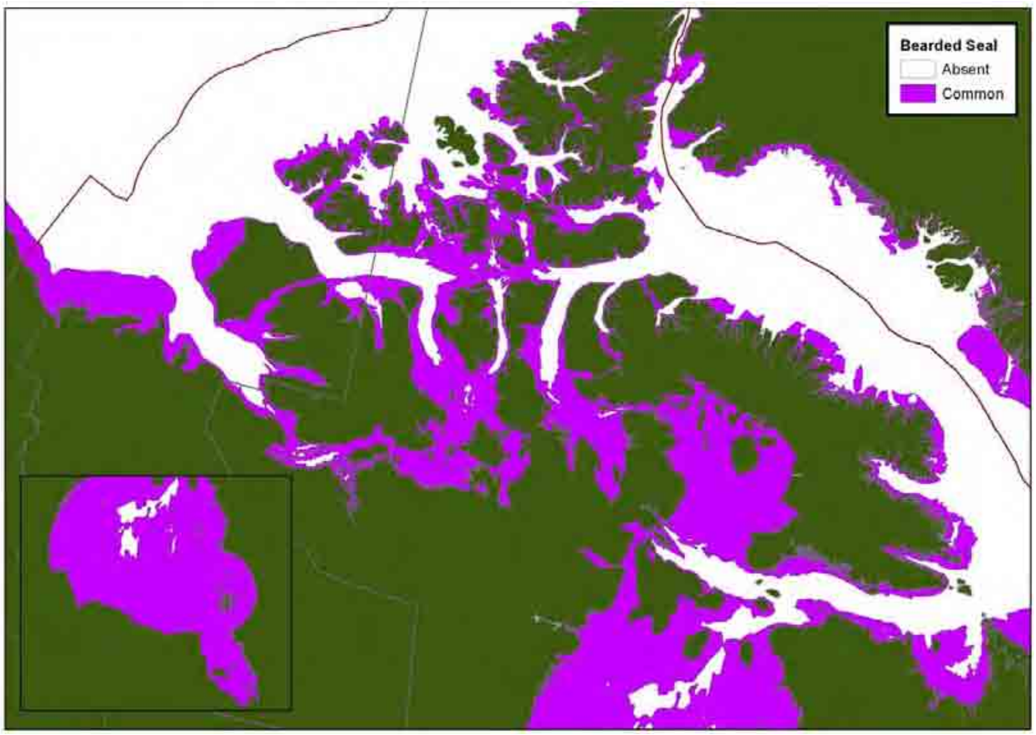

Figure 17. Distribution of Bearded Seal (*Erignathus barbatus*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

4.5.3 Harp seals (*Phoca groenlandica*)

Harp seals (*Phoca groenlandica*) are known to occur in large numbers during the summer season in the region. The population of Harp Seals is presently estimated to be about 6 million individuals (Stephenson and Hartwig 2010). Harp seals migrate westward throughout the summer, from Baffin Bay into Lancaster Sound (Stephenson and Hartwig 2010) and may travel in large groups (50 to 500+) during ice break-up (Fallis et al., 1983). They are common at the floe edge feeding or hauled out on ice floes (DFO, 2005). Their migratory pathways and whelping grounds are shown in Figure 18. Groups tend to be smaller during the open water season. Harp Seals are hunted throughout Nunavut primarily during the months of June through September Table 7 (Priest and Usher 2004). Their general distribution/range is shown in Figure 19.

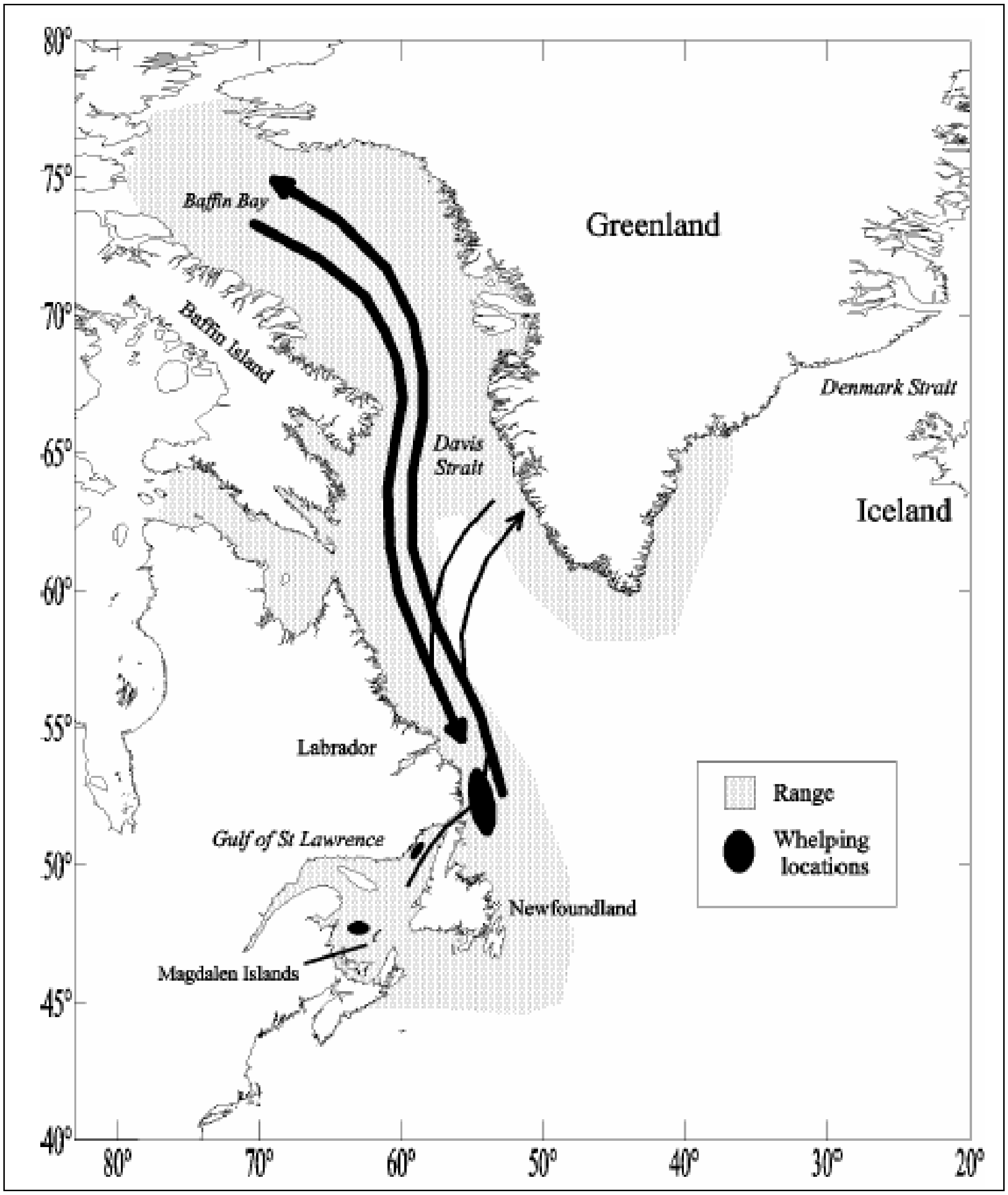

Figure 18. Range, Migratory Pathways, and Whelping Locations of Harp Seals in the Northwest Atlantic (DFO, 2005)

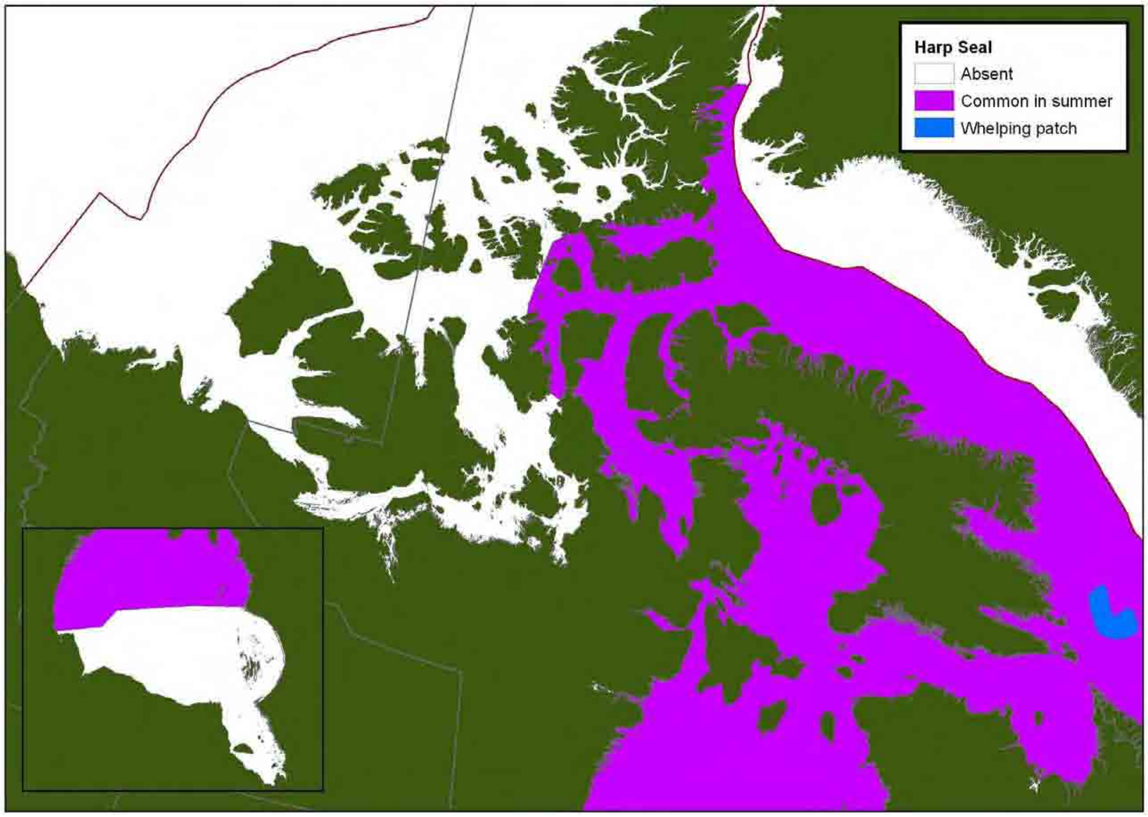

Figure 19. Distribution of Harp Seal (*Pagophilus groenlandica*) in the Canadian Arctic (Stephenson and Hartwig 2010)

4.5.4 Harbour Seal (*Phoca vitulina*)

The Harbour Seal, *Phoca vitulina*, is a coastal species and is generally associated with near shore shallow water with regions of up welling and tidal action or out on the floe edge (Mansfield, 1967). In general they prefer not to venture greater than 11 km offshore in waters that are in the order of 50 m (COSEWIC 2007). This depth limitation has been supported by radio telemetry studies that have indicated that the 50 m benthic contour line may be used to demarcate their offshore limit of distribution (Stephenson and Hartwig 2010). This distribution pattern may be related to the fact that this species of seal does not maintain breathing holes in the ice and thus they are restricted in their offshore distribution to areas with open water during ice-covered seasons (Stephenson and Hartwig 2010). Harbour Seals are harvested by members of the Nunavut community primarily during the period from July through October (Table 7). Their distribution and range is shown in Figure 20.

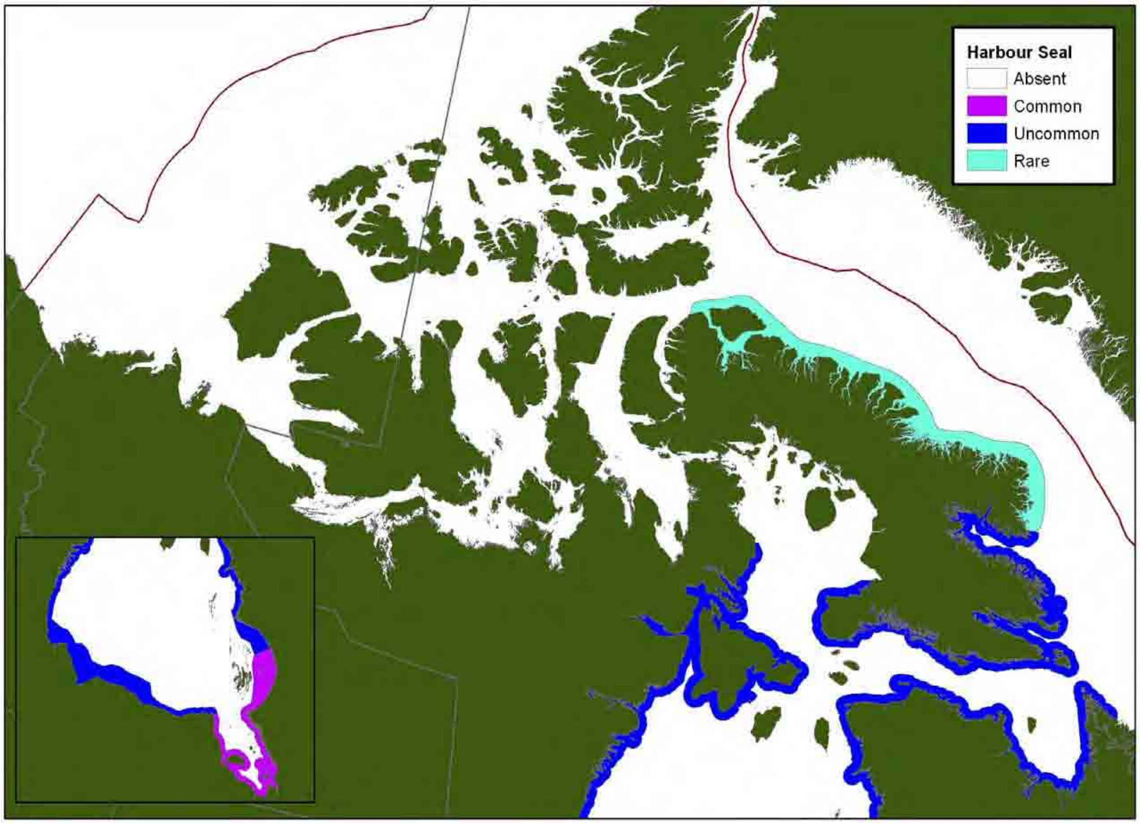

Figure 20. Distribution of Harbour Seal (*Phoca vitulina*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

4.5.5 Hooded seals (*Cystophora cristata*)

Hooded seals (*Cystophora cristata*), within Nunavut are occasionally seen migrating into Lancaster Sound from Baffin Bay (Sergeant, 1976, Hammill and Stenson 2006). Although they have not been extensively studied, they are generally associated with heavy pack ice and their presence would extend until ice break-up (Sergeant, 1974). Hooded Seals are considered a deep-water feeder (Stephenson and Hartwig 2010). Since they are primarily deep-water feeders, the 200 m bathymetric contour interval has been adopted to estimate the offshore distribution boundary of this species (Stephenson and Hartwig 2010). Native hunting for this seal takes place primarily during the months of June through December (Priest and Usher 2004, Table 7). Their general distribution throughout the region is presented in Figure 21. Furthermore, the Nunavut Wildlife Management Board has produced a series of species distribution maps for resources that occur within the Nunavut Settlement Area. These maps, based on many years of traditional ecological knowledge (TEK), provide insight on the local distribution patterns of marine related aquatic resources important to the members of the Nunavut community.

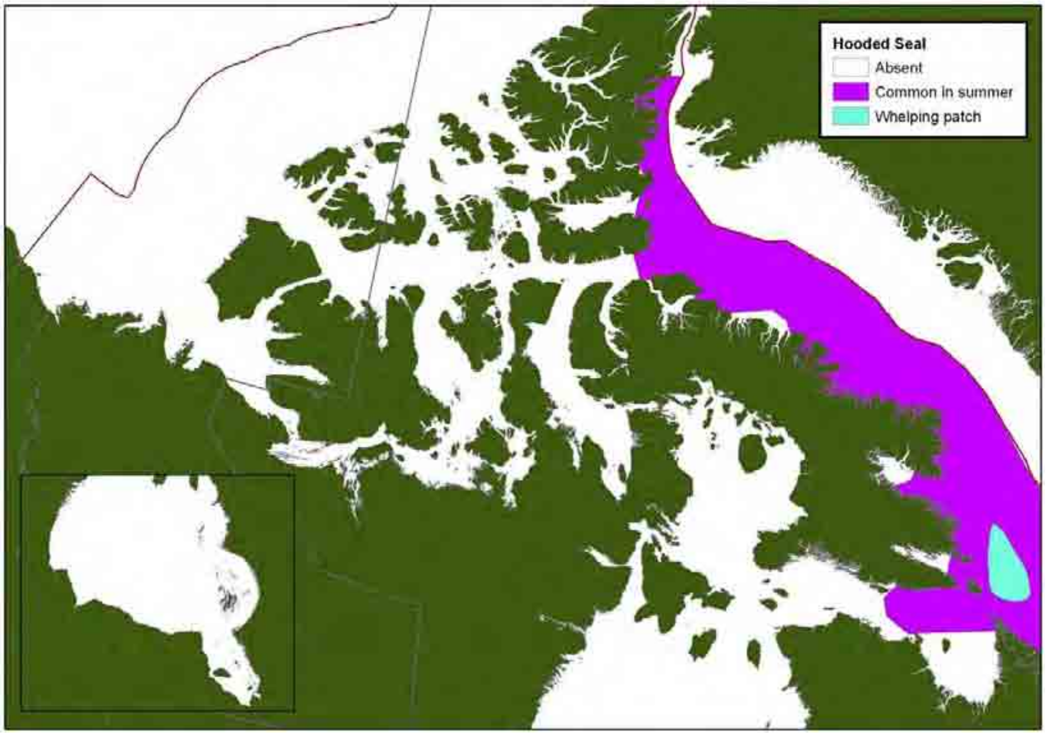

Figure 21. Distribution of Hooded Seal (*Crystophora cristata*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

Nunavut traditional ecological knowledge for the sea species in their jurisdiction has been mapped. This map, Figure 22, shows the high density distribution pattern of the most important species to the Nunavut, notable the Harp Seal, Ring Seal and to some extent the Bearded Seal (Nunavut Planning Commission 2009).

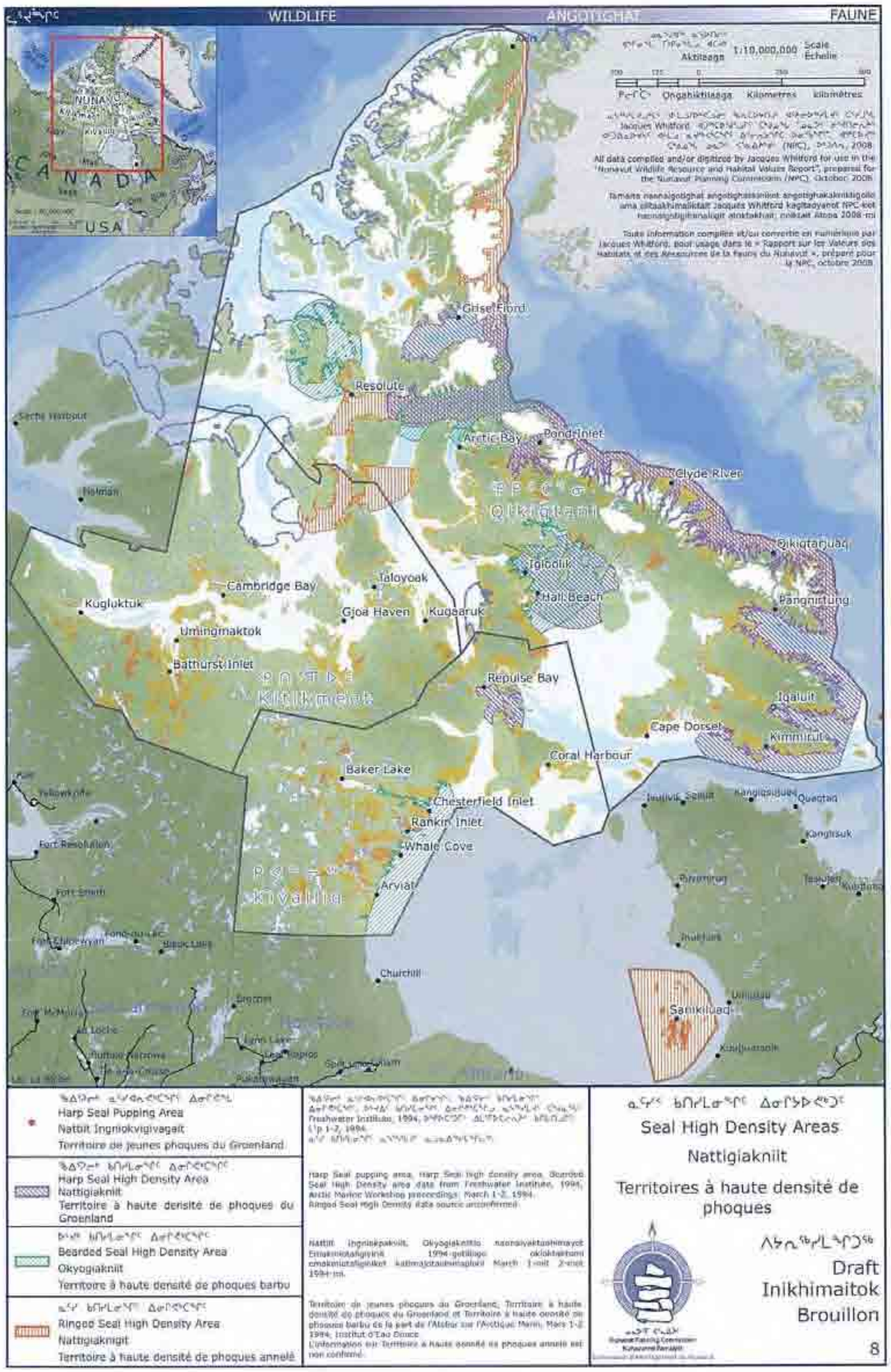

Figure 22. High density distributional pattern of major seal resources within Nunavut (Nunavut Planning Commission 2009).

4.5.6 Atlantic walrus (*Odobenus rosmarus*)

The Atlantic walrus, *Odobenus rosmarus*, once common in the region, is now more rare and has recently been up-listed by COSEWIC from a designation of “not at risk” to a designation of “Special Concern” (COSEWIC, 2006). Ecologically, the Atlantic walrus prefers shallow water (<80 metres) regions with high bivalve productivity. Bivalves are their primary prey (Evans and Raga 2001). The general distribution and range of this species is shown in Figure 23. There are several populations within the Canadian Arctic and their specific distribution pattern is presented in Figure 24 and Figure 25. The Nunavut Wildlife Management Board has mapped the seasonal distribution of walrus for the Nunavut region, this pattern of seasonal distribution is presented in Figure 26. Walrus are hunted in the Nunavut region year round (Priest and Usher 2004). The general distribution pattern and their habitat preference for shallow near shore areas substantially reduce the potential for interaction with this project in far offshore regions.

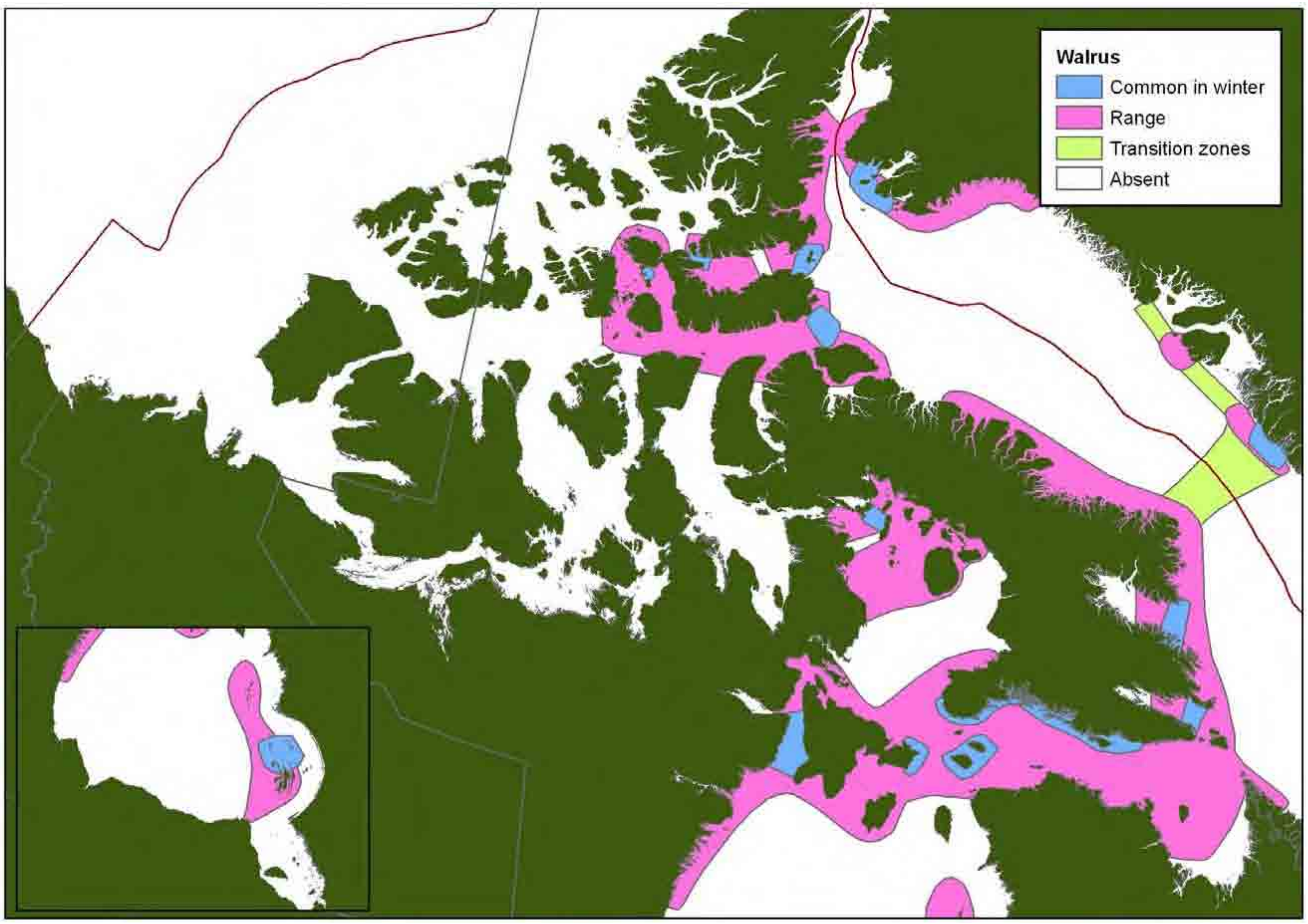

Figure 23. Distribution of Walrus (*Odobenus rosmarus*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

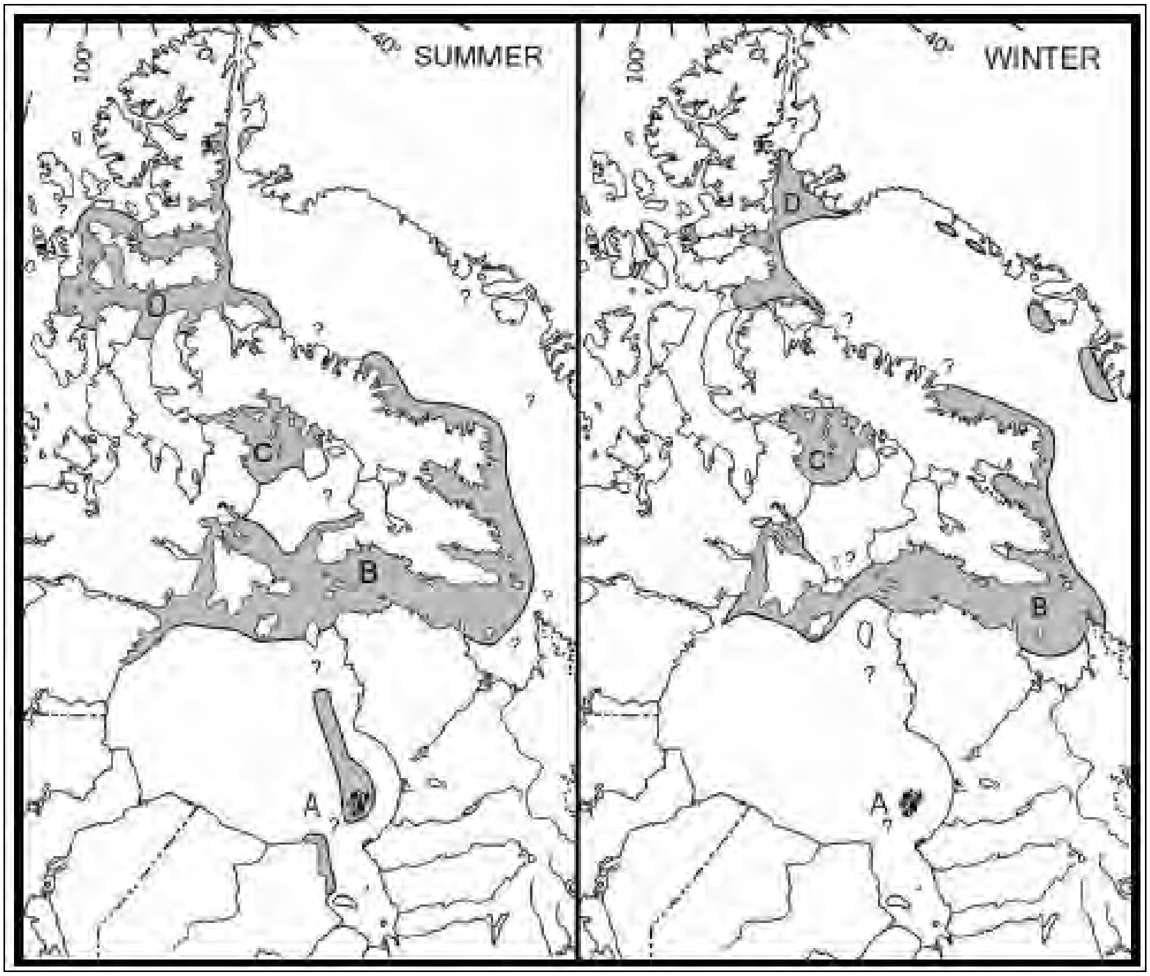

Figure 24. Approximate summer and Winter Distributions of Atlantic Walrus Populations in Canadian Waters South and East Hudson Bay (A), Northern Hudson Bay - Davis Strait(B), Foxe Basin (C), and Baffin Bay (High Arctic) (D) populations. Question marks indicate uncertainty with respect to distributions and/or movements (COSEWIC 2006).

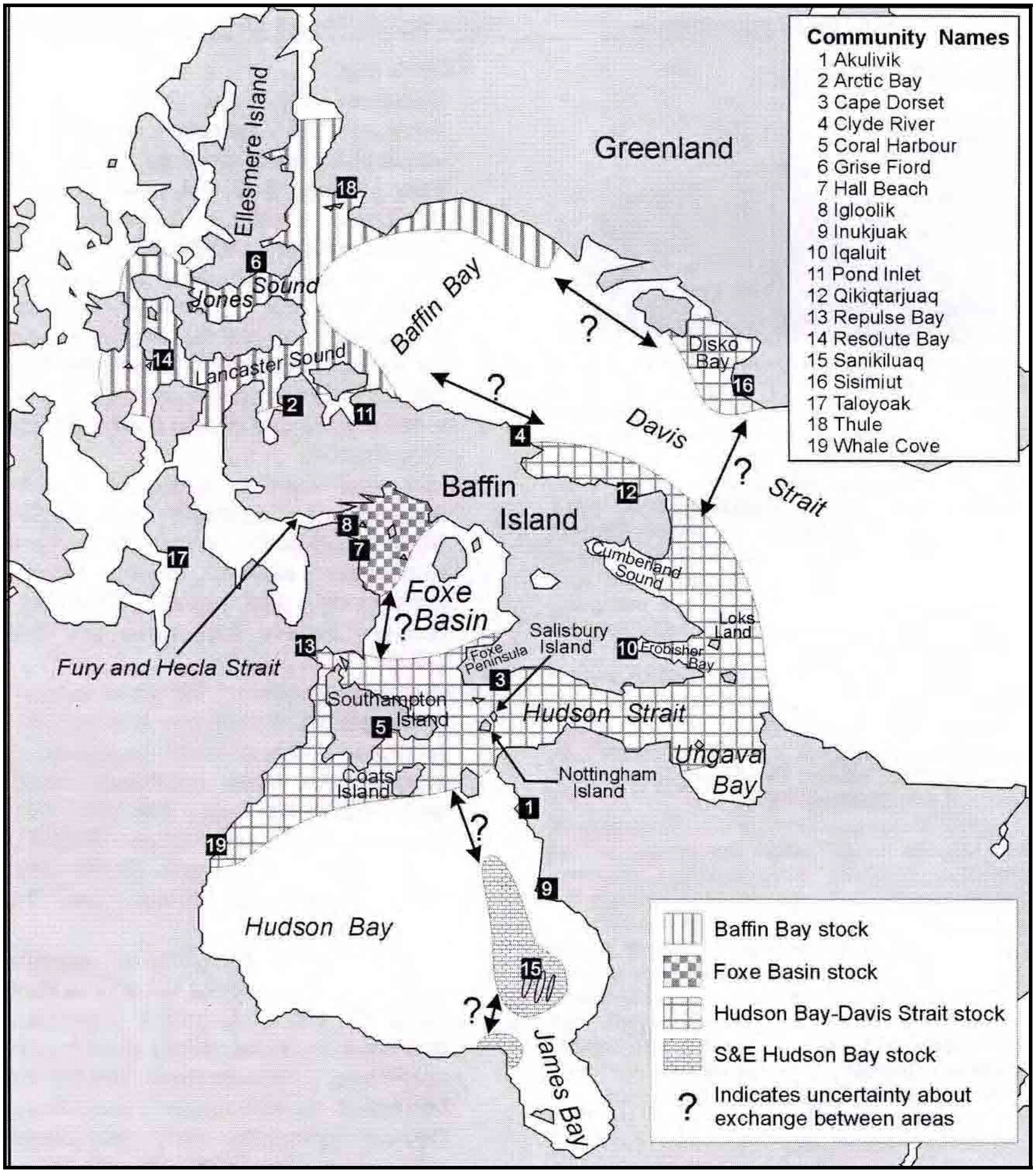

Figure 25. Map of the range and distribution of Atlantic walrus stocks in eastern Canadian waters (from DFO 2000).

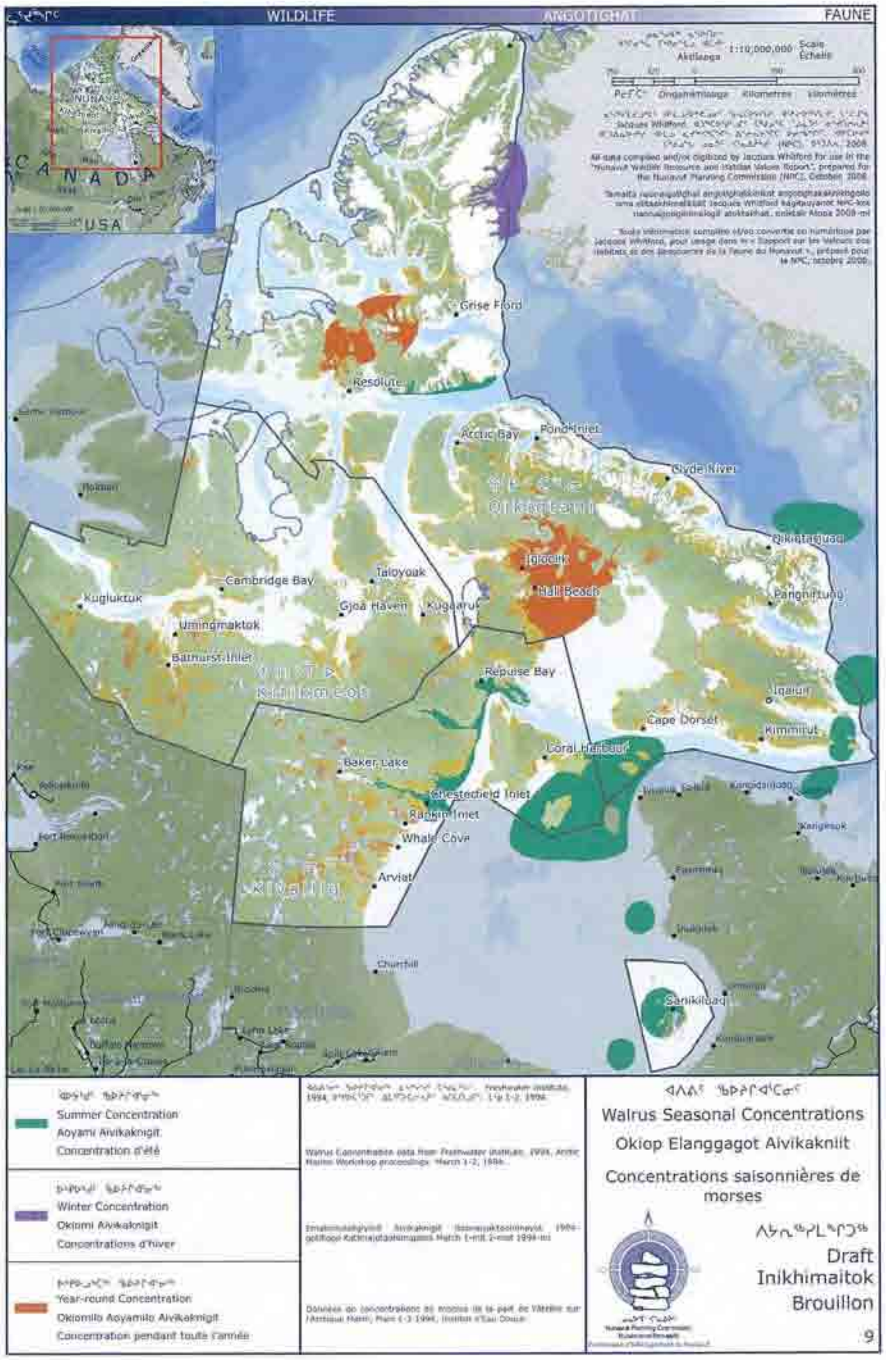

Figure 26. Walrus seasonal concentrations within Nunavut

4.6 CETACEANS

Toothed Whales

4.6.1 Killer Whale (*Ornicus orca*)

The killer whale, *Ornicus orca*, frequents the eastern Canadian Arctic Davis Strait and Baffin Bay Region in summer (MacLaren, 1978a, 1978b, Dunbar and Moore 1980, COSEWIC 2008). Current detailed information on their distribution within Nunavut is lacking. Killer Whales tend to be seen inshore during the spring and summer, likely searching for prey such as seals (Leatherwood et al., 1976) and juvenile bowhead whales (Finley, 2001). Information regarding use of offshore habitat by killer whales is lacking. Inuit are reporting increases in killer whale presence within coastal Nunavut waters. Killer whales are not actively hunted by the peoples of Nunavut. Killer whale distribution and range is shown in Figure 27.

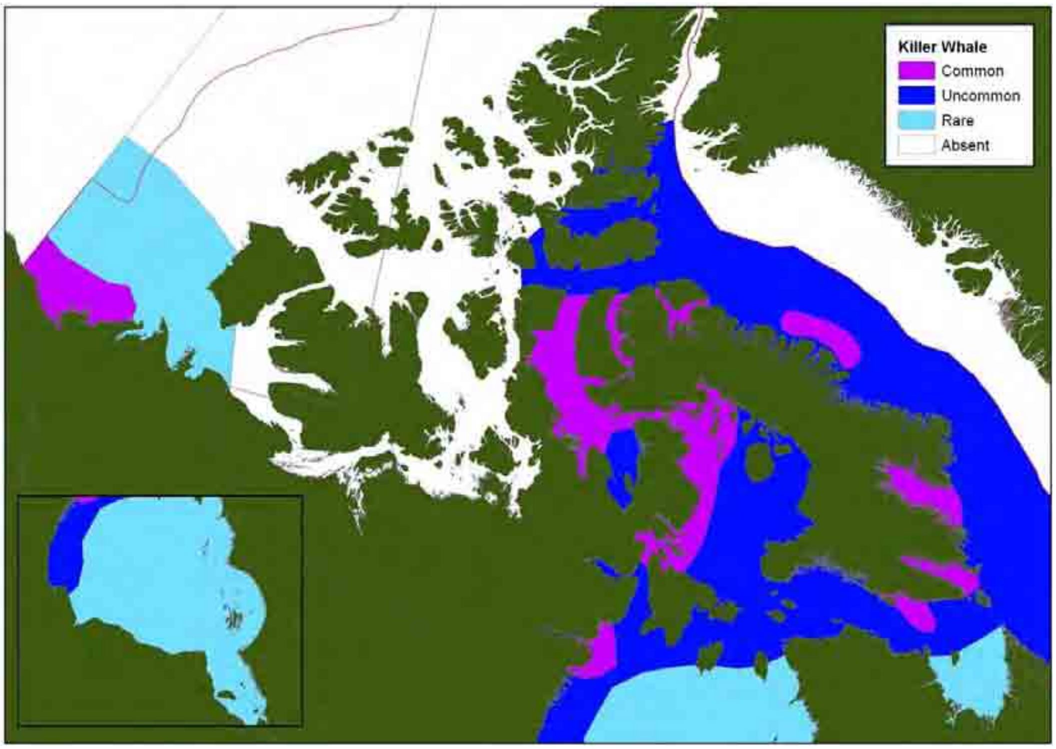

Figure 27. Distribution of Killer Whale (*Orcinus orca*) in the Canadian Arctic (Stephenson and Hartwig 2010)

4.6.2 Beluga Whale (*Delphinapterus leucas*)

Beluga whales (*Delphinapterus leucas*) are circumpolar in distribution. In the summer, it can be found in the warm shallow bays and estuaries of large rivers, whereas in the fall (mid-September) it migrates south to over-winter amongst the pack ice, in leads and polynyas, where open water provides access to air (Doidge and Finley, 1993; DFO 2002; NAMMCO, 2005). Their general distribution and range is shown in Figure 28. The highest concentrations of Beluga Whales in the Canadian Arctic waters are found in Hudson Bay especially in the Nelson River area in summer (Stephenson and Hartwig

2010). This population is called the Western Hudson Bay population (WHB) and they migrate to the Hudson Strait area in winter (Stephenson and Hartwig 2010).There is also an Eastern Hudson Bay population (EHB) that summer around the Nastapoka River of eastern Quebec (Stephenson and Hartwig 2010). In general, Beluga over-winter in highly productive areas like Baffin Bay, Hudson Strait and Davis Strait (Stephenson and Hartwig. 2010.), (DFO 2010), (Hammill and Lesage 2009, Hammill et al. 2009), (Gosselin et al. 2009). Both SARA and COSEWIC (2004) have identified that the Cumberland Sound beluga population with a “Threatened” status and the Eastern Hudson Bay Beluga population assigned a status of “Special Concern”. Their distributions are shown in Figure 29.

Due to the beluga’s summertime preference for shallow warm estuarine waters, it is unlikely that it would be encountered offshore at this time where the majority of the seismic activity will take place. Beluga is harvested by members of the Nunavut community on a year round basis (Table 7).

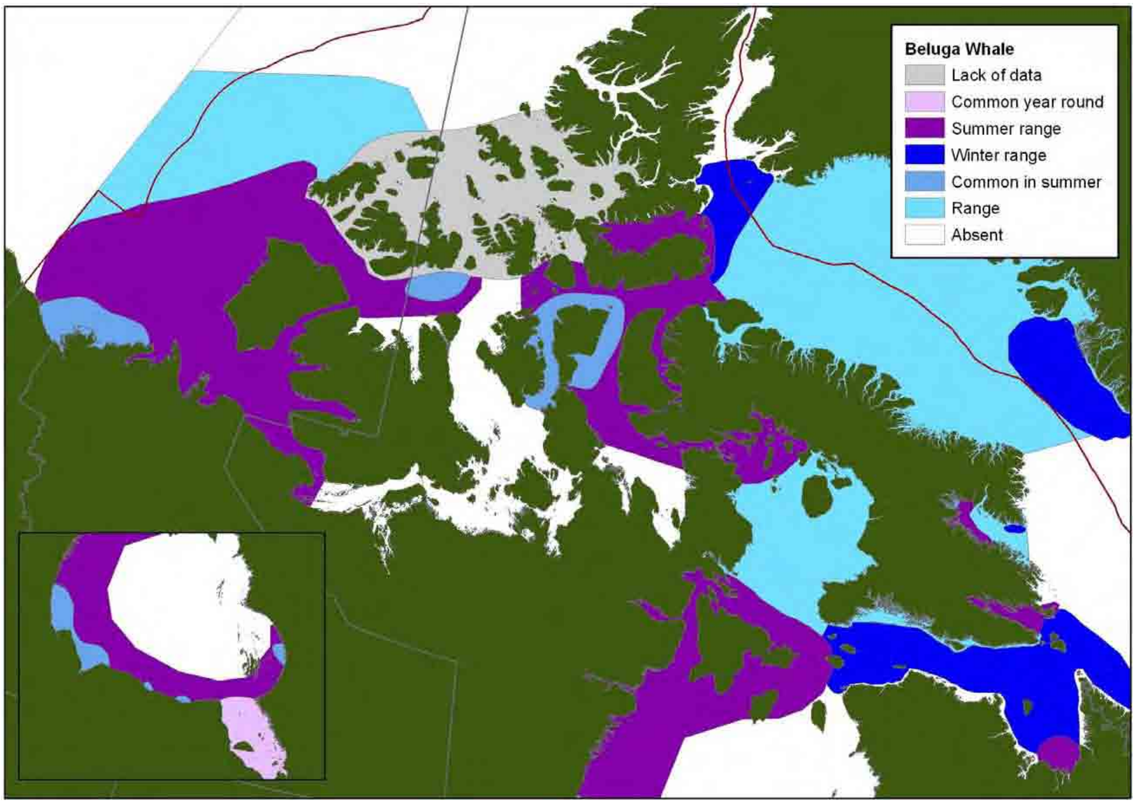

Figure 28. Distribution of Beluga Whale (*Delphinapterus leucas*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

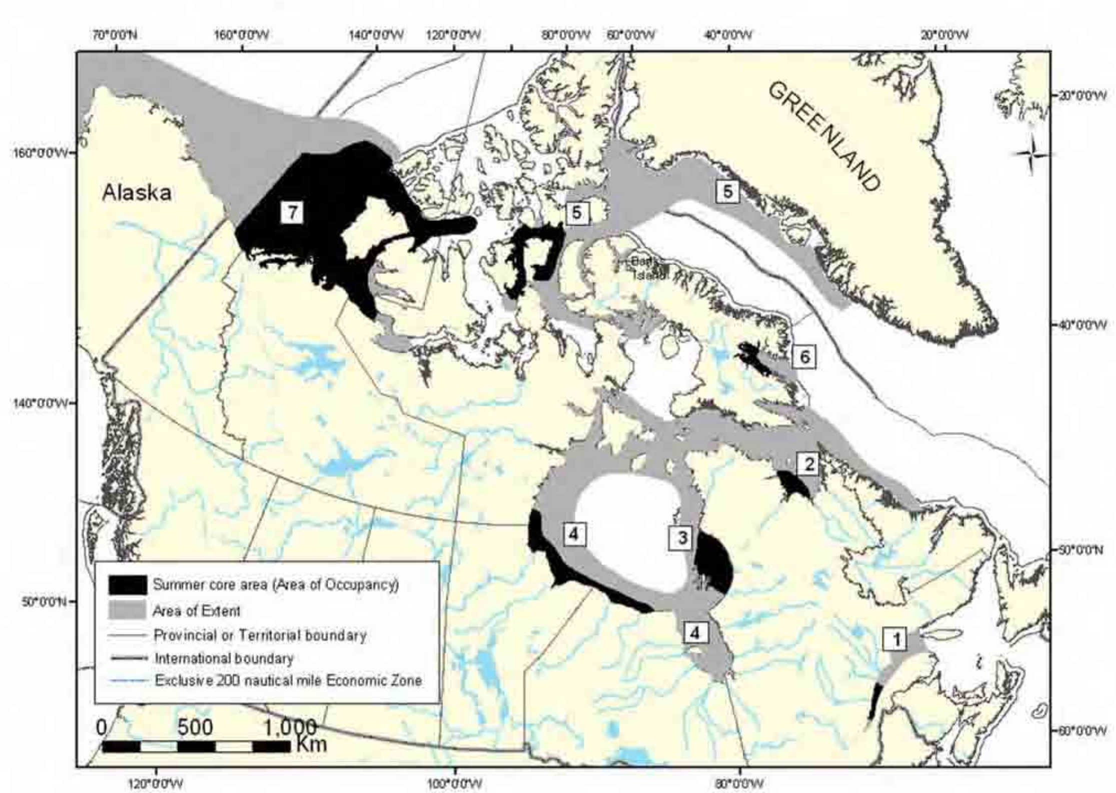

Figure 29. Location of Canadian Beluga Populations: (1) St. Lawrence Estuary population (2) Ungava Bay population (3) Eastern Hudson Bay population (4) Western Hudson Bay population (5) Eastern High Arctic – Baffin Bay population (6) Cumberland Sound population (7) Eastern Beaufort Sea population (COSEWIC 2004).

4.6.3 Narwhal (*Monodon monoceros*)

The narwhal, *Monodon monoceros*, is a toothed whale and its distribution and range in the Canadian Arctic is shown in Figure 30. The Narwhal also is common in coastal areas (Figure 31 and Figure 32) (COSEWIC, 2004). Most animals are believed to over-winter in Baffin Bay, Davis Strait, and Hudson Strait. When the pack ice breaks up in Davis Strait these whales move up the leads into Pond Inlet and Lancaster Sound. (Mansfield et al. 1975).

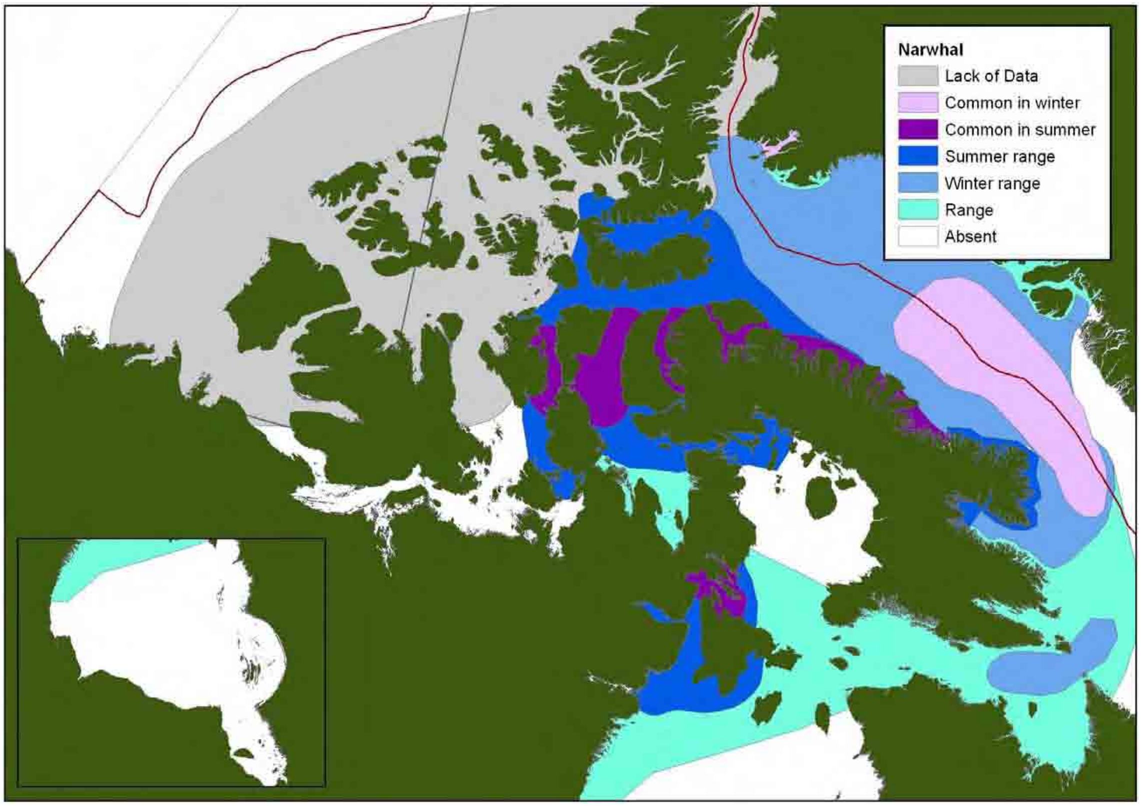

Figure 30. Distribution of Narwhal (*Monodon monoceros*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

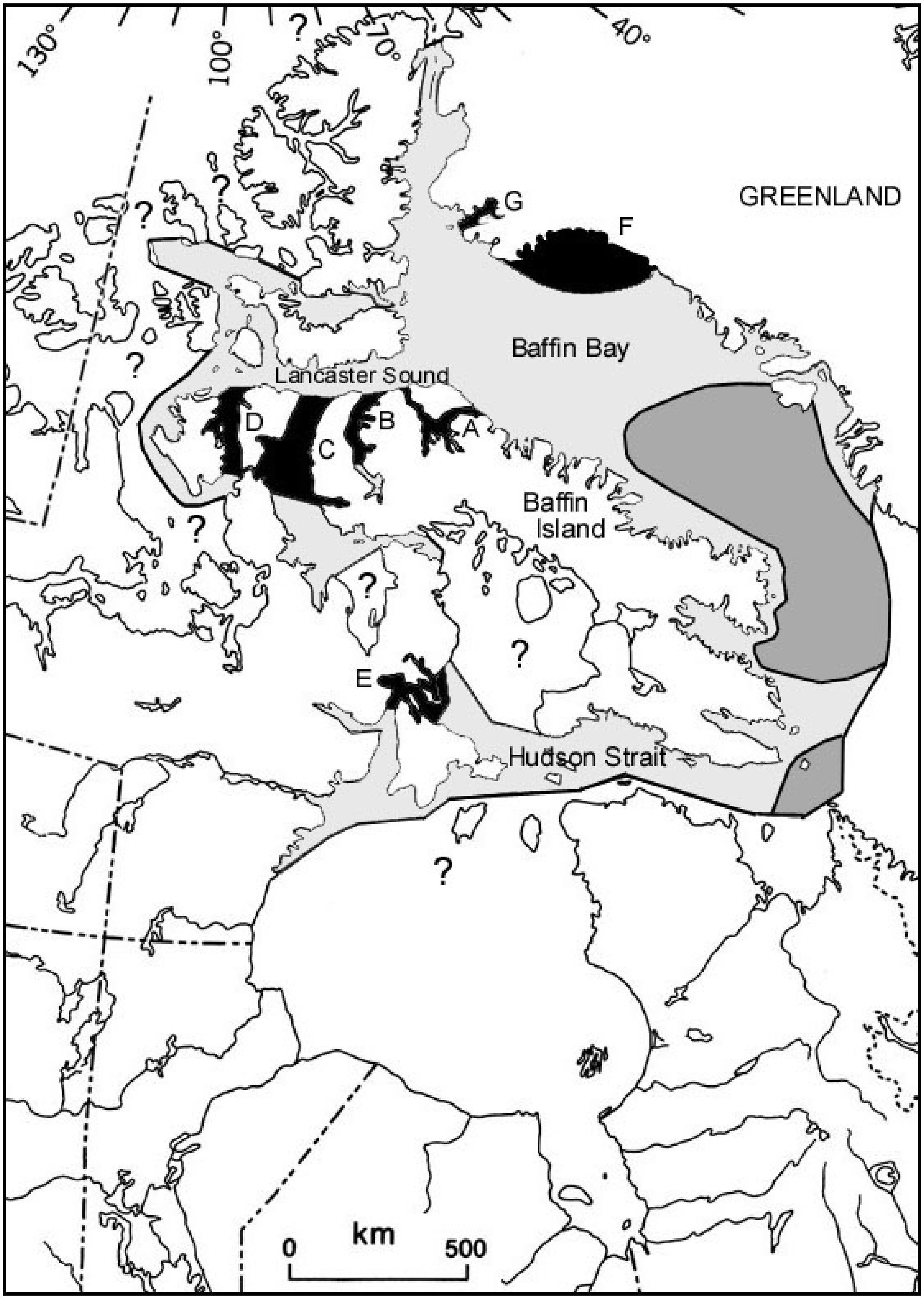

Figure 31. Narwhal summer concentrations in solid black include: A. Eclipse Sound/Navy Board Inlet, B. Admiralty Inlet, C. Prince Regent Inlet,D. Peel Sound, E. Foxe Channel, F. Melville Bay, and G. Inglefield Bredning. Wintering concentrations are shown in medium grey and known range in pale grey. Question marks indicate areas where the extent of the narwhal's distribution is uncertain. (Stephenson and Hartwig 2010).

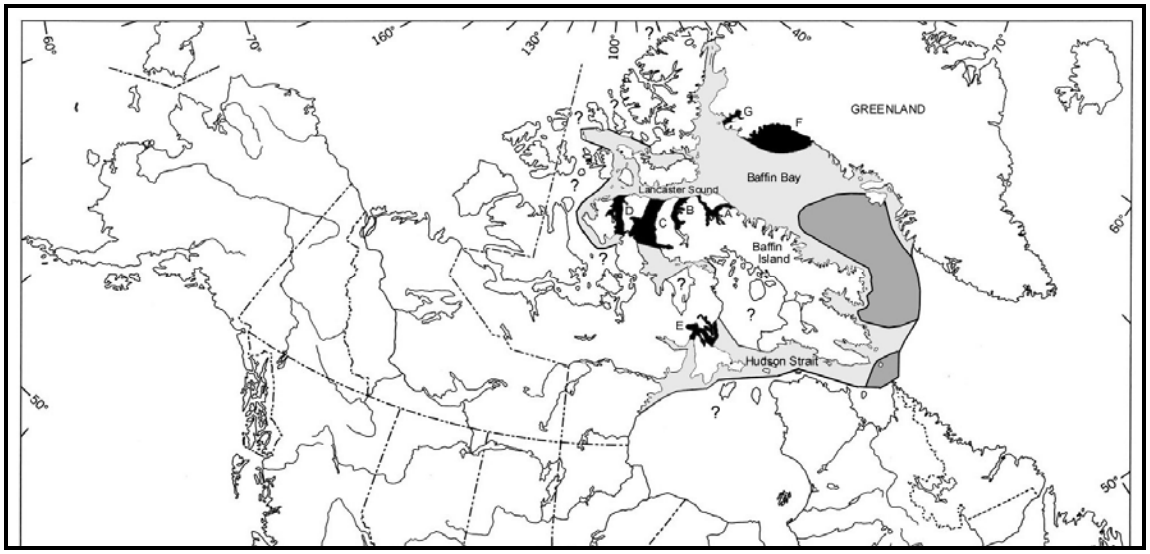

Figure 32. Distribution of Narwhals in Northern Canada

Summer concentrations in are shown in solid black, wintering concentrations in medium grey, and known range in pale grey (COSEWIC, 2004).

Narwhal research in Nunavut waters is conducted primarily by the Department of Fisheries and Oceans. Studies on summer and fall movements of narwhals, as determined through satellite telemetry, suggested that Narwhals showed a preference for deep fjords and for the continental slope (1,000-1,500 m) along eastern Baffin Island Figure 33 (Dietz et al., 2001, Dietz and Heide-Jørgensen, 1995). Within Nunavut narwhal are hunted from May through September Table 9, Priest and Usher (2004). COSEWIC (2005) and SARA have identified that Narwhal, in the Canadian Eastern Arctic are of “Special Concern” with respect to their population stability.

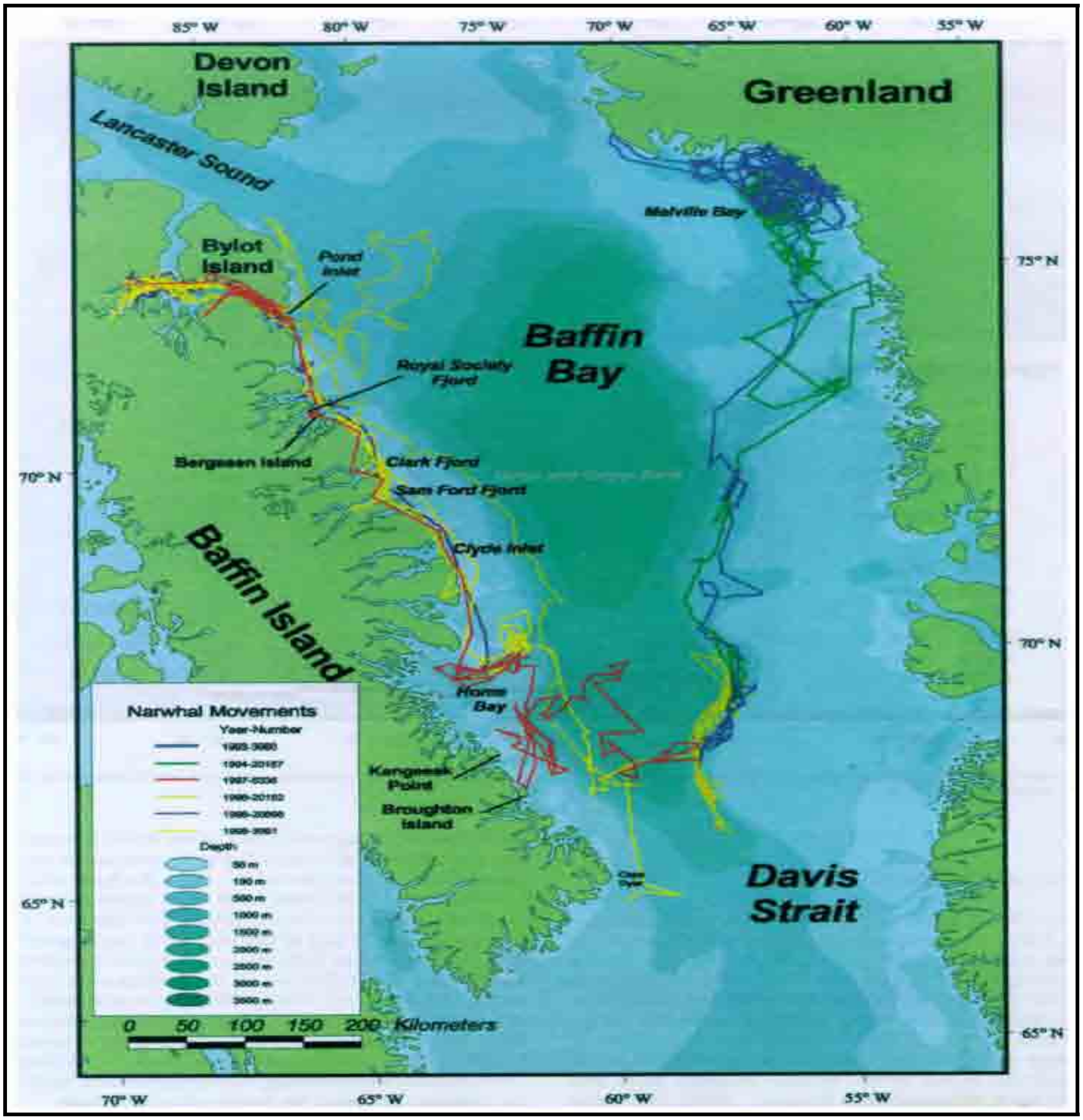

Figure 33. Map of Narwhal Movements (Dietz et al., 2001)

4.6.4 Bowhead whale (*Balaena mysticetus*)

The bowhead, *Balaena mysticetus* (or Greenland right whale), was once common and abundant in the region (Leatherwood et al., 1976, COSEWIC 2005). The present general distribution/range is shown in Figure 34. This whale is often associated with the edge of the pack ice and moves closer to shore during the summer months (MacLaren 1977 1978a and 1978b; Moshenko 2003). Both SARA and COSEWIC (2005) have identified that both the Hudson Bay/Foxe Basin and Davis Strait /Baffin Bay population of Bowhead whale populations are "Threatened". Seasonal distribution of this species as well as general ranges are presented in Figure 34 to Figure 39. Inuit TEK for this species is shown in Figure 40.

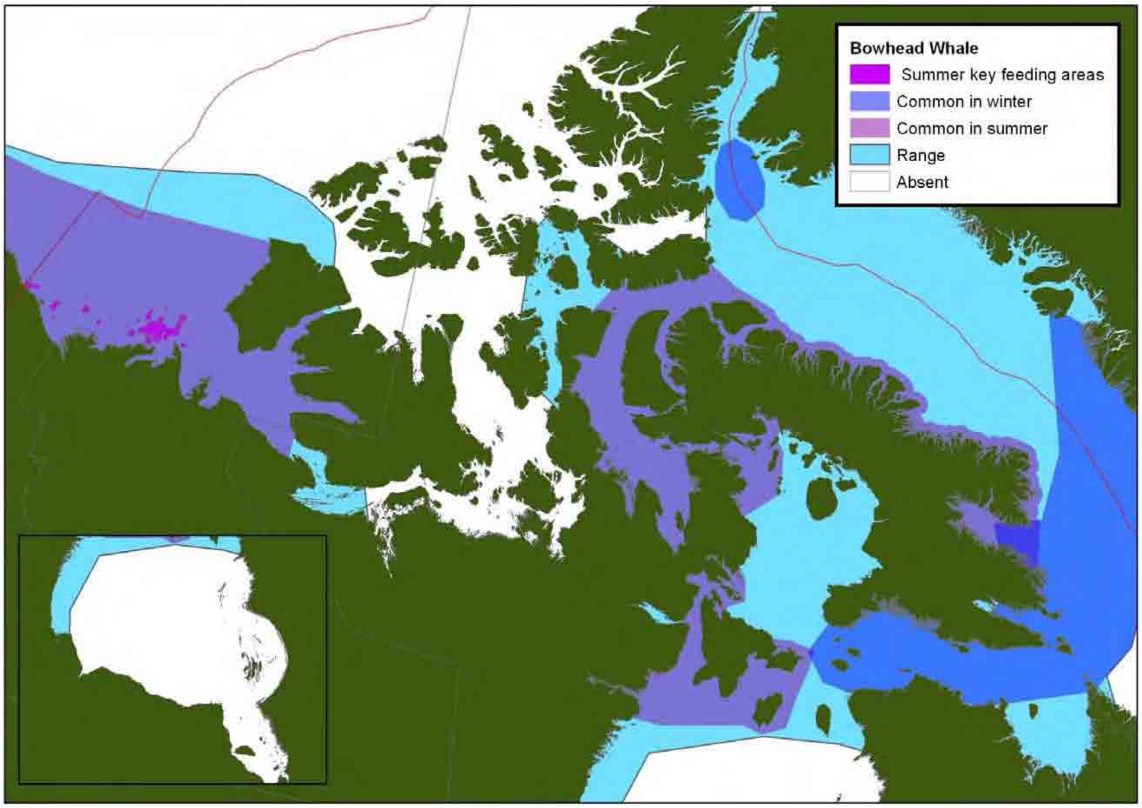

Figure 34. Distribution of Bowhead Whale (*Balaena mysticetus*) in the Canadian Arctic. (Stephenson and Hartwig 2010)

In the high Canadian Arctic the understanding of bowhead movements within Baffin Bay and Davis Strait has been refined through the use of satellite-linked telemetry combined with habitat modeling techniques (Dueck et al. 2006, Husky 2008). Remote telemetry studies show that bowheads migrate large distances throughout the eastern Canadian Arctic from both Foxe Basin and Baffin Bay regions Figure 35, COSEWIC 2005, Cosens et al. 2006). Some satellite tracking information of bowheads in the proposed study area is summarized in Figure 36 (Heide-Jorgensen et al, 2003, COSEWIC 2005). This figure demonstrates that migrating bowheads may be encountered in offshore regions and perhaps with higher likelihood east of Bylot Island, although the bowhead habitat near Bylot Island will likely not be impacted by the project due to temporal differences (i.e. bowhead's use this habitat primarily in June and surveys here will be conducted later in the season). Bowheads using the east coast of Baffin Island in August and September may however be encountered during this period. Bowheads using the offshore habitat due east of the Clyde Inlet region will also be potentially encountered during seismic surveys. Migration within Davis Strait of whales tagged in west Greenland indicated a general westward movement across Davis Strait using leads in the ice in the spring to the Lancaster Sound and northern Baffin Island region in the summer (Dueck et al., 2006). Tagged whales in Baffin Bay and Davis Strait migrated southward along the east coast of Baffin Island using bays and fiords in late summer and early fall (Dueck et al., 2006). Please note that the number of whales tagged was only 19 in Canadian and 25 in Greenlandic waters.

Habitat modeling of known bowhead locations with environmental and geographic variables suggests that at least one discrete area of highly suitable bowhead habitat may exist along the coastal region (within approximately 30 kilometres from shore) of the eastern shore of Baffin Island. Positions from satellite-tagged bowheads have been recorded in this coastal area during the summer (Dueck et al., 2006).

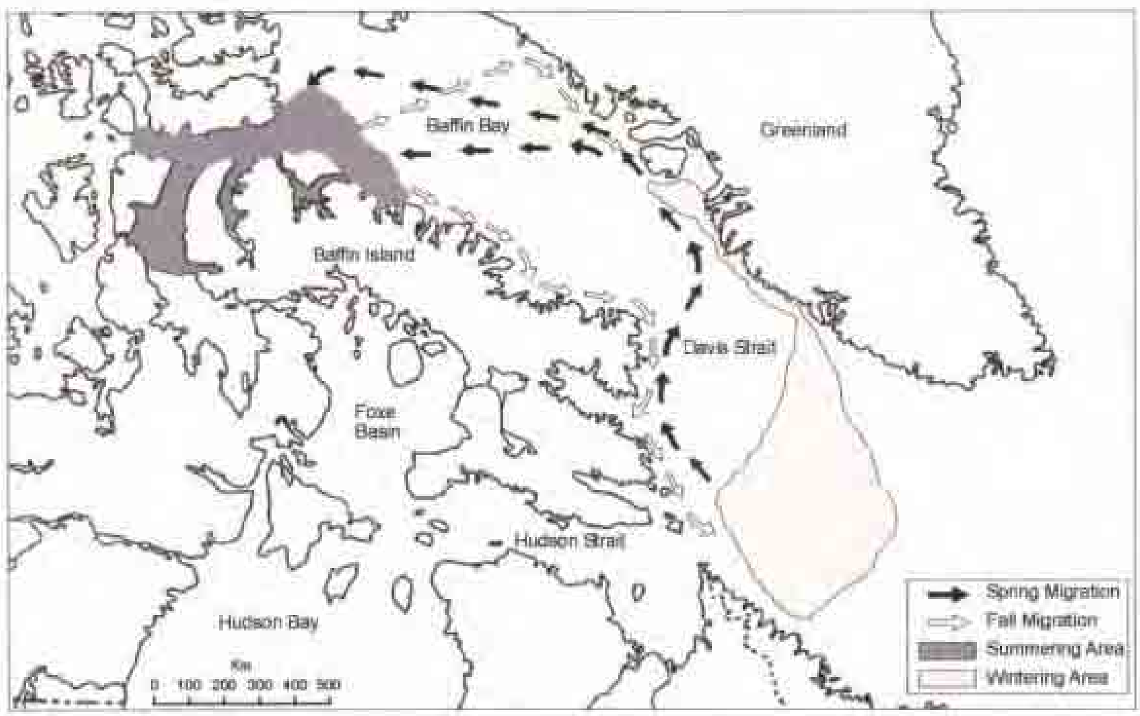

Figure 35. . Generalized seasonal occurrence and migration corridor for the Davis Strait-Baffin Bay population of bowhead whales (COSEWIC 2005).

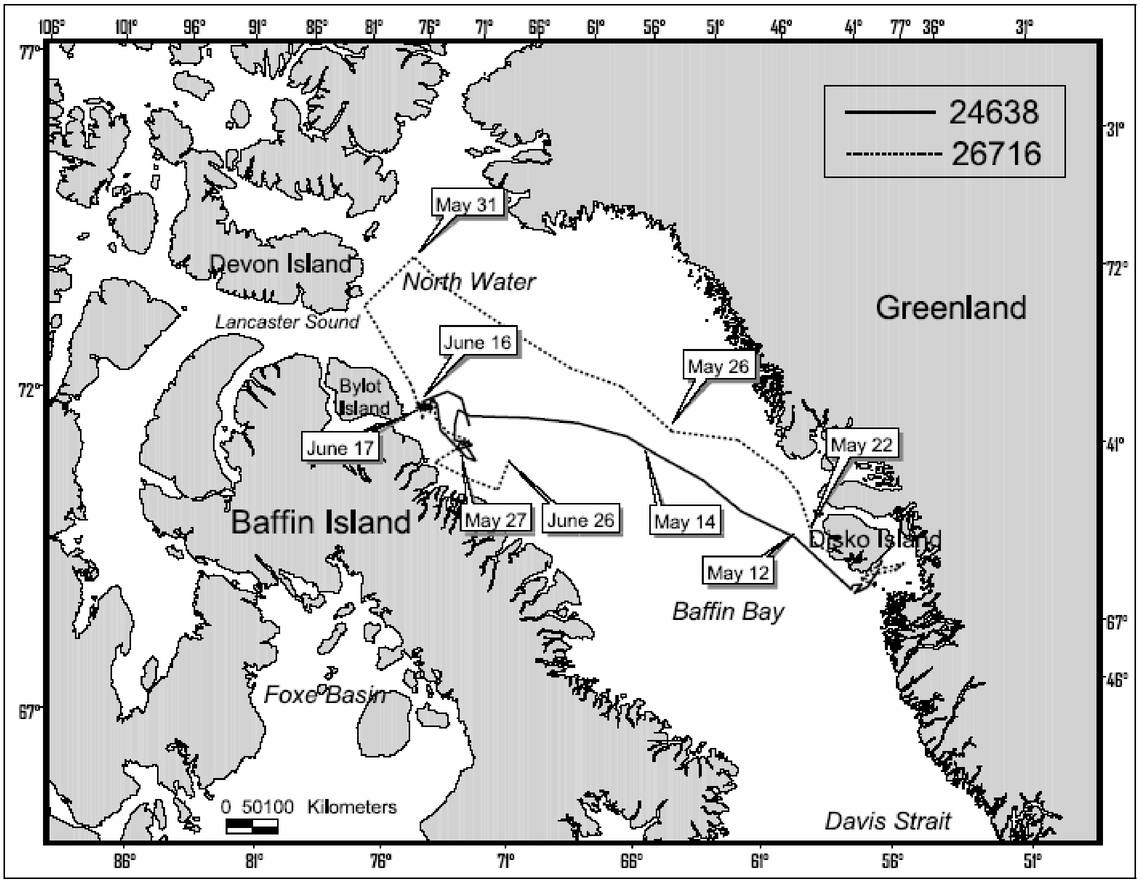

Figure 36. Satellite Tracks of Bowhead Whales (Heide-Jorgensen et al., 2003)

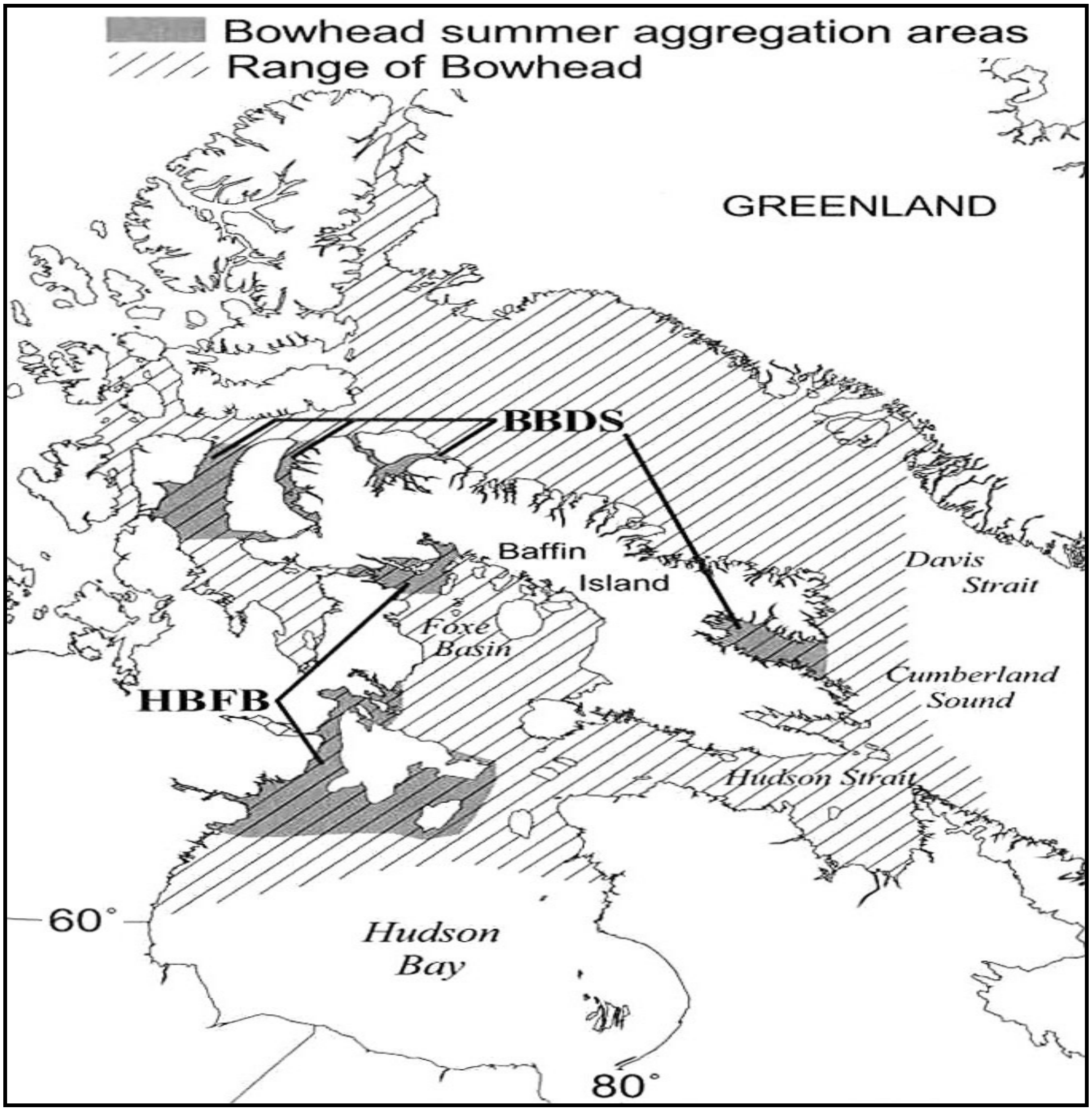

Figure 37. Ranges and summer aggregation areas of the two putative stocks of bowhead whales in eastern Canadian Arctic waters (modified from Reeves and Cosens 2003:284). BBDS = Baffin Bay-Davis Strait stock; HBFB = Hudson Bay-Foxe Basin stock) (Stephenson and Hartwig 2010).

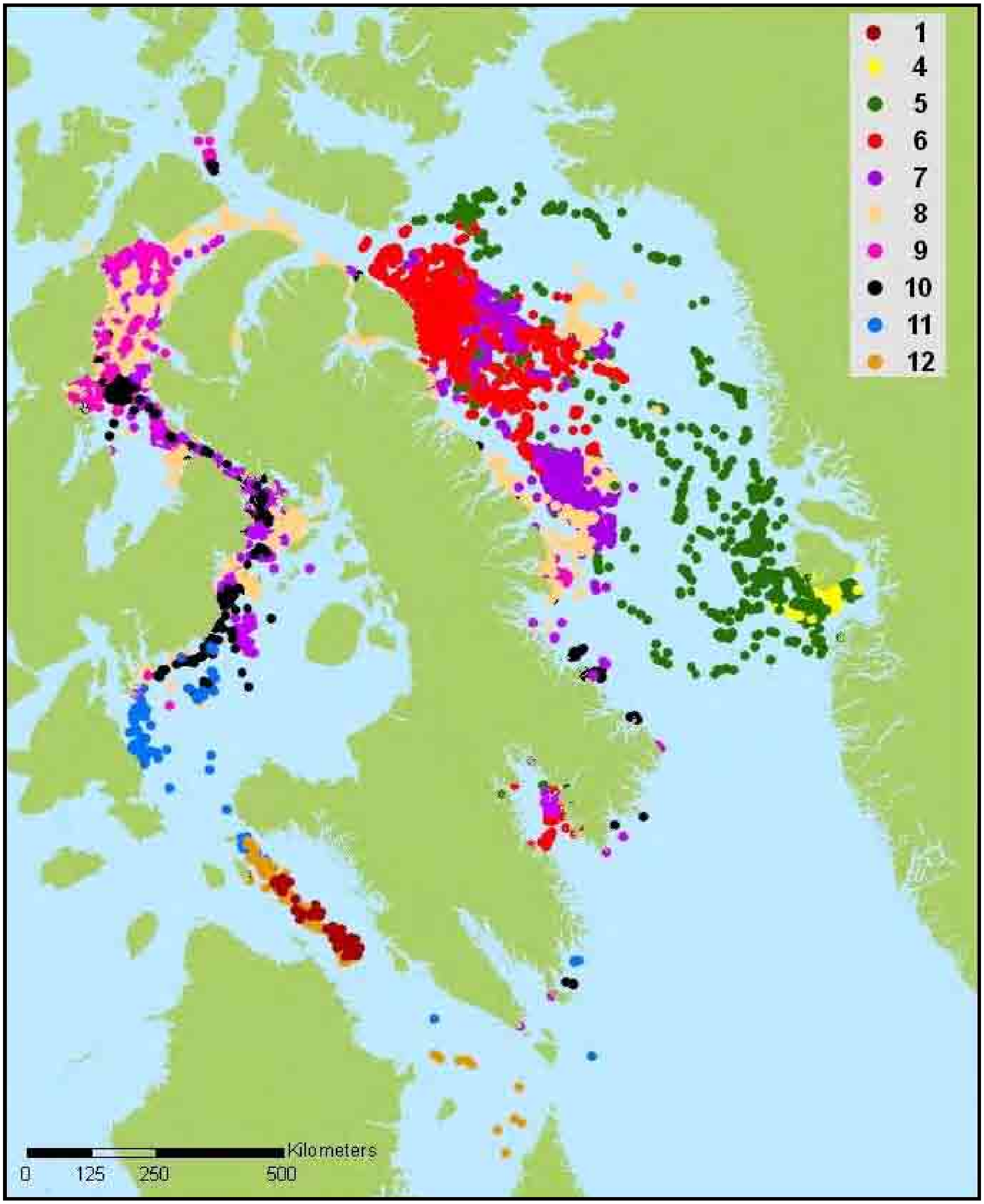

Figure 38. Seasonal Distribution of Bowhead Whale Locations Based on satellite-linked telemetry; results for whales tagged in Canada (n = ~19) and west Greenland (n = ~25); numbers for colour codes refer to calendar month (Dueck et al., 2006 including Mads Peter Heide Jørgensen's unpublished data).

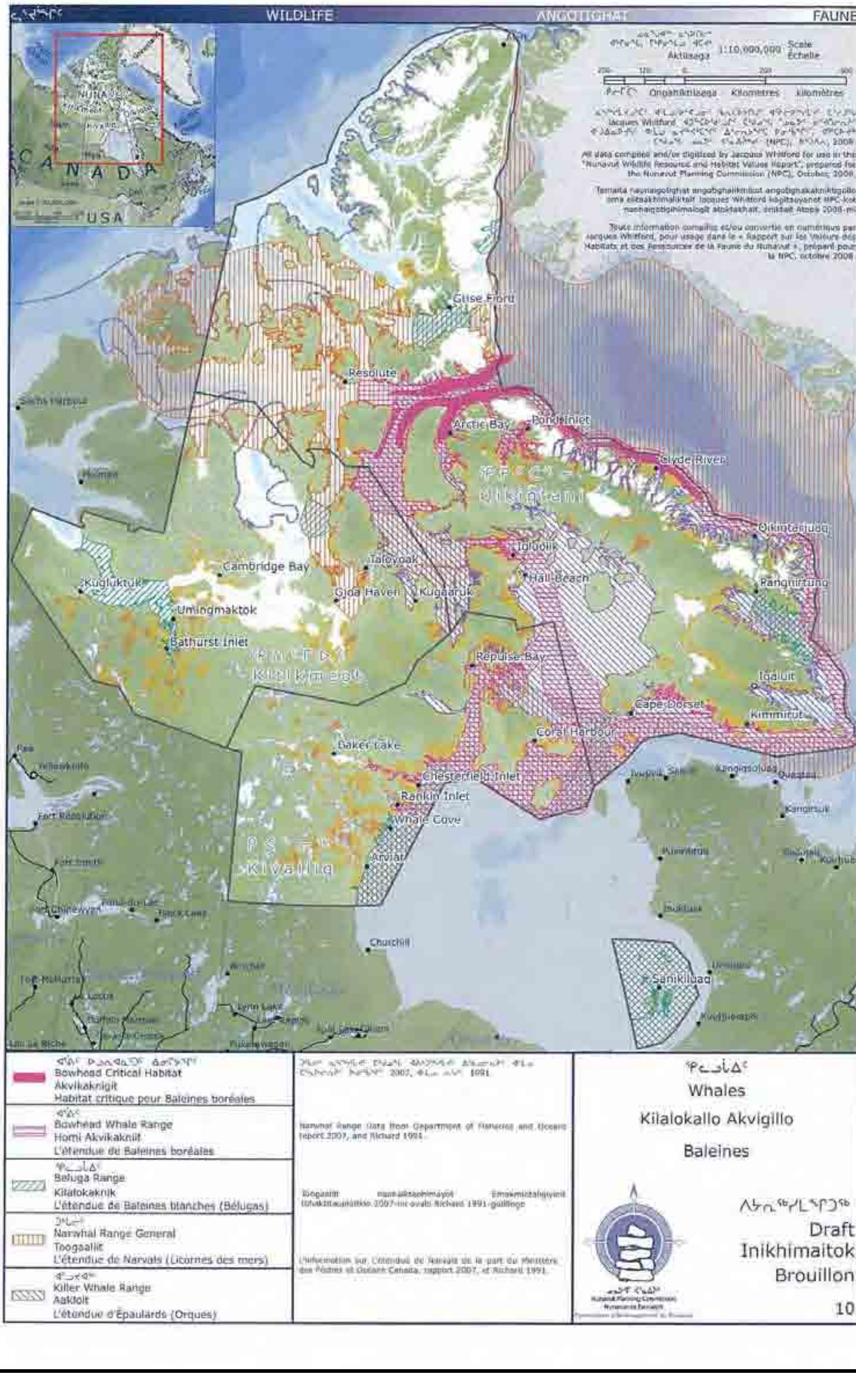

Figure 39. Whale distributions

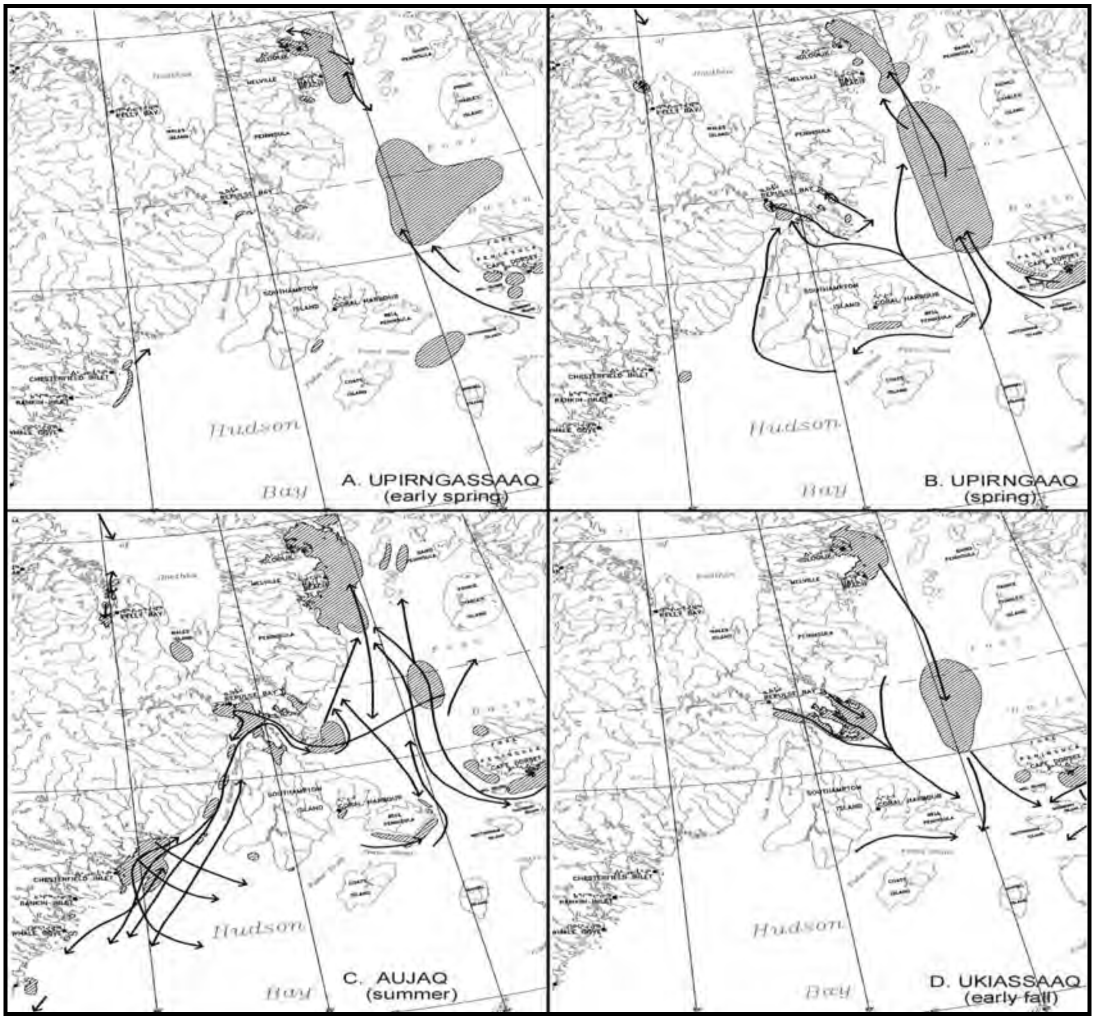

Figure 40. Inuit knowledge of the seasonal movements of bowheads in Hudson Bay and Foxe Basin from A. UPIRNGASSAAQ (early spring) to D. UKIASSAAQ (early fall) (adapted from NWMB 2000) (Stephenson and Hartwig 2010).

4.6.5 Harbour Porpoise (*Phocoena phocoena*)

There are three sub-populations of harbour porpoise (*Phocoena phocoena*) in Atlantic Canadian waters. There is the Newfoundland and Labrador, the Gulf of St. Lawrence and the Bay of Fundy-Gulf of Maine population. Harbour porpoise are most commonly occurring in association with continental shelves, where they frequent bays and harbours. No dedicated harbour porpoise surveys have been conducted in the study area (COSEWIC 2006). It is assumed that harbour porpoise winter along the coast of the US, as far south as North Carolina, and very little is known about the movements of harbour porpoise sub-populations in the far north (COSEWIC 2006, Figure 41). As they are not commonly found in deep oceanic waters, it is unlikely that they will be measurably influenced by the project if they are seen at all. SARA and COSEWIC (2006) have classified the Northwest Atlantic population of Harbour porpoise as a population that is of “Special Concern”.

Figure 41. Distribution of harbour porpoises in eastern Canada. Dashed lines indicate approximate delineations of the three subpopulations. (COSEWIC 2006).

4.6.6 Polar Bear (*Ursus maritimus*)

Polar bears (*Ursus maritimus*) are year-round inhabitants of the Arctic. There general arrange and distribution is shown in

Figure 43. Two populations overlap within the study area; the Baffin Bay population and the Davis Strait population (Figure 42,

Figure 43, Figure 45 COSEWIC, 2002/2008). By in large the most important factor influencing the seasonal distribution pattern as well as movement is the seasonal variation in sea-ice condition (Stephenson and Hartwig 2010).

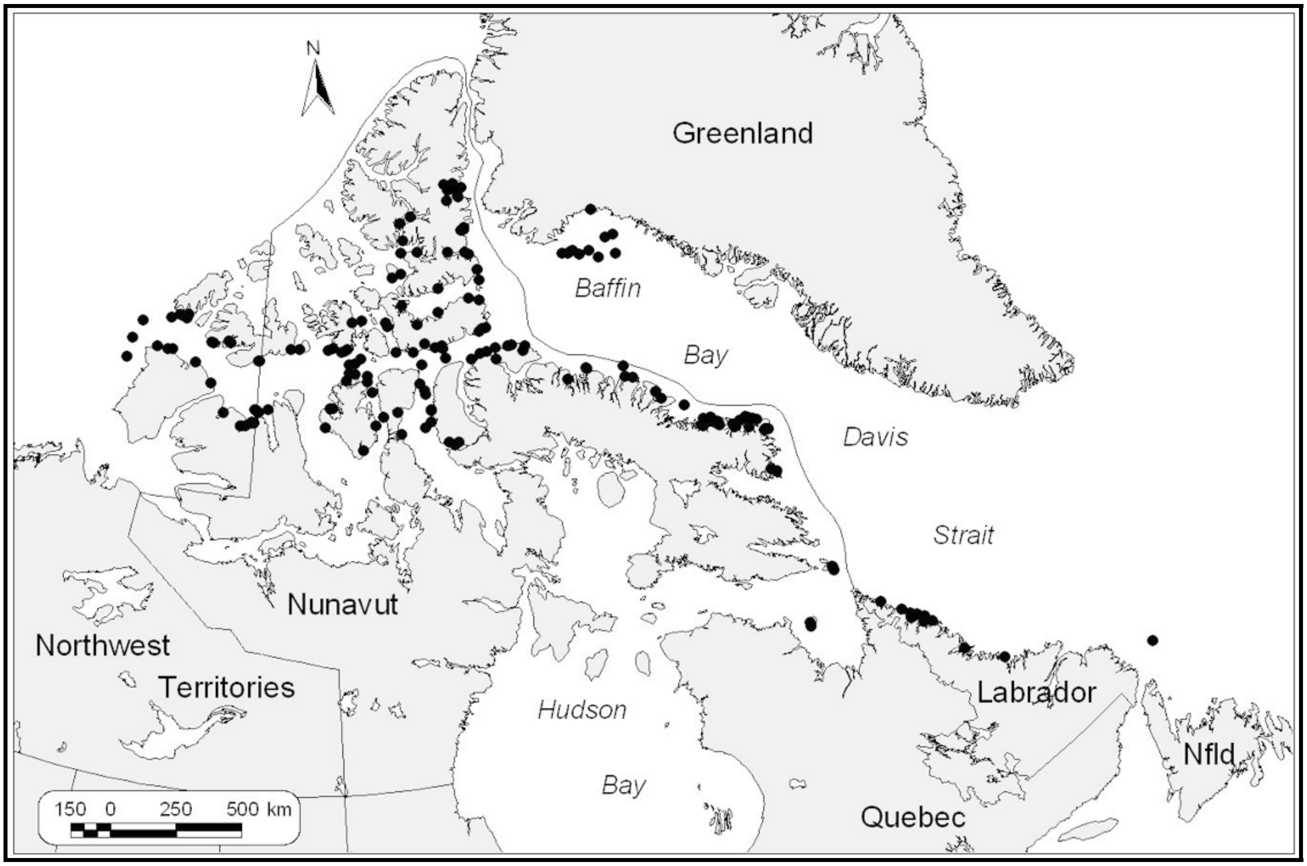

Figure 42. Initial Capture Locations for Adult Female Polar Bears Fitted with Satellite Radio Collars
(Taylor et al. 2001)

Polar bears are often associated with flow edges and pack ice where they can forage. For ringed seals, their main prey. Polar bears readily traverse this pack ice and can travel over large distances (Taylor et al., 2001). When large swells from autumn storms begin to wash over the remaining ice, individuals within Baffin Bay retreat from the offshore pack ice to live on land in late August and early September (Taylor et. al., 2001). In Davis Strait, most bears seek land as the ice retreats in early July (Taylor et. al., 2001). Both of these populations spend the open-water season on Bylot Island and the windward shores of Baffin Island (Taylor et al., 2001). SARA and COSEWIC (2008) have determined that the Polar Bear is a species of "Special Concern". A distribution/range map for Nunavut based on traditional ecological knowledge is presented in

Figure **43**. As the seismic program will take place offshore in the summer and fall when there is no pack ice over the proposed seismic survey area, it is unlikely that polar bears will be encountered.

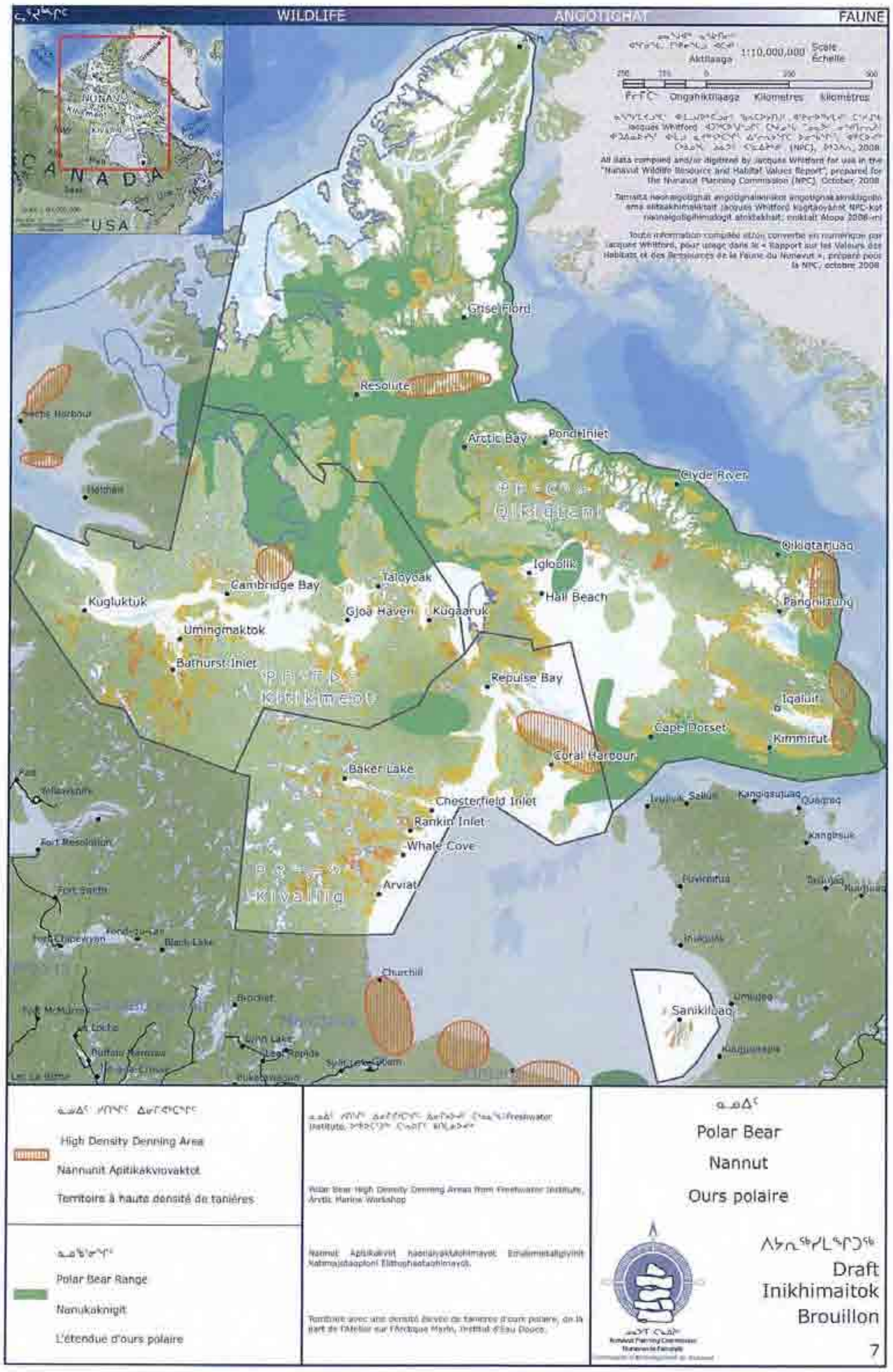

Figure 43. Polar Bear distribution according to Inuit traditional ecological knowledge.

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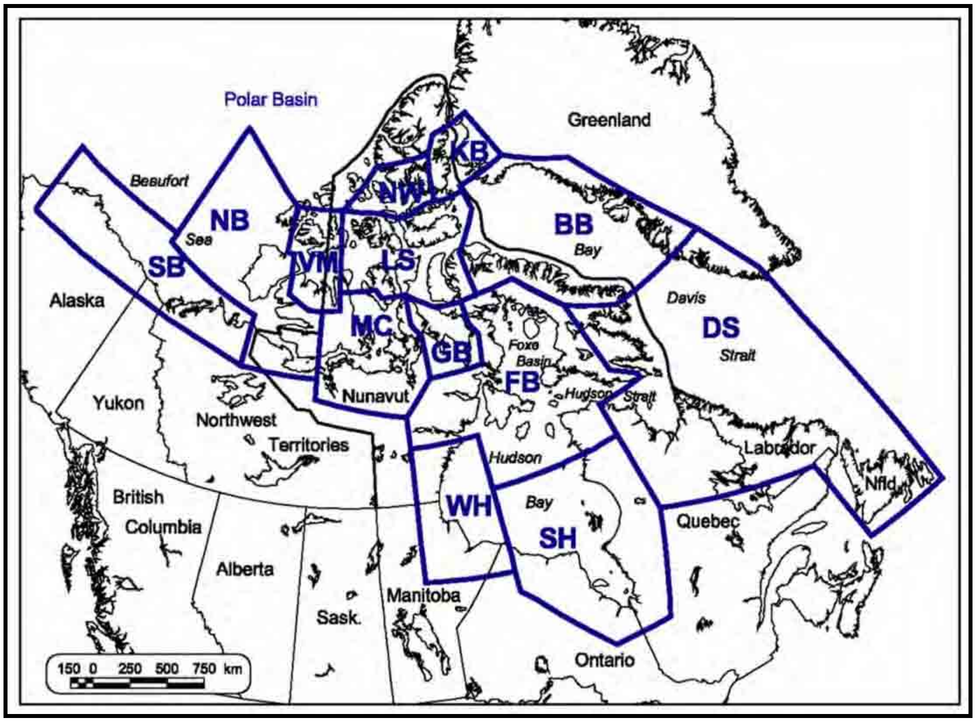

Figure 44. Initial Capture Locations for Adult Female Polar Bears Fitted with Satellite Radio Collars (Taylor et al. 2001)

Figure 44 shows a map of the boundaries of Canadian Polar Bear Populations (1996).These boundaries have been determined from analyses of movements of bears in mark-recapture studies, returns of tags from bears killed by Inuk hunters, and the movements of adult females with satellite radio collars (Taylor et al., 2001; reproduced from COSEWIC, 2008).

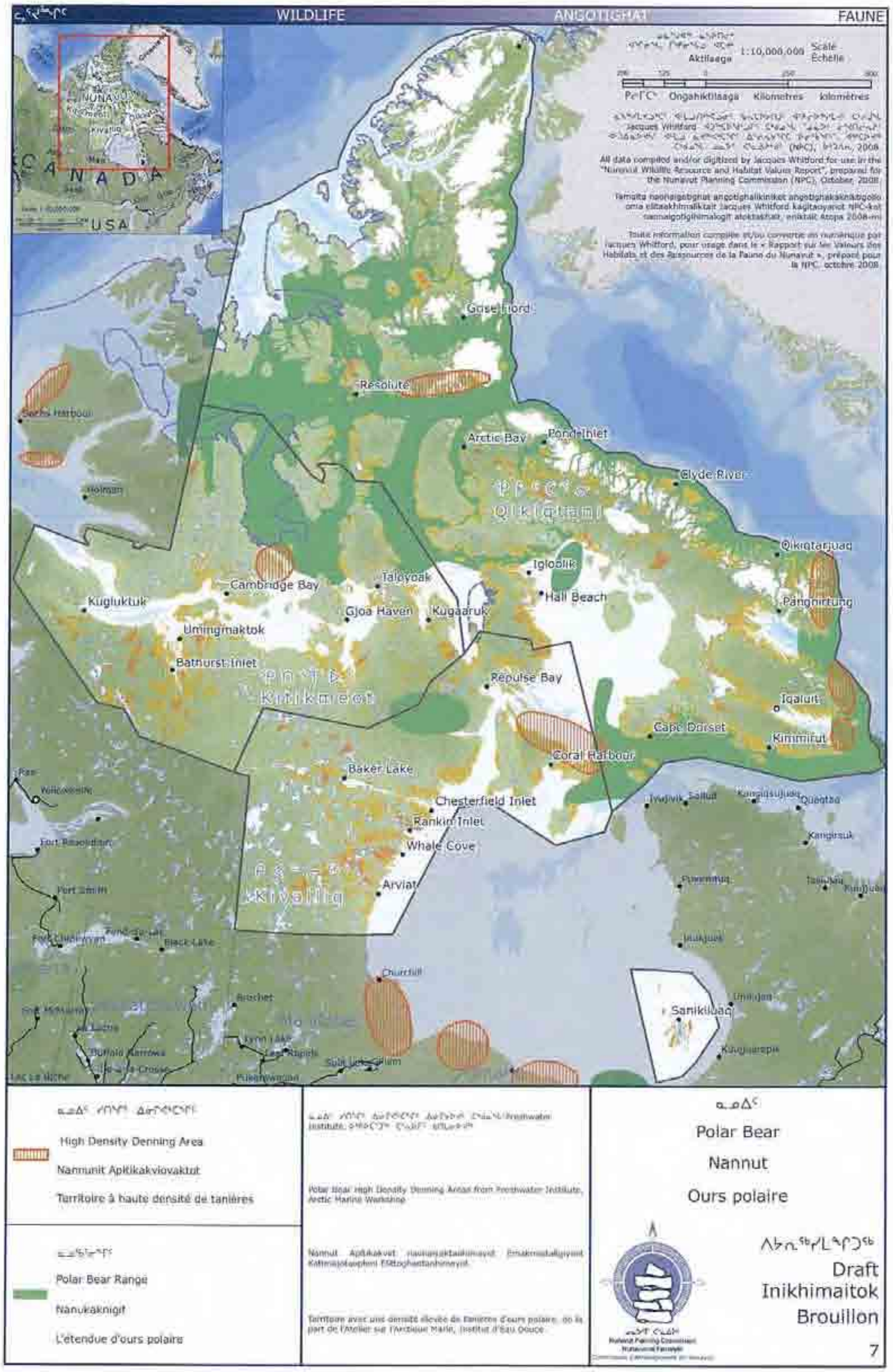

Figure 45. Map Polar Bear distribution according to Inuit traditional ecological knowledge.

4.6.7 Marine Reptiles

There is only one marine reptile that may be encountered in the North Atlantic, the leatherback sea turtle (*Dermochelys coriacea)*. The leatherback has been recorded off Labrador by Bleakney (1965), and Goff and Lein (1988) determined from survey studies that this species is found off Labrador and may occur further north during July to September when seawater temperatures are seasonally high. This species has been relegated to a Species at Risk category of Endangered. Figure 46 illustrates the distribution of the leatherback turtle in Canadian waters (COSEWIC, 2001). Note that the extent of the leatherback sea turtle is not in the vicinity of the presently proposed survey area; therefore, no further discussion is presented.

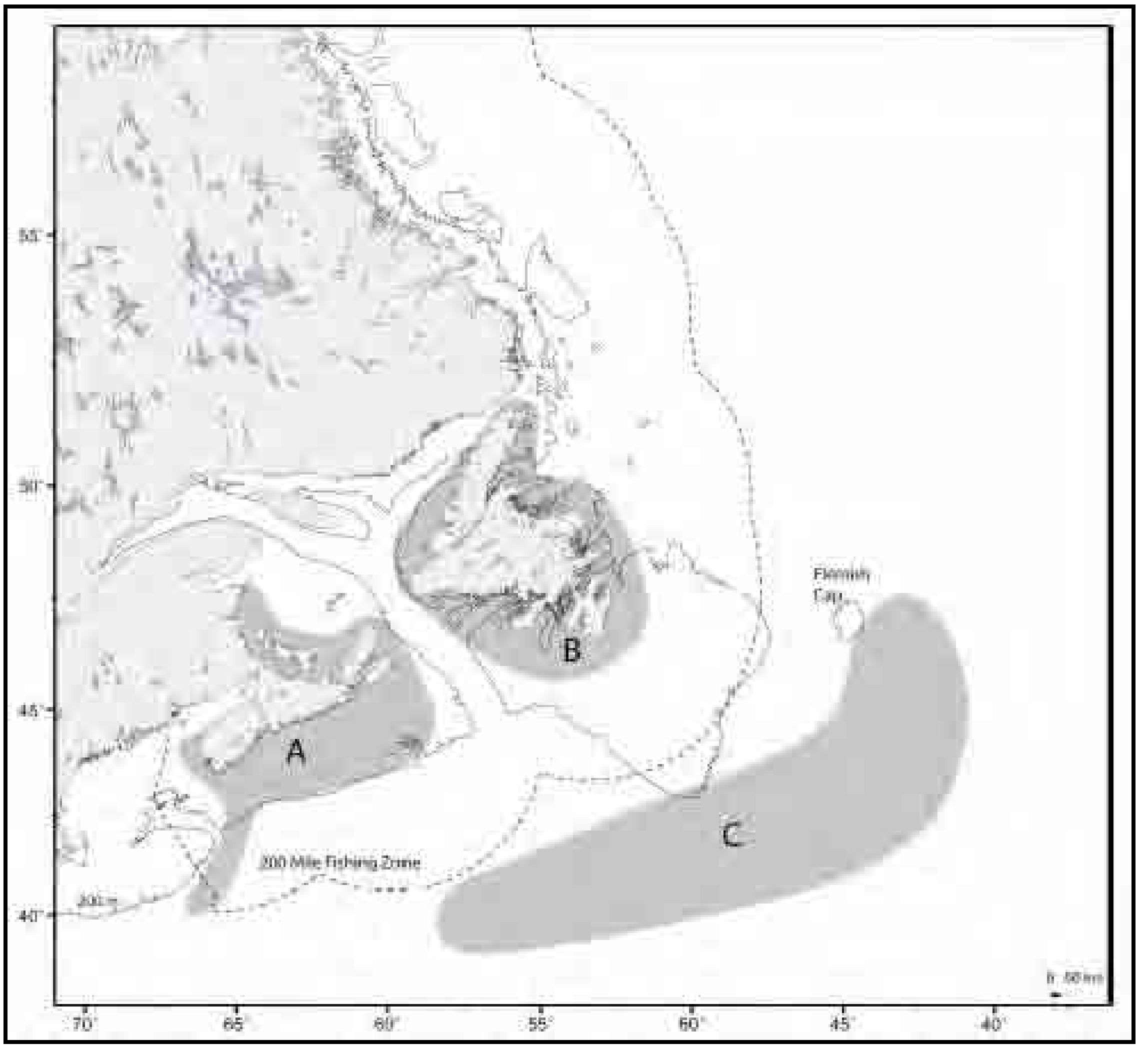

Figure 46. Distribution of the Leatherback Turtle in Canadian Waters
(COSEWIC, 2001)

4.7 SPECIES AT RISK

Canada's Species at Risk Act (SARA) received Royal Assent on December 12th, 2002, and took full effect on June 1st, 2004 when the prohibitions and enforcement provisions came into effect. The overall goal of the SARA is to prevent wildlife species from extinction and to help in the recovery of species at risk, and will confer legal standing on the species listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Act also builds on other laws and programs, such as the Fisheries Act, the National Parks Act, the Migratory Birds Convention Act, and the North American Waterfowl Management Plan, as well as other legislation and programs.

The Act incorporates measures to protect species and their environment and prohibits the killing, harming, harassing, capturing, or taking of species protected under the Act (Schedule 1) which are listed as threatened, endangered, or extirpated, and the destruction of their residences. Once identified, critical habitat will be protected by conservation agreements, provincial or territorial legislation, or federal prohibitions. No critical habitat has yet been identified under SARA.

Initially, 233 species were included on Schedule 1 (Wildlife Species at Risk) of the Act, under the designations of Extirpated, Endangered, Threatened, and Special Concern.

In January 2005, the Schedules were revised and 73 additional species were added to Schedule 1 (SOR 2005-14). Some of the species added to Schedule 1 had been on Schedules 2 and 3, and others were added from the current COSEWIC listings. As with the original 233 species, recovery strategies and action plans must be developed for SARA species listed as Endangered or Threatened, and management plans must be established for those of Special Concern.

The SARA species that might be within or adjacent to the north project are listed in the following **Table 8** and discussed in sections that follow.

Table 8 also identifies "Species at Risk" that could be found within the Study area during the scheduled survey period.

Table 8. Month with Species

Species	Risk Category	Comment	Source
Marine Mammals			
Beluga whale (Eastern Hudson Bay Population)	Endangered	Not in survey area during seismic activity	COSEWIC (2004a)
Bowhead Whale (Davis Strait Population)	Threatened	Late fall wintering area north tip off Labrador , unlikely to be in study area	COSEWIC (2005)
Narwhal	Special Concern	Potentially in study area	COSEWIC (2004b)
Harbour Porpoise	Special Concern	Potentially in study	COSEWIC (2006a)

		area	
Atlantic Walrus	Special Concern	Potentially in study area and coastal	COSEWIC (2006b)
Polar Bear	Special Concern	Potentially in study area	COSEWIC (2002)
Birds			
Ivory Gull	Endangerd	Potentially in study area	COSEWIC (2006c)
Marine Fish	See note below		
NOTE: According to the SARA Registry, there are no marine fish within the Nunavut Region that have a SARA or COSEWIC status rating.			

4.7.1 Cetaceans and Pinnipeds

The Bowhead whale (East Canada – West Greenland) was listed as a Threatened species until April of 2009. It is presently listed as a species of Special Concern. Although the population was severely depleted by whaling, recent trends indicate an increase in their numbers, thus downgrading it to special concern status (COSEWIC, 2009).

The Narwhal is presently listed as a species of Special Concern. The Baffin Bay population appears to be large, however, this population could be affected if hunting in Greenland is not effectively managed (COSEWIC, 2004a).

The Atlantic Walrus has been assigned the status of Special Concern, as the total size of the Northern Hudson Bay – Davis Strait population could be as small as 4,000 to 6,000 individuals. The population's ability to sustain minimum current removals is questionable, as some portion of this population is hunted in Greenland waters (COSEWIC, 2006b).

Additional marine mammal species that have the potential to occur, but are not likely to be encountered during the survey, include the Blue and North Atlantic Right Whale, with SARA Endangered status designation, nor are the Nova Scotia populations of the Northern Bottlenose Dolphin. SARA has assigned the Fin Whale to a status of Special Concern, but these species are not known in the area where seismic activity will occur. COSEWIC has assigned Special Concern to other marine mammals, including the Polar Bear and Sowerby's Beaked Whale, however, as survey activity will commence at a distance of 12 nautical miles offshore (from the shoreline and Outer Land Fast Ice Zone), the survey will unlikely measurably impact those species that may be in the region.

The mitigation measures proposed for this seismic survey will ensure that any potential interaction with marine mammals of any designation is kept to a minimum. It is unlikely that any individual will be measurably impacted by the program if encountered during the survey considering the mitigation methods adopted.

4.7.2 Marine Birds

There have been no studies on the effect of seismic airgun exploration on seabirds (Davis et al., 1998), although Stemp (1985) made observations on the reactions of seabirds to seismic exploration programs in Davis Strait over three summer periods, and no distributional or mortality effects were detected.

The Ivory Gull is considered a species of Special Concern by SARA. This species spends summers in the extremely high Arctic (Ellesmere Island area) and winters in the Baffin Bay and the northern Davis Strait region. This species is not expected to be in the region at the time of the seismic survey.

4.7.3 Fish

Three wolfish species may occur in the most southern regions of the survey area. However, all species are at the limits of their northern extents in Canadian waters off the north of Labrador. It is unlikely that any individual will be measurably impacted by the seismic program.

In summary, by adopting all industry mitigation standards, as well as more stringent measures discussed below, no anticipated measurable environmental impacts are predicted on SARA species for this seismic exploratory research field program.

4.8 SENSITIVE AREAS

4.8.1 Niginganiq (*formerly Igaliqtuuq*) National Wildlife Area

The Niginganiq (*formerly Igaliqtuuq*) National Wildlife Area, near Clyde River in Isabella Bay, represents a sensitive marine area adjacent to the project area (Figure 47). This marine wildlife area extends from the coast to 12 nautical miles (approximately 22.2 kilometres, 13.8 statute miles). As the survey area does not commence until the 12 nautical mile limit, the project area does not encroach into this area. Furthermore, the closest survey line is approximately 28 kilometres from the seaward limit of this area, and approximately 60 kilometres from the entrance to Isabella Bay.

Note that a Proposed Biosphere Reserve also exists around this area, and its seaward limit is approximately defined by the limit of land-fast ice. As described in Section 3.2, only a very small portion of the survey area exists within the Outer Land Fast Ice Zone. Within this zone approximately 245 line kilometres of 2D data are proposed to be acquired, which represents approximately 2.2% of the total line kilometres for the survey (10,970 kilometres).

The mitigation measures that will be adopted during the survey will ensure minimal, if any, measurable interaction with local marine related wildlife that may be in the area at the time of the survey.

Other (terrestrial) wildlife areas / parks on the eastern coast of Baffin Island include:

- Qaqulluit National Wildlife Area (also known as Cape Searle, near Qikiqtarjuaq)
- Akpait National Wildlife Area (near Qikiqtarjuaq)
- Bylot Island Migratory Bird Sanctuary (Pond Inlet)
- Nirjutiqavvik National Wildlife Area (Grise Fiord)

The figure below illustrates the Niginganiq (*formerly Igaliqtuuq*) National Wildlife Area and Proposed Biosphere Reserve (New Parks North, 2004).

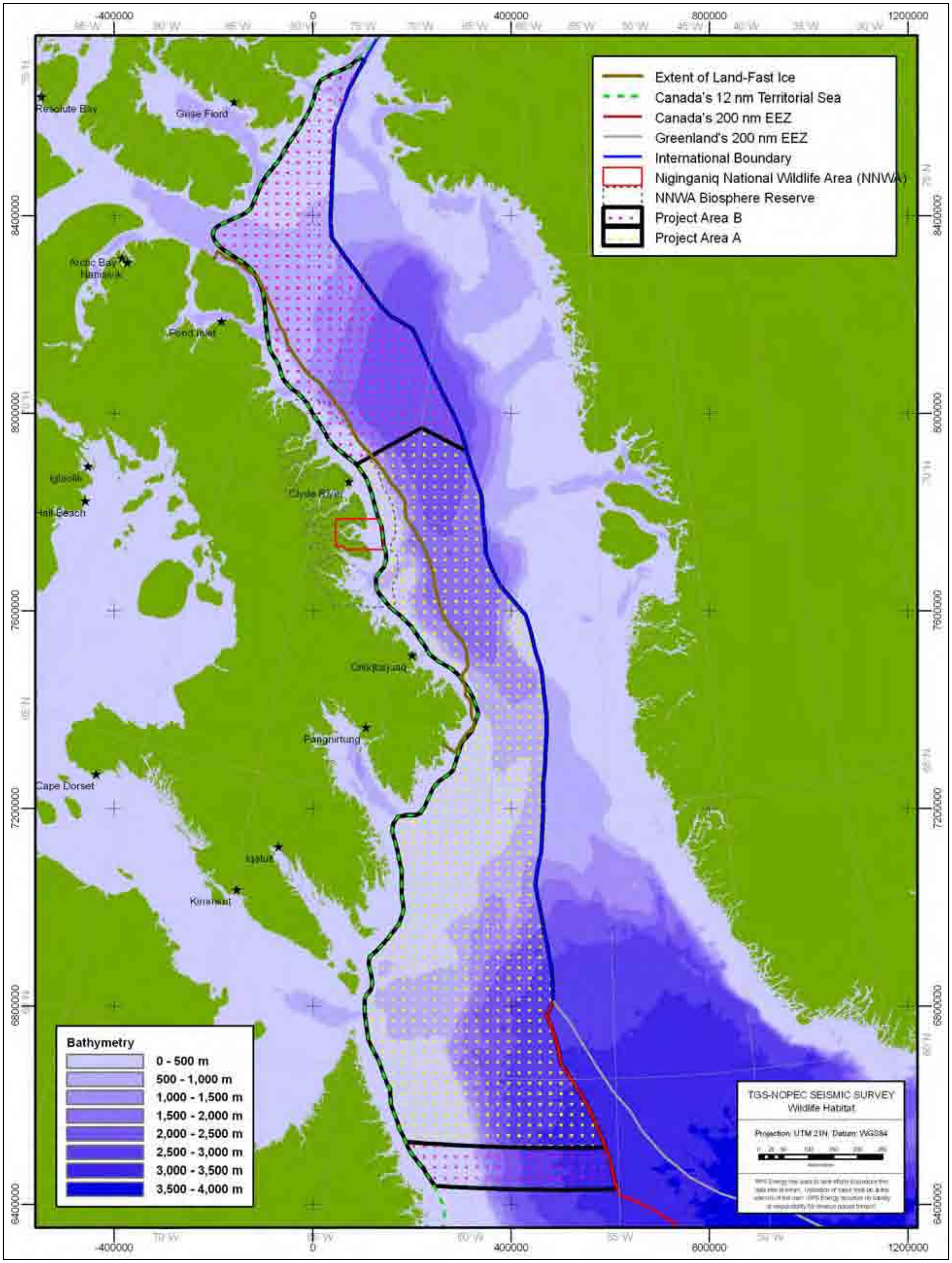

Figure 47. Niginganiq (*formerly Igaliqtuuq*) National Wildlife Area

4.8.2 Narwhal Over-Wintering Area

Since 1998, fishing effort restrictions have been in place to limit the time spent by vessels fishing for Greenland halibut (turbot) in an area identified as a narwhal over-wintering area in Davis Strait.

In April 2006, DFO Fisheries Management decided that a large portion of the narwhal over-wintering grounds should be closed to all Greenland halibut fishing. Reasons for this decision included the status of “special concern” of the narwhal that use this area, the importance of halibut in its diet during the winter, concerns over entanglement in gillnets, and the presence of deep-sea corals (see below), which may play an important role in this ecosystem (Fisheries and Oceans Canada, 2007). The closed area was described and included in the draft 2006-2008 Fisheries Management Plan NAFO SA0, and DFO is currently developing related policies (Fisheries and Oceans Canada, 2007).

The northern narwhal over-wintering area is illustrated in Figure 48, and overlap with the proposed 2011 survey lines; however, narwhals do not tend to occupy this area until November (Dietz et al., 2001; Mosbech et al., 2000). The survey will not take place in the area during this critical period; consequently, it is unlikely that narwhals will be in the area during active surveying.

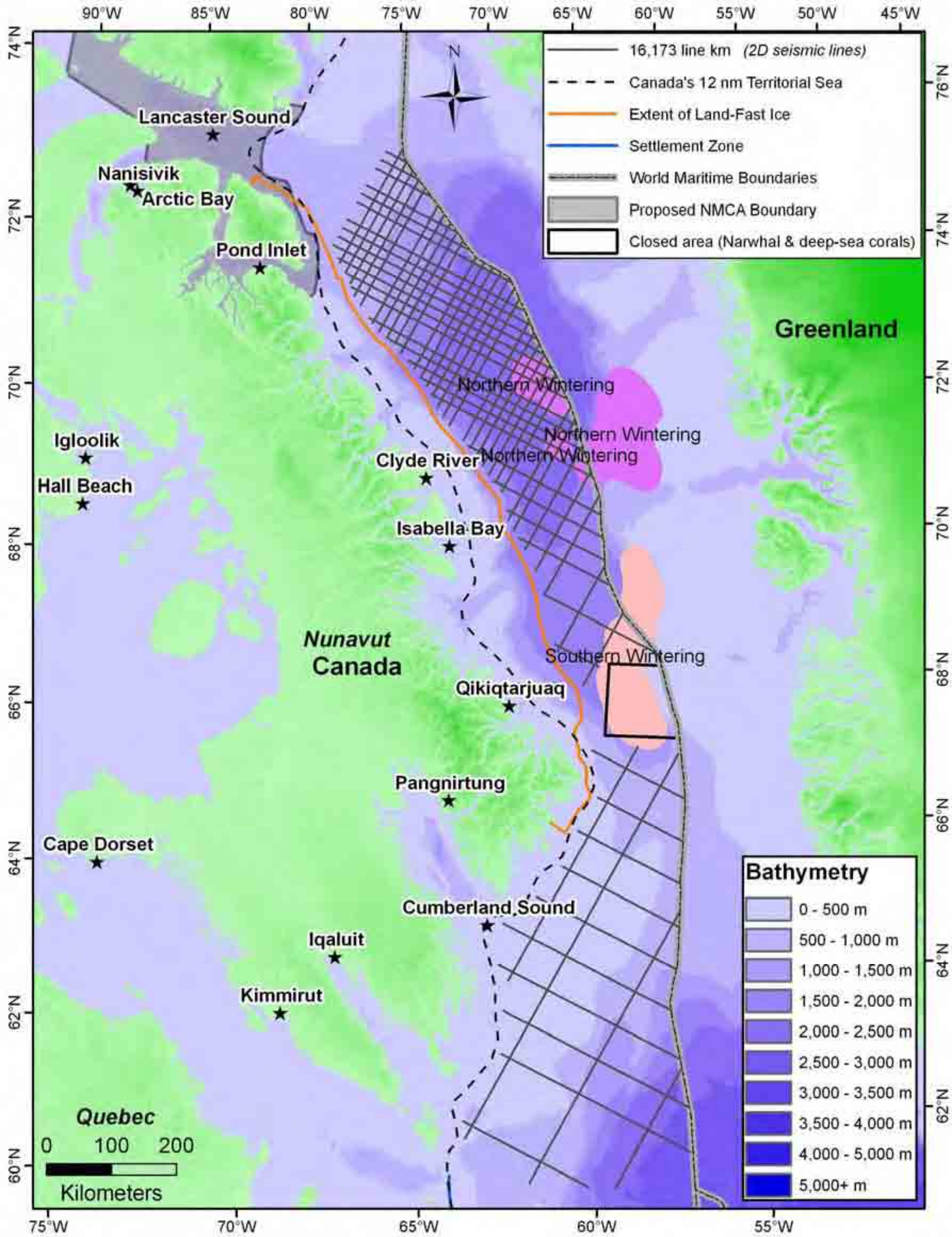

Figure 48. Location of Narwhal Over-wintering Areas Relative to the 2011 Survey

4.8.3 Deep-Sea Corals

There are more than 27 species of deep sea corals identified off the coast of Atlantic Canada but their distribution is largely unknown. The coral have been identified along the edge of the continental shelf from the Gulf of Maine to the Davis Strait by DFO fisheries observers and local fishermen (Gass and Willison 2005). A personal communication from K. MacIsaac (DFO) confirms that deep sea corals are present in Baffin Bay.

Deep-sea corals, by the nature of their physiology (i.e. having no pressure sensitive or sound detecting organs such as swim bladders and ears), are extremely unlikely to be impacted by seismic array activity. Also, the acoustic source is towed at a fixed depth (<7 metres) during seismic surveying, well above the coral that grow on the seafloor.

4.8.4 Lancaster Sound

Ottawa, Ontario, December 6, 2010 – John Baird, Canada's Environment Minister, John Duncan, Minister of Indian Affairs and Northern Development, Christian Paradis, Minister of Natural Resources, and Leona Aglukkaq, Minister of Health, all today proudly announced the Government of Canada's position on a potential future boundary for a national marine conservation area (NMCA) in Lancaster Sound, Nunavut. Today's announcement represents a key step in Canada's commitment to protect the marine waters and wildlife of Lancaster Sound, a globally-significant ecological treasure that has been referred to as the "Serengeti of the Arctic". Ministers also announced that the government will immediately begin consultations to finalize the boundary. (Reference: CP2010-01348 Government of Canada presents boundary proposal for Lancaster Sound National Marine Conservation Area), shown in Figure 50. This present survey will not encroach more than 180km from the mouth of Lancaster Sound.

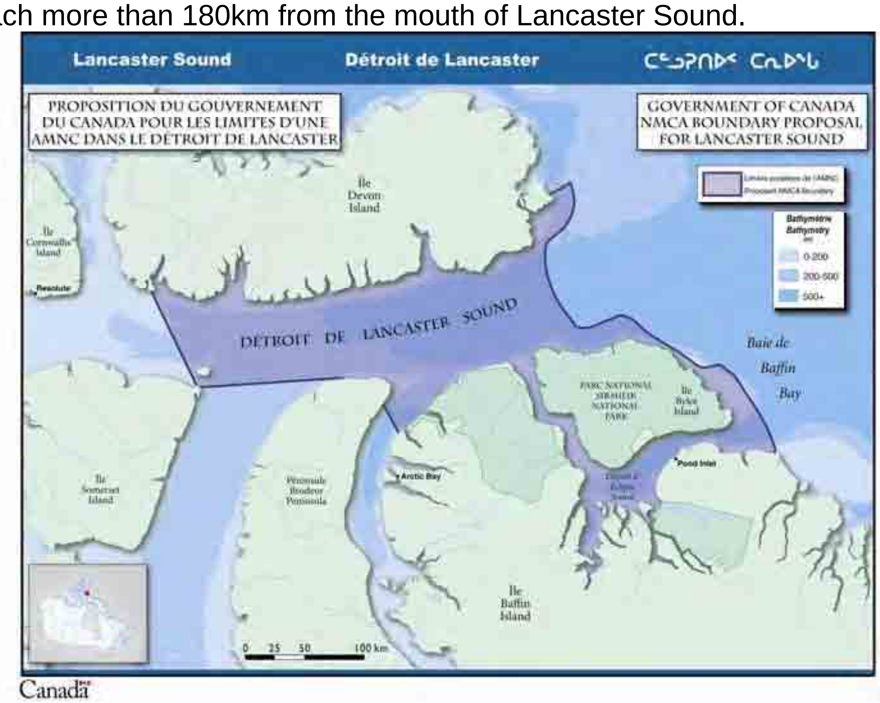

Figure 49. NMCA Boundary Proposal for Lancaster Sound

4.9 COMMERCIAL FISHING

There are two major commercial fisheries in the Baffin Bay – Davis Strait area; the Greenland halibut, also known as the Greenland turbot, (*Reinharditus hippoglossoides*), and shrimp (*Pandalus borealis*).

4.9.1 Greenland halibut (*Reinharditus hippoglossoides*)

Bowering and Nedreaas (2000) note that "Greenland halibut spawning in the western Atlantic has long been postulated to occur in Davis Strait during the late fall-early winter near the submarine ridge between Baffin Island and Greenland at about 67° N." More recently, spawning Greenland halibut have been sampled at various times of the year throughout the range of its offshore distribution along the continental slope from Davis Strait to the Flemish Pass (Morgan and Bowering, 1997). Junquera and Zamarro (1994) studied turbot spawning in the Flemish Pass and observed peak spawning in winter and another in summer. These spawning differences might be the result of a change in fish behaviour associated with a shift in distribution pattern (Bowering and Power, 1995). This could represent normal behaviour observed as a result of now obtaining samples from very deep water (1,250 to 1,800 metres) compared to earlier years. The only recognized major nursery area is near the northern end of its distribution, west of Disko Bay, approximately 69°N (Smidt, 1969; Jørgensen, 1997a, 1997b; in Bowering and Nedreaas, 2000). The fishing methods used in this area include long-lines, gill nets, and bottom trawls.

The turbot fisheries occur from August to November and peak in the months of August and September. Turbot catches in 2007 were near the survey area but were concentrated within extent of the land-fast ice and along the Canada – Greenland international boundary (Figure 50); this represent the farthest extents of the survey. Interactions with this fishery are not expected to be significant.

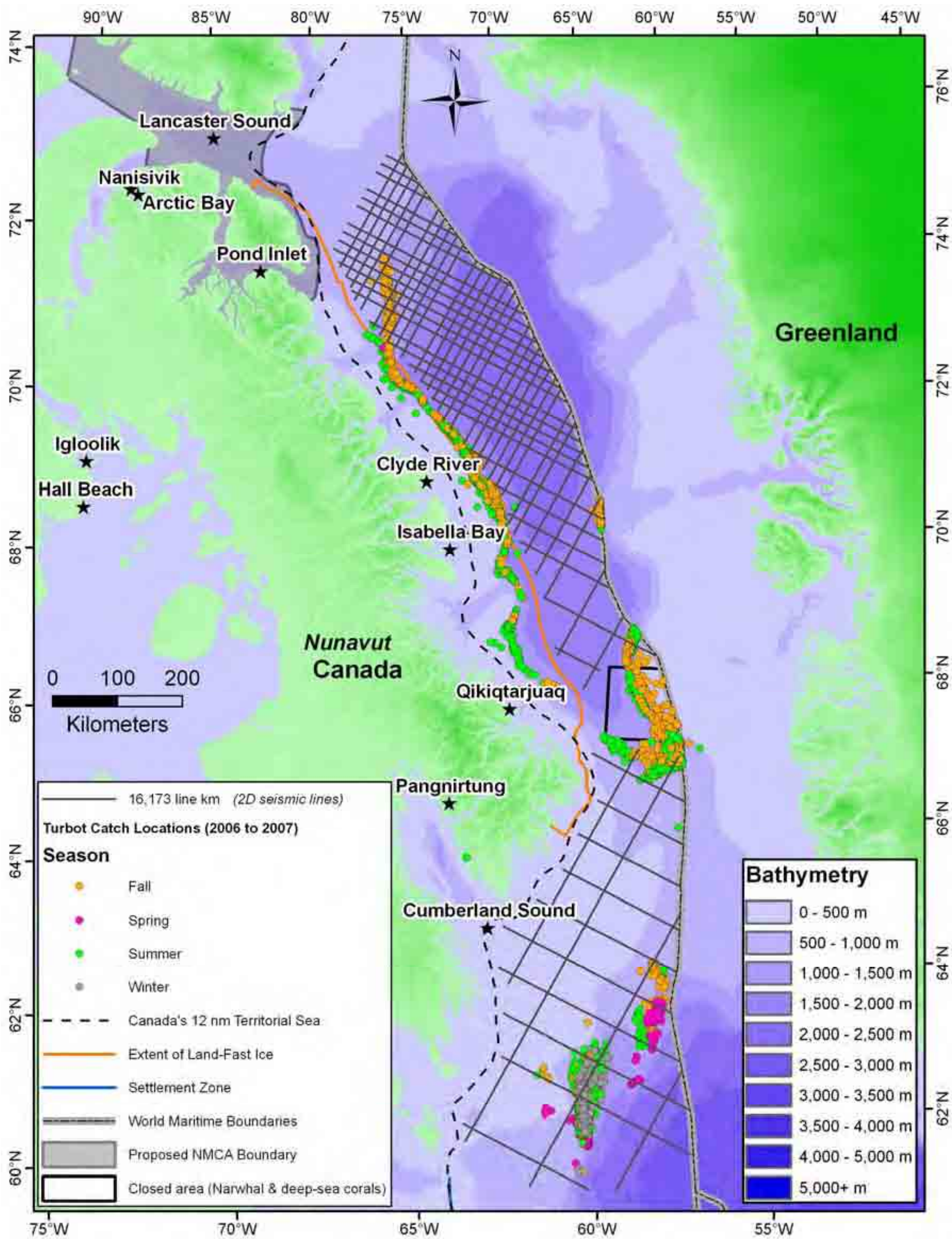

Figure 50. Turbot Fisheries Catch Data for 2006 – 2007 by Season

4.9.2 Northern Shrimp (*Pandalas borealis*)

The Northern Shrimp (*Pandalas borealis*) is the most important commercial invertebrate species within the project area. They are generally found in deep depressions and capture using trawl nets. Northern shrimp spawn during late summer and fall, with the eggs remaining attached to the female until spring. Females with eggs move inshore in late autumn and winter to release the eggs (Parsons, 1993). The proposed 2011 survey lines do not occur in an area of shrimp fishing, which is active south of the survey area from May through December, with peak activity in September and October.

The shrimp are caught from trawlers, which are mobile, whereas turbot are caught in gill nets, which are fixed in position. Gill nets may be anchored to the seabed to keep the gear stationary or positioned in varying water depths, depending on the location of the species, and are marked by buoys on each end, which float on the sea surface. Gill nets may be joined together to increase the efficiency of the operation.

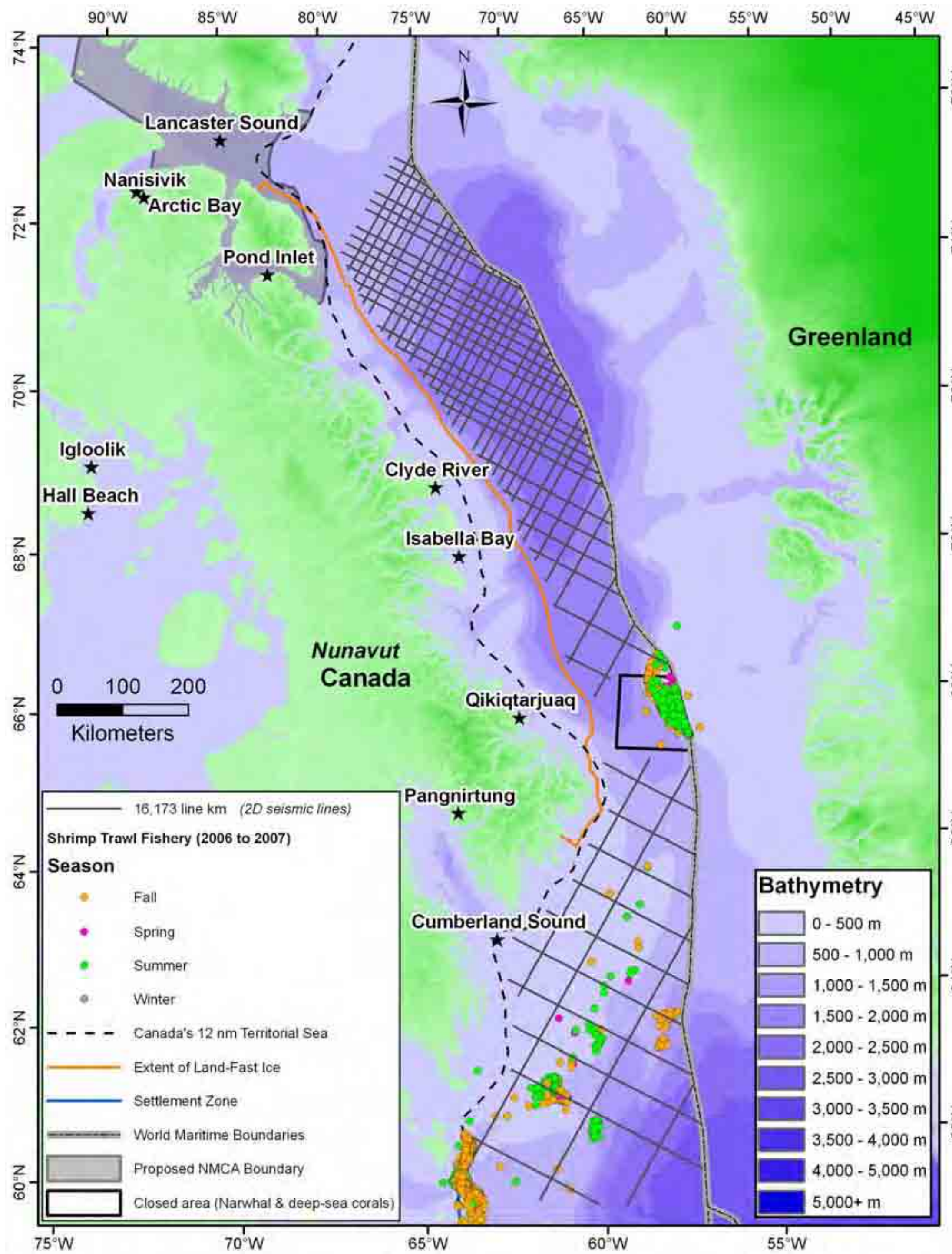

Figure 51. Harvest Data – Shrimp

4.9.3 Fishing Gear

Avoiding fishing gear is a very important component of seismic operations and fixed gear historically is more of a hazard than mobile gear due to the fact that direct communication is maintained between trawlers (using towing mobile gear) and seismic vessels at sea. Refer to Section 5.2.4 for additional discussion on potential fishing gear conflict management.

4.9.4 Fisheries Liaison Officer

The operator will provide a Fisheries Liaison Officer for the duration of the survey to facilitate communications with the fishing industry. The operator will provide a single point of contact in the event of a suspected conflict with fishing gears or vessels during the 2011 program.

4.10 HUMAN AND SOCIOECONOMIC ENVIRONMENT

The seismic survey will take place entirely in marine waters no closer than 12 nautical miles (approximately 22.2 kilometres, 13.8 statute miles) from the Canadian coastline, as defined by the limit of Canada's territorial sea. No Geophysical data will be collected within the Land Fast Ice Zone. Therefore, no survey work will be performed in fjords, inlets, or bays and the survey will be well removed from harvesting areas.

The largest consideration related to the human and socioeconomic environment is with respect to traditional harvesting activities. An appreciation of the traditional knowledge was obtained by consulting two major studies: The Nunavut Wildlife Harvest Study (Nunavut Wildlife Management Board, August 2004), and the Final Report of the Inuit Bowhead Knowledge Study (Nunavut Wildlife Management Board, March 2000). In addition, the operator will employ an Inuit Observer to advise the crew of local knowledge.

Both of these reports are available on the Nunavut Wildlife Management Board website:

http://www.nwmb.com/english/resources/harvest_study/NWHS%202004%20Report.pdf

http://www.nwmb.com/english/resources/Bowheadreport.pdf

Of particular importance are the harvesting activities related to marine species from coastal communities (including Iqaluit, Pangnirtung, Qikiqtarjuaq, Clyde River, and Pond Inlet). The figures below show these data for the Davis Strait and Baffin Bay, and illustrate that harvesting occurs within coastal areas well removed from the proposed survey lines.

The following harvesting data are presented in the figures below:

- Figure 52. Harvest Data – Marine Mammals
- Figure 53. Harvest Data – Fish
- Figure 54. Harvest Data – Big Game
- Figure 55. Harvest Data – Waterfowl
- Figure 56. Harvest Data – Eggs

These harvesting data represent the most comprehensive study completed regarding harvesting levels and patterns of Inuit use of wildlife resources, and are the results of five (5) years of harvest data. The raw data from this study were transposed from the study report to the EIA GIS files and project maps for this assessment purposes. Subject to funding constraints, the NWMB intended to continue to gather, review, and analyze such data into the future, and to report on the results of its efforts, however at this time the data presented in the EIA represent the most recent data published.

The Nunavut Wildlife Harvest Study (NWHS) was mandated by the Nunavut Lands Claim Agreement (NLCA) and carried out under the direction of the Nunavut Wildlife Management Board (NWMB). Harvest data were collected monthly from Inuit hunters for a total of five (5) years covering the harvest months from June 1996 to May 2001. The

Harvest Study covered the entire Nunavut Settlement Area (NSA) involving participants from 28 communities, in all of the three administrative regions: Baffin, Kitikmeot, and Kivalliq regions.

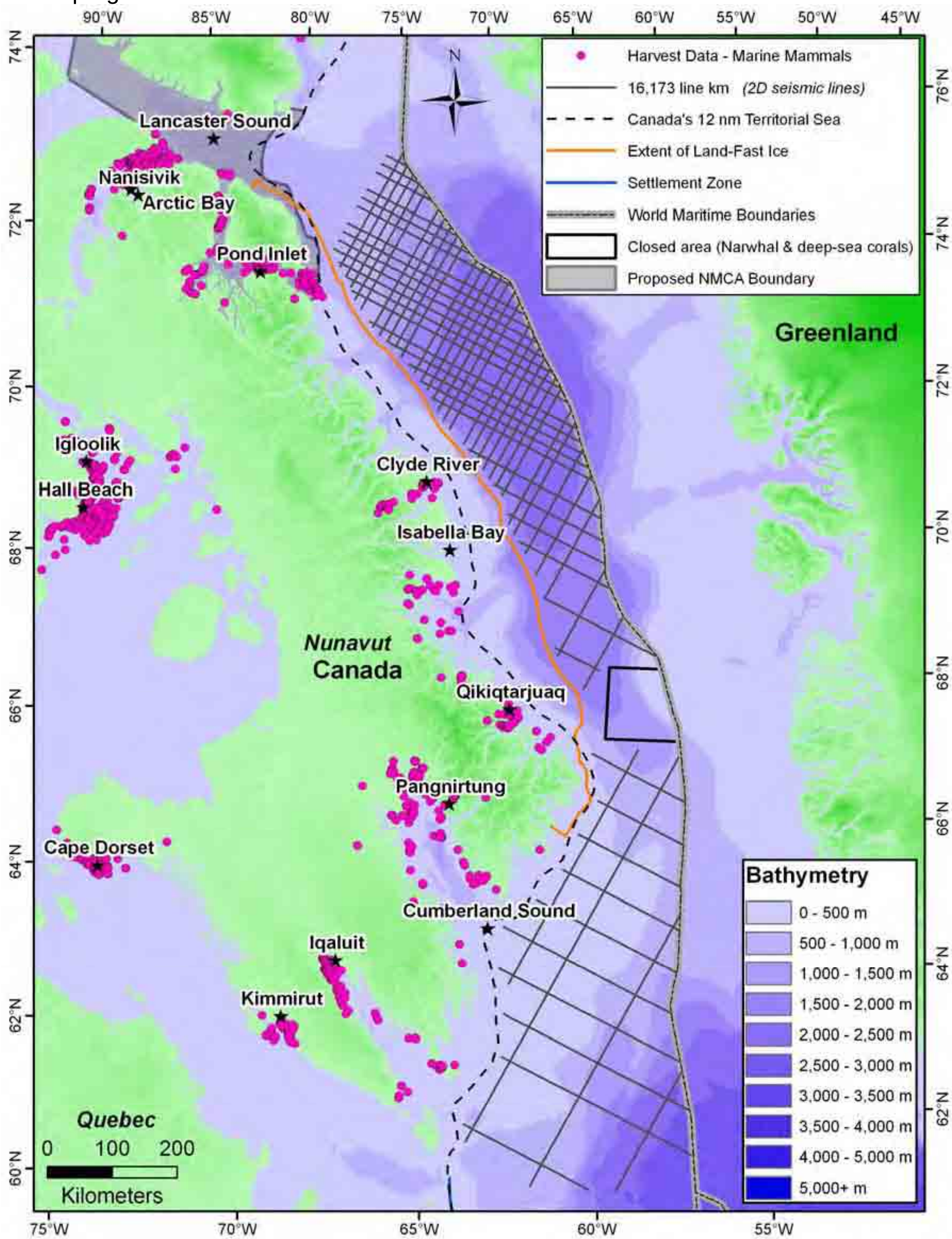

Figure 52. Harvest Data – Marine Mammals

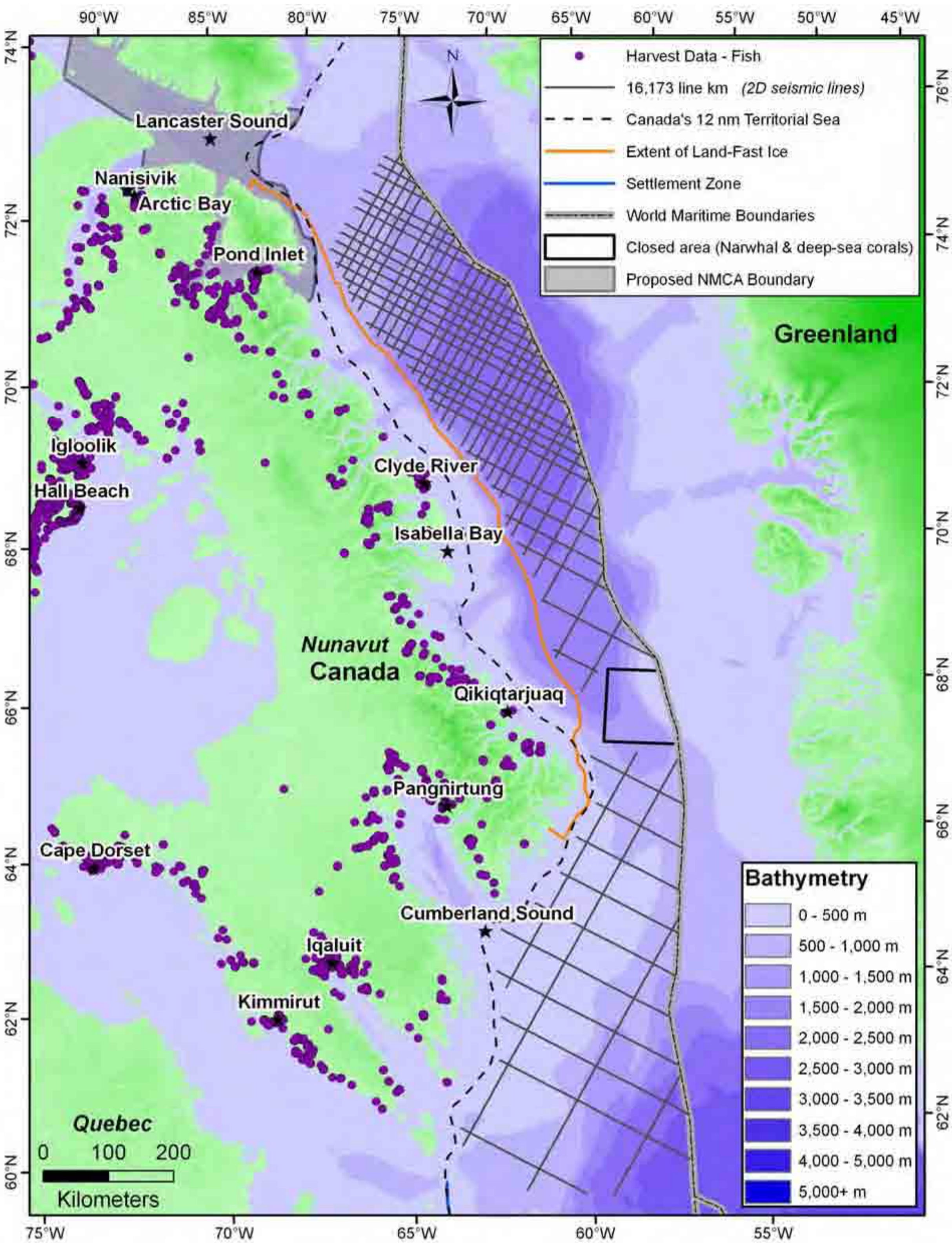

Figure 53. Harvest Data – Fish

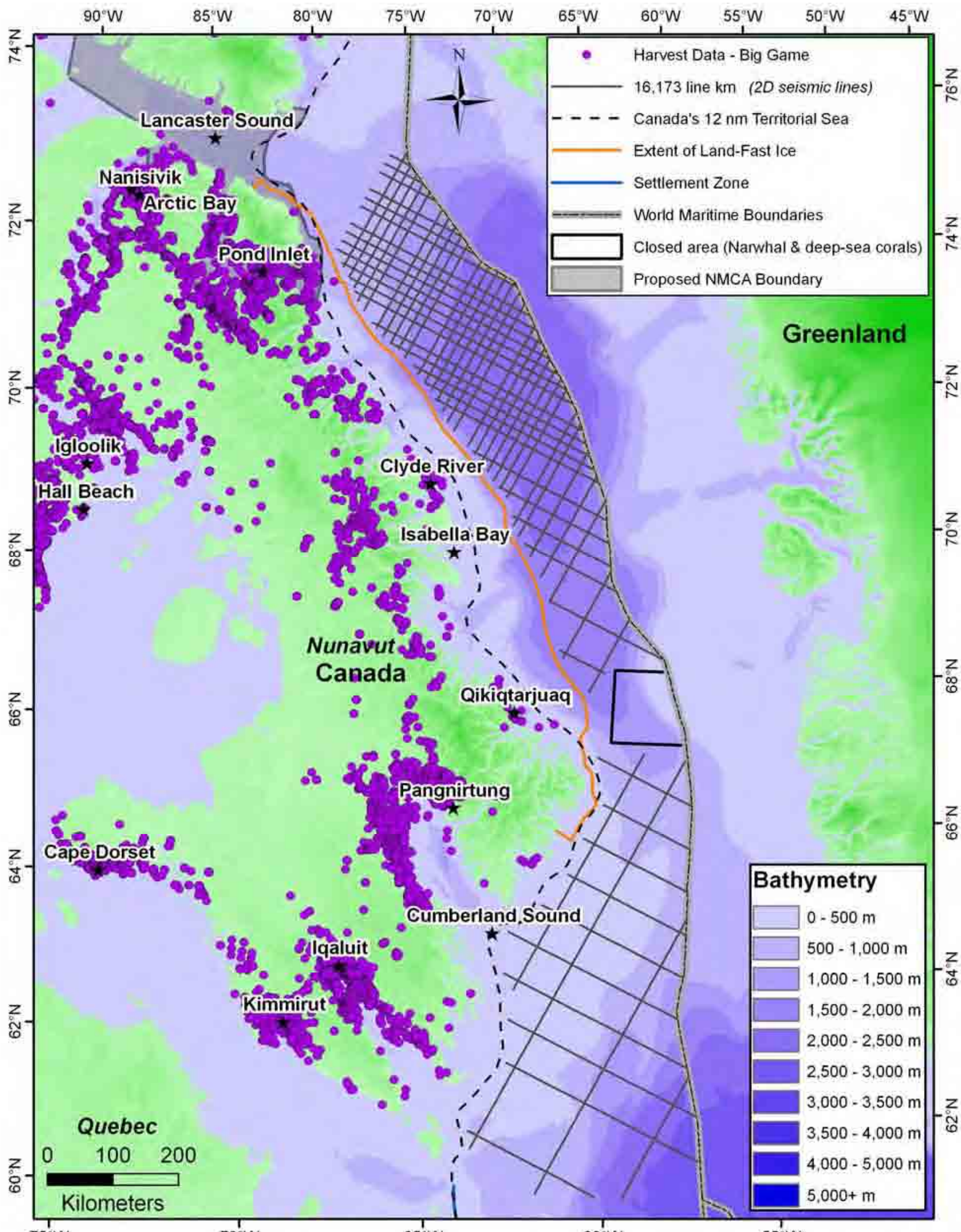

Figure 54. Harvest Data – Big Game

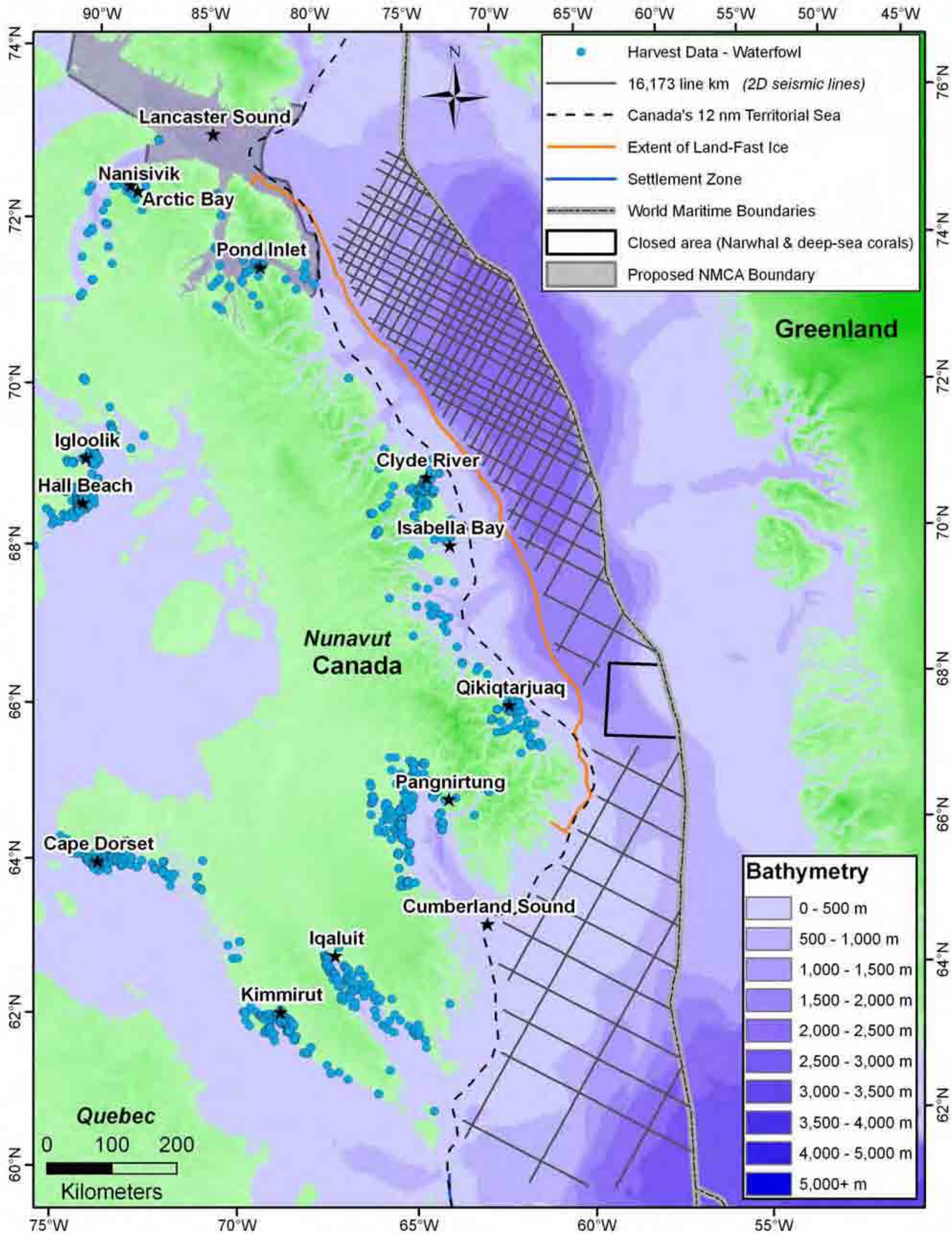

Figure 55. Harvest Data – Waterfowl

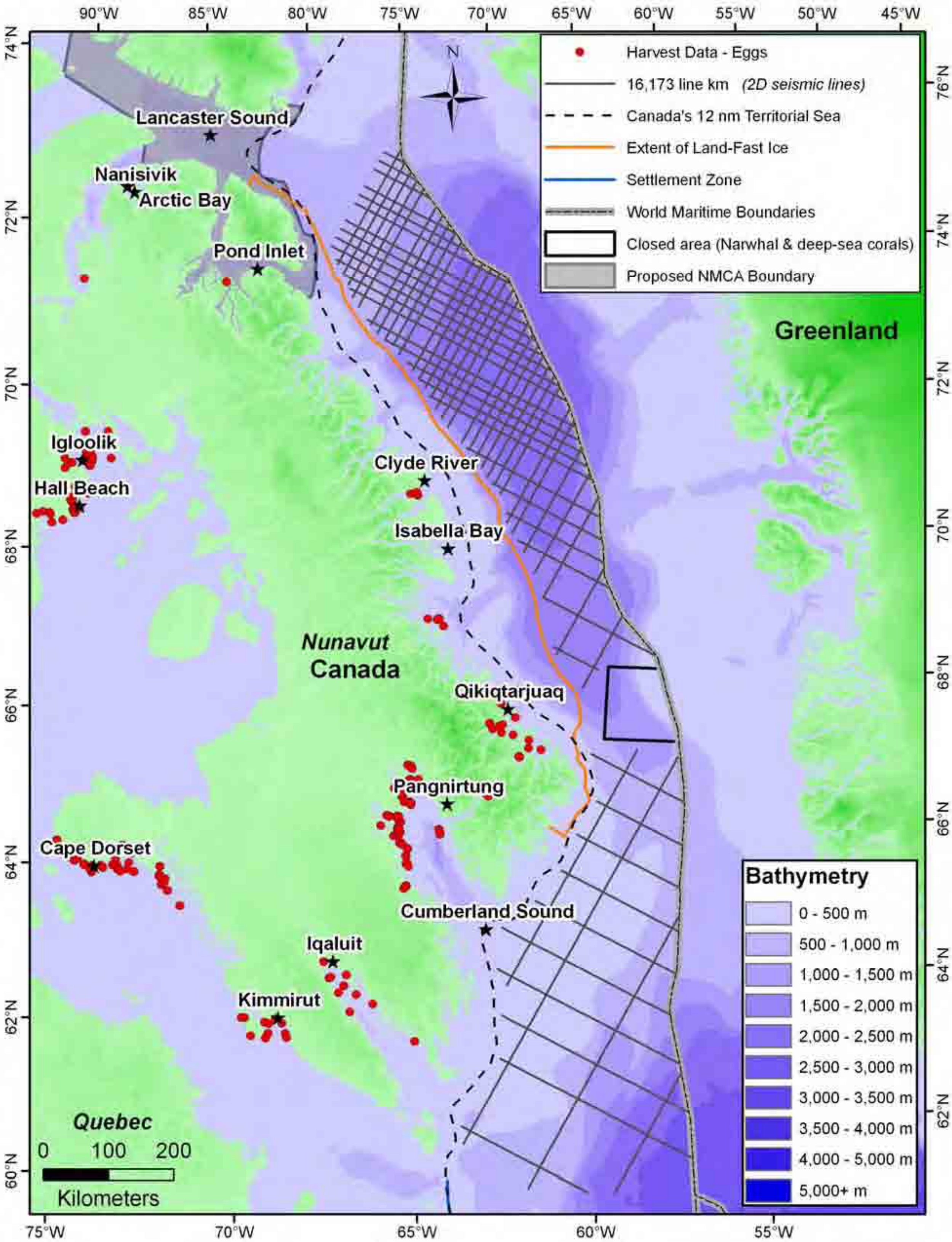

Figure 56. Harvest Data – Eggs

5. ENVIRONMENTAL IMPACT ASSESSMENT

5.1 VALUED ECOSYSTEM COMPONENT (VEC) SELECTION

This assessment uses a valued ecosystem component (VEC) approach to define and focus the issues and factors considered in this assessment. These include components that are important for a variety of reasons, such as their economic or social value, their status (e.g. at-risk species), or their importance to/as habitat. The selection of VEC's is limited, however, to those components that have some reasonable potential for interaction with, or sensitivity to, the planned project activities, most notably the Field Data Acquisition Program during the period of active profiling. This approach was also used in the '*Environmental Impact Assessment for Marine 2D Seismic Reflection Survey, Baffin Bay / Davis Strait / Labrador Sea, Offshore Canada*', also prepared by RPS Energy (April 2007), as commissioned by TGS.

5.1.1 Impact Definitions and Criteria

The Canadian Environmental Assessment Agency's Practitioner's Guide states that "the criteria for determining significance include magnitude, geographic extent, duration and frequency, irreversibility, ecological context" and that the assessment considers the likelihood of an adverse impact occurring. Significant adverse environmental effects are those that will cause a change in the VEC, such that its status or integrity is altered beyond an acceptable level. In other words, a significant adverse anthropogenic environmental effect may alter the assigned VEC in terms of its physical, chemical, or biological quality or extent to such a degree that there is a detrimental change in its ecological integrity beyond which natural mechanisms would not return that VEC to its former level of ecological integrity within the system. The following Table 9 describes the criteria applied for this project within the ecological context described in this report. Residual impacts are determined after application of applicable mitigation measures.

Table 9. Impact Definitions and Criteria

Magnitude	LOW > within natural variation/less than one generation
	MEDIUM > temporarily outside natural variation / 1 to 2 generations
	HIGH > permanently outside natural variation / whole population affected
Geographic Extent	LOW > localized
	MEDIUM > sectoral
	HIGH > widespread
Duration	LOW > less than one month
	MEDIUM > one to two months
	HIGH > greater than two months
Frequency	LOW > one time event
	MEDIUM > several events low duration
	HIGH > continuous

Reversible / Irreversible	Reversible > by natural processes and / or mitigation
	Irreversible > permanent regardless of mitigation
Limits of Confidence	LOW > high degree of scientific uncertainty
	MEDIUM > medium degree of scientific uncertainty
	HIGH > low degree of scientific uncertainty (conclusions are accurate)
Significance Characterization Post-Mitigation	No Significant Residual Impact Significant Residual Impact Positive Residual Impact

The assessments for each VEC considered: impact pathways, a review of relevant literature / research, evaluation of potential effects, and identification of specific appropriate mitigation. Table 10 shows which potential VEC's are considered in this document. Explanation of why phytoplankton, zooplankton, and invertebrates are not considered is discussed in Section 5.1.2.

Table 10. Initial Potential Interactions Matrix Field Acquisition Component

Potential Valued Ecosystem (VEC)	Seismic Air-Gun Interaction Project Component
Phytoplankton	-
Zooplankton	-
Macro-Invertebrates (pelagic and benthic)	-
Marine Reptiles	-
Marine Birds	√
Marine Fish	√
Marine Mammals	√
Fishing Gear Conflict	√

5.1.2 Fish Eggs, Zooplankton, and Invertebrates

While it is recognized that fish eggs, zooplankton (*including icthyoplankton and pelagic / benthic invertebrates*), and their larvae could be killed or damaged at distances up to or less than 5 metres from a large array, various studies have indicated that the impact would be indistinguishable from natural mortality, given the extent of exposure and the numbers of organisms involved.

Sætre and Ona (1996), in a worst-case risk analysis, estimated the total mortality from a typical 3D seismic survey (conducted in a tight, close grid over a relatively small area) on a typical larval population in the North Sea and calculated an effective mortality radius. Their results showed that the maximum population mortality from a large 3D seismic survey would be just 0.45% of the fish larvae, or 0.18% of the total population in the area per day. They note that since natural mortality for eggs and larvae is estimated at 5-15% per day, the effects of the array on fish larvae would be impossible to differentiate from natural mortality, and well within natural variability.

A workshop with oil industry, Fisheries and Oceans Canada, and fisheries participants from Nova Scotia and Newfoundland (sponsored by Environmental Studies Research Funds (ESRF)) took place in Halifax in 2000. During the workshop, LGL Griffiths Muecke (Thomson et al., 2001) noted that studies of seismic effects on fish eggs and larvae were of low priority and were not considered further at the workshop.

In addition, the 1998 seismic Scotian Shelf class screening assessment (Davis et al., 1998) calculated that, a volume of water equivalent to about 1% of the volume of water in the study area would contain impulses lethal to fish larvae, but not all types of fish larvae would be affected by the seismic pulses and those that have the potential to be affected would not be within range at all times. For example, herring spawning occurs close to shore in very shallow water and eggs would not be affected by seismic exploration. During the day, few pollock, redfish, flatfish, and mackerel larvae would be found in surface waters and they tend to be found at or below the thermocline. At night, the larvae of mackerel and redfish and other species do rise in the water column and are found in surface waters. Lethal ranges for flatfish larvae, which have no swim bladders, would be considerably less than those with swim bladders. Therefore, considerably less than 1% of fish larvae, in the potentially affected water mass, would be affected by seismic pulses. The assessment concluded that “Impacts on fish eggs and larvae, including those in nursery areas, would be minor, sub-local and short-term and likely to occur’. Authors concluded that “Direct physical impacts on invertebrates and their larvae are likely to be negligible”.

In another study, Kostyuchenko (1973) concluded that damage to fish eggs would likely be limited to within 5 metres. Dalen and Knutsen (1986) exposed Atlantic cod eggs, larvae, and fry to airguns, with no effects seen on eggs, larvae, and fry at a distance of 1 metre from a seismic energy source where received levels were 222 dB re 1 µPa. Fry that were 110 days old were also exposed to received levels of 231 dB re 1 µPa from a seismic energy source and all survived. Booman et al. (1996) conducted a study of close-range exposure of fish, fish larvae, and eggs (cod, pollock, plaice, turbot, and herring) to seismic sounds from an airgun cluster (242-220 dB re 1 µPa). Mortality and reduction in hatching success were not measurable beyond a few metres from the cluster. The report concludes that the existing mortality and injuries are near distance incidents with highest mortality rates and most frequent injuries observed out to 1.4 metres distance, while low and no mortality rate and more infrequent injuries were observed out to 5 metres distance.

Studies of invertebrate species show similar results. Pearson et al. (1988) reports that stage II zoeae of the Dungeness crab (*Cancer magister*) were not affected by exposure up to 231 dB re 1 µPa. They concluded that exposure did not affect survival, development, or behaviour.

With regard to phytoplankton, Kosheleva (1992; cited in Turnpenny and Nedwell, 1994) reported that arrays with source levels of 220-240 dB re 1 µPa had no effect on phytoplankton or benthos at distances of 1 metre or more. Studies by the Minerals Management Services of the United States Department of the Interior have indicated that, in general, seismic surveys are expected to have little or no effect on plankton, since the energy source (the airgun array) does not appear to have any effect on this group of organisms. Seismic activities are, therefore, considered to elicit little or no effect on lower trophic level organisms (MMS, 1998).

In 2004, Fisheries and Oceans Canada concluded a detailed review of scientific information on impacts of seismic sound on fish, invertebrates, marine turtles, and marine mammals (Fisheries and Oceans Canada, 2004b). It concluded, in relation to zooplankton, eggs, and larvae of fish and invertebrates, the following:

1) Few studies of the effects of seismic sound on eggs and larvae or on zooplankton were found. A number of these studies provided inadequate description of experiment design; properties of the sound applied as treatments, or had methodological shortcomings.
2) Data are generally insufficient to evaluate the potential damage to eggs and larvae of fish and shellfish (or other planktonic organisms) that might be caused by seismic sound under field operating conditions.
3) From the experiments reported to date, results do show that exposure to sound may arrest development of eggs, and cause developmental anomalies in a small proportion of exposed eggs and/or larvae; however, these results occurred at numbers of exposures much higher than are likely to occur during field operation conditions, and at sound intensities that only occur within a few metres of the sound source.
4) Effects of seismic sounds on behavioural functions and sensory perception of fish and invertebrate eggs and larvae are unknown.
5) In general, the magnitude of mortality of eggs or larvae that models predict could result from exposure to seismic sound would be far below that which would be expected to affect populations. However, special life history characteristics such as extreme patchiness in distribution and timing of key life history events in relation to the duration and coverage of seismic surveys may require case-by-case assessment.
6) No studies were found which specifically investigated the role of seismic sounds in recruitment variation of marine fish or invertebrates. There have been a large number of research studies on causes of variation in recruitment of marine fish or invertebrates, and none has considered that there are recruitment anomalies (positive or negative), which might be linked in space or time to seismic survey operations. This negative evidence applies at the scale of stocks, but does not provide information about the potential for effects on local-scale recruitment dynamics.

Given the above findings and since the exposure for most such organisms would be a “one time” occurrence, environmental elements such as phytoplankton, zooplankton, invertebrate (pelagic and benthic), their associated larvae, as well as fish eggs and larvae were not directly assigned VEC status (Table 10).

Studies by Payne et al. (2007) have indicated that adult American lobsters may experience physiological effects from intense seismic sound / pressure. American lobsters are not found in the proposed seismic study area and consequently will not be potentially impacted by seismic operations. Payne et al. (2007) further indicate that the damaging exposure levels could reach a depth of 100 metres. Most of the seismic survey will take place in deeper waters and there are no commercially exploited benthic macro-invertebrates within the study area. Thus it is unlikely that the seismic survey will measurably impact benthic macro-invertebrates within the study area. Furthermore, although there are commercially exploited pelagic macro-invertebrates within the study area, there are no scientific studies that address the potential impact of seismic exploration practices on them. There has been considerable seismic activity within the region historically, and no measurable effects have been identified and documented for either benthic or pelagic macro-invertebrates of the region.

Furthermore, since the impacts on eggs, larvae, and juveniles are expected to be insignificant, no specific mitigations are required. The proposed survey does not adversely impact critical or unique spawning grounds, including those of Species at Risk, and the majority of the survey is not on the upper shelf or banks (i.e. shallower than 200 metres). Line spacing, frequency of exposure (effectively 1 time event), location, and water depths, reduce the likelihood of impacts on any areas of concentration. Furthermore, the survey will be conducted progressively by a single vessel, the area occupied by the survey at any given time will be a moving “point” in deeper waters away from the near shore, and there will be no continuing ensonification in any one area.

5.2 SELECTED VEC ASSESSMENT

5.2.1 Impacts on Marine Fish

Marine fish species differ widely in their ability to hear or identify sound. Fish, such as herring, in which the swim bladder is connected directly to the inner ear, appear to perceive sounds more acutely than those that do not. Herring, for example, have the upper frequency limit of hearing ranges from 4,000 to 13,000 Hz, whereas the upper limit in fish without the swim bladder connection to the inner ear is about 1,000 to 1,200 Hz (Enger, 1967). While herring are relatively sensitive to sound, cod do not have a direct connection between swim bladder and inner ear, and, therefore, are less sensitive (Olsen, 1969).

Finfish held in cages and unable to avoid an approaching array have shown physical damage to their hearing, and fish held immediately under an array may be killed (Thomson et al., 2001). For instance, Falk and Lawrence (1973; cited in Davis et al., 1998) exposed adult Arctic cisco and other small *coregonids* with swim bladders to a 300 cubic inches source unit operating at 2,000 to 2,200 psi. While no mortalities were observed, some fish sustained damage to their swim bladder. Based on the damage observed, they concluded that the lethal radius of the airgun was between 0.6 and 1.5 metres (at 226-234 dB re 1 µPa). Weinhold and Weaver (1982) tested effects on salmon smolts (130 millimetres, 25 grams). Nineteen of twenty fish survived exposure to pressures of 70 to 166 psi (234 dB re 1 µPa) at a distance of 1 metre from airguns. Studies by Enger, (1981) and Hastings et al. (1996) suggest that exposure to continuous sounds of 180 dB re 1 µPa RMS for 1 to 5 hours can cause damage to the sensory hair cells that are the fundamental sound receptors in fish, McCauley (2000b c.f. Thomson et al, 2001) found some damage to fish hearing organs after 10 exposures to seismic sounds at received energy levels of 132-182 dB re 1 μPa^2.

In general, under normal circumstances, most fish would be expected to swim away to avoid the source as it approaches. Gausland (2000), in a review of known impacts on marine organisms, concluded that airgun operations cause little direct physical damage to fish at distances greater than 12 metres from the source. Nevertheless, it is evident that fish respond to sounds emitted from airguns. Reactions to the sound impulses are reported at levels from 180 dB re 1 µPa, but the full extent of the reactions is unknown. Due to the avoidance behaviour by free-swimming fish, they should not suffer physical damage from the airguns. However the immediate catch rate near surveys can be affected, but the reduction in catch rates is not expected to be long lasting. The reason for reduced catches is probably because fish dive to the bottom or disperse when exposed to high-level sound. For mitigation it is standard industry practice to ‘ramp-up’ airguns when starting a survey to ‘warn’ fish and marine mammals in the area.

Similarly, the Western Australian Department of Minerals and Energy’s “*Guidelines on minimising acoustic disturbance to marine fauna”* (2001, Section 5) state that the effects of seismic surveys on fish are generally observed to be transitory, except at close range. Seismic shots are known to elicit a startle response in fish, resulting in a movement away from the source of the noise, and changes in schooling behaviour. Behavioural changes are observed to cease during the exposure period, sometimes within minutes of commencement of surveying, indicating habituation to the noise. Fish are considered to have good low frequency hearing and so are likely to be able to hear seismic shots for up to several kilometres from the source. Disturbance of fish is believed to cease at noise levels below 180 dB re 1µPa (Western Australian Department of Minerals and Energy, 2001).

Davis et al. (1998) also concluded that adult fish on the Scotian Shelf would not be physically injured by seismic arrays unless immediately adjacent to an airgun and direct impacts of seismic exploration on adult fish should be negligible.

McCauley et al. (2000a) investigated physiological stress indicators in several species of caged finfish exposed to airgun arrays by measuring changes in cortisol levels. They report, for all species studied, there were no significant increases in stress measurements, which could be definitively associated with airgun exposure. They concluded that there had been no significant physiological stress increase as a result of exposure.

The recent 2004 Fisheries and Oceans Canada review of potential seismic impacts (Fisheries and Oceans Canada, 2004b) in relation to physical effects on marine fish concluded the following:

1) There are no documented cases of fish mortality upon exposure to seismic sound under field operating conditions. With regard to the detect ability of fish kills, if they occurred, it was noted that in Canada seismic surveys have frequently, but not always, included follow-on vessels instructed to watch for fish kills, and none have been observed. It was also noted that fish kills are not necessarily cryptic events, and kills caused by anoxic events, toxic spills etc are often readily detected. However, it was also argued that the efficiency of detecting fish kills by the follow-on vessels was not tested independently, so the possibility of undetected fish kills cannot be eliminated.
2) Under experimental conditions one study found that some subjects from three of four species tested suffered lethal effects from low-frequency (<500 Hz) tonal sounds, under exposure levels of 24 h at >170 dB. Participants noted that the experimental regime differed greatly from field operating conditions of seismic surveys, so extrapolation of the results to seismic surveys was not warranted. However some participants argued that the result indicates that risk of direct fish mortality from sounds with some characteristics of seismic sound cannot be discounted completely.
3) One anecdotal report of fish mortality upon exposure to an airgun less than 2 metres away was discussed and found to be inconclusive when considered relative to field operating conditions. Overall, exposure to seismic sound is considered unlikely to result in direct fish mortality.
4) Under experimental conditions, sub-lethal and/or physiological effects, including effects on hearing, have sometimes been observed in fish exposed to an airgun. The experimental design made it impossible to determine to the satisfaction of all experts what intensity of sound was responsible for the observed damage to ear structures, nor the biological significance of the damage that was observed. Simulated field experiments attempting to study such effects have been inconclusive. Currently, information is inadequate to evaluate the likelihood of sub-lethal or physiological effects under field operating conditions. The ecological significance of sub-lethal or physiological effects, were they occur, could range from trivial to important depending on their nature.

Considering the limited duration that the survey will be in any particular area and expected distances from the array based on fish avoidance, physical impacts on fish, including sub lethal and chronic impacts (e.g. permanent effects on hearing), are not expected. Nevertheless, to avoid potential impacts on fish the survey will employ a “ramp-up” procedure (i.e. starting with low energy array components and slowly increasing the volume) each time it starts the array. This will allow finfish (and other non-planktonic organisms such as marine mammals and turtles) to move away from the area before they can be exposed to the full array energy. The ramp-up procedures will begin prior to the use of seismic equipment in accordance with the Statement of Canadian Practice (Appendix A) and will progress continuously until recording starts. Ramp-up will begin with a single low cubic inch airgun firing singly, followed gradually by other airgun units in the array.

Overall, seismic operations will not measurably impact marine fish within the profiling area (Table 11).

5.2.2 Impacts on Marine Mammals

Many species of marine mammals, such as cetaceans, depend on sound to communicate, forage, avoid danger, and navigate. Increases in anthropogenic noise levels can result in the masking of these sounds or a decrease in the distance over which they can be detected. The likelihood that an animal would be impacted by a noise is dependent on its intensity, frequency, duration of exposure, and the distance between the animal and the source. It is also dependent on the frequency of the noise being emitted relative to the hearing sensitivity of the marine mammal.

Because of the potential affects of seismic surveys on marine mammals, with close proximity to the seismic array, a marine mammal observer (MMO) will be employed on the seismic vessel and an additional MMO onboard the supply vessel during the proposed survey. MMO’s are used to detect cetaceans and pinnipeds in the survey area and advise the crew to take corrective action and shut down operations if marine mammals enter the exclusion zone. They will keep a daily log of wildlife sightings, observation location, and effort data using the forms associated with the guidelines. The MMO will be a trained observer, preferably with experience working in the Arctic.

As a group, marine mammals have a functional hearing range of 0.01 to 200 kHz. However, different species of marine mammals have different acoustic abilities and sensitivities. Toothed and baleen whales, for instance, are known to be sensitive to different frequencies of noise. Toothed whales are less sensitive to low frequency sounds (<500 Hz), but have good sensitivity at up to 100 kHz or more (Evans and Raga, 2001). In contrast, baleen whales are thought to be sensitive to the low frequency sounds (<500 Hz), the frequencies at which they vocalize (Evans and Raga, 2001). If man-made noises occur within these frequencies there is the potential to negatively affect marine mammals either physiologically or behaviourally.

The potential effects of acoustic emissions on marine mammals can be divided into four categories:

- Permanent threshold shift (PTS): Long-term hearing damage due to physical injury to a marine mammal's hearing apparatus. Occurs when an animal is exposed to high peak pressure sound impulses (Richardson et al., 1995).
- Temporary threshold shift (TTS): Temporary reduction in hearing sensitivity. Occurs when an animal is exposed to a strong sound that results in a non-permanent elevation of the hearing sensitivity threshold (Richardson et al., 1995).
- Masking: Failure to distinguish the signal when both the signal and masking noise have similar frequencies and either overlap or occur very close to each other in time (NRC, 2003); and
- Changes in the behaviour and/or distribution (i.e. habitat avoidance) of a marine mammal that is of sufficient magnitude to be "biologically significant" (Richardson et al., 1995; NRC, 2005).

The noises emitted during seismic operations have higher peak source levels than other man-made noises including drilling, construction, and vessel activity. However, seismic exploration sounds tend to be short, discontinuous pulses, which are separated by quiet periods.

The energy from seismic activity varies; however, airgun arrays and other "high energy" sources are generally between 20 and 1,500 Hz. As a result, it is likely below the hearing sensitivities of toothed whales. This may explain why there is no known seismic data on the behaviour of toothed whales exposed to seismic noise. However, overall received levels of airgun pulses are often ≥ 130 dB re 1 μPa, a level that is potentially audible to toothed whales. Therefore, despite the toothed whales poor low-frequency hearing, it has been suggested that they may be able to hear seismic noise out to a radius of 10-100 kilometres.

In contrast to toothed whales, the low hearing sensitivity of baleen whales makes them much more sensitive to seismic noise. Baleen whales have been seen slowing, turning away, and increasing respiration rates as a result of airgun noise (Richardson et al., 1995). These behavioural observations have been detected in bowheads 5-10 kilometres away from the sound source and in humpbacks at ranges of up to 3.2 kilometres away (Richardson et al., 1995).

A scientific review on what is known regarding marine mammals and acoustic noise is presented in Appendix I (Fisheries and Oceans Canada, 2004b). This document, titled *Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals*, forms the basis of the *Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment* described in Section 5.3 of this document (Fisheries and Oceans Canada, 2004a), and is available on the Fisheries and Oceans Canada website:

http://www.dfo-mpo.gc.ca/csas/Csas/status/2004/HSR2004_002_E.pdf

Based on current knowledge on hearing sensitivities, it is possible that seismic activity related to the project may affect marine mammals, particularly baleen whales. However, because the project will be following the Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment, the more serious PTS and TTS effects are unlikely. Impacts to marine mammal behaviour, particularly habitat avoidance, are possible (e.g. bowheads at the Isabella Bay sanctuary may hear the seismic operation and temporarily alter their behaviour), but overall these impacts are expected to be limited due to the short term and periodic nature of the proposed seismic activity. The survey acquisition plan (i.e. order of survey lines to be acquired) is intended to maximize separation between marine mammals and the survey vessel, and includes starting acquisition in the south and progressing north. This detailed survey acquisition plan will be prepared prior to project initiation.

5.2.3 Impacts on Bowheads and Baleen Whales

Oil and gas exploration in the Arctic has prompted considerable research to investigate the potential effect of seismic noise on bowhead whales. Early studies on the effects of seismic noise indicate that bowheads show behavioural changes when seismic noises are within 8.2 kilometres, a range where received levels would be 142-157 dB re 1 µPa. In addition, whales will move away from the noise when it is within 3 to 7.2 kilometres (152-178 dB) (Richardson et al., 1986). These responses result in the whales being displaced by approximately 2 kilometres and their behaviour being altered for up to 1 hour (Ljungblad et al., 1988).

Findings from a more recent study by Richardson et al. (1999) suggest that these early sensitivity estimates may be an underestimate. Richardson et al. (1999) reported bowheads avoiding areas within 20 kilometres of seismic sources, corresponding to received noise levels of 120-130 dB re 1 µPa. The presence of this large avoidance zone was supported by the observation that areas outside of the zone had significantly higher densities of whales.

Other changes in behaviour that have been associated with seismic activity include reduced surface interval and dive duration, lower numbers of blows per surfacing, and longer intervals between successive blows. These effects have been detected at distances of up to 5-10 kilometres (Richardson, 1995).

Thresholds for temporary threshold shift (TTS) and permanent threshold shift (PTS) in baleen whales are unknown (Davis et al., 1998). It is not prudent to assume that the measured TTS thresholds for bottlenose dolphins apply to baleen whales, which seem to be much better adapted for low frequency hearing. TTS threshold levels could be important for assessing effects on baleen whales because individuals of some species of baleen whales occur quite close to ships and to seismic operations. McCauley et al. (1998) found that some individual humpback whales approached an operating seismic airgun to within 100-400 metres. Thus, the received levels that induce TTS may be particularly relevant for baleen whales such as the bowhead. The US National Marine Fisheries Service uses the threshold received level of 180 dB when considering potential TTS and PTS to marine mammals.

Based on United States National Marine Fisheries Service, available bowhead and acoustic impact information, they are likely to be disturbed only temporarily when encountered by the survey vessel. This disturbance is unlikely to result in auditory damage (i.e. TTS and PTS), especially given that professional marine mammal observers will ensure operations are suspended if marine mammals are identified within 500 metres of the arrays (see the following mitigation section for details). The most significant behavioural reactions are likely to consist of mid-range avoidance movements

(Davis et al., 1998), and it is not presently possible to quantify the overall long-term biological significance of such disturbances, however the proposed survey is well-removed from the continental shelf region, in particular from the Niginganiq (formerly Igaliqtuuq) National Wildlife Area (Isabella Bay). Bowheads are closely associated with pack-ice (possibly for feeding, protection, or other reasons), hence survey lines approaching summer pack-ice regions may potentially induce temporary habitat displacement, but will likely return after several hours. It is unlikely that this temporary disturbance will significantly reduce the overall value (i.e. feeding, resting) of this habitat.

5.2.4 Impacts on Narwhals and Toothed Whales

There is very little information about the behavioural responses of *odontocetes* to seismic exploration (Davis et al., 1998); this is especially true for responses of narwhals. The narwhal, in particular, is poorly studied and no scientific reports addressing hearing sensitivity and reactions to noise are available. However, it is known that narwhals are very sensitive to vessel activity and exhibit “freeze” or “flight” responses similar to those seen in beluga whales (Richardson et al., 1995). Their acute responsiveness has been linked to their confinement to heavy ice and the associated good sound propagation conditions. Goold (1996a) found that common dolphins (conceivably having comparable hearing sensitivity to narwhals) were tolerant of the noises from an array at distances of over 1 kilometre. The threshold levels for behavioural responses by bottlenose dolphins to single 1-second pulse ranged from 178 to 186 dB re 1 μPa for frequencies from 75 to 3 kHz (Finneran et al., 2002).

It is concluded that the effects of seismic pulses on narwhals would be minor, sub-local, short-term, and likely to occur. The use of professional marine mammal observers onboard the survey vessel will ensure operations are suspended if marine mammals are identified within 500 metres of the array (see the following mitigation section for details). The possibility of non-auditory physiological effects cannot be evaluated with present data, however if they occur they would be limited to animals very close to the operating array.

The situation for sperm whales is less clear, as the available data limited. Nevertheless the initial results of a major MMS study in the Gulf of Mexico involving the tagging and tracking of endangered sperm whales suggests that these whales may not significantly alter their behaviour when seismic arrays are active (Biers, 2003), and the US National Marine Fisheries Service (1995, 2000) has advised that whales in general should not be exposed to impulse noise at received levels exceeding 180 dB re 1 μPa (RMS), and have established a 500 metre radius precautionary safety zone for seismic arrays.

With the proposed mitigation methods in place the predicted effects for this study in the proposed study area are negligible to minor, local, short-term, and therefore not considered significant.

5.2.5 Impacts on Pinnipeds

Preliminary results of a radio telemetry study by Thompson et al. (1998; cited in Anderson Resources 2001) suggest that pronounced (but short-term) behavioural changes can occur in harbour seals and gray seals exposed to airgun pulses. They stated that normal foraging dives were interrupted and that avoidance reactions usually occurred. The seals returned to their previous foraging areas after airgun operations ceased. The USNMF Service has also set a safety limit of 190 dB for seals.

Overall, on the basis of the above information, as well as implementation of appropriate mitigation measures, no measurable impact on marine mammals is anticipated during the period of seismic acquisition in the Baffin Bay region (Table 11).

5.2.6 Impacts on Marine Birds

There are many species of seabirds and related species that can be found associated with the waters of proposed survey area. Not all are breeding populations and may only contact water or the shore area for brief period in the summer. There are no endangered or threatened species within the seismic survey area according to the latest information on the Species at Risk (SARA) Registry, however, the Ivory Gull is designated a species of special concern by COSEWIC. Environment Canada protocols for seabird observations will be used for seabirds for this project.

In general, there is little scientific information about impacts of seismic array sounds on birds. Davis et al. (1998) reports, “Stemp (1985) made observations on the reactions of birds to seismic exploration programs in southern Davis Strait over three summer periods. No distributional or mortality effects were detected. Evans et al. (1993b) made observations from operating seismic vessels in the Irish Sea. They noted that, when seabirds were in the vicinity of the seismic boats, there was no observable difference in their behaviour, birds neither being attracted nor repelled by seismic testing.

Many of the birds that might forage in the project area are divers, such as the Dovekie, Thick-billed Murre, and Atlantic Puffin that dive quite deeply and may spend considerable time under water. Murres regularly dive to depths of 100 metres and have been recorded underwater for more than three minutes (Gaston and Jones, 1998; cited in LGL, 2003).

Since the array will be gradually ramped-up at each start, and the array will generate impulses every 13 seconds, seabirds will be warned as they approach the ship and array. This will reduce or remove the likelihood that birds will choose to come close enough to the array to experience hearing damage or other physical harm.

In terms of risk to birds from pollutants, oil slicks, or wastewater, the survey vessel will comply with all applicable regulations concerning discharges of materials into the marine environment, as described above. The vessel is equipped to minimize risk of any spills and has an emergency response plan in place.

With respect to seabird interaction with surface oil, Lehoux and Bordage (2000) present deterrent techniques and a bird dispersal approach for oil spills that could be applied to any significant spill of oil of any variety. By utilizing the proposed mitigation measures, no measurable contribution of hydrocarbons is anticipated to enter the marine environment and impact marine life.

Onboard lights are known to attract birds, though the situation on the survey vessel is not expected to be any different than for any other similar-sized cargo or fishing ship, and the survey vessel will not typically be stationary.

In general, considering the small impact of seismic sounds in the air and the brief time the survey vessel will be in specific areas, the presence of the survey vessel should pose little risk and no measurable impact is predicted on seabirds within the area of survey (Table 11).

Table 11. Matrix of Potential Environmental Effects of the Project Components on Value Ecosystem / Environmental Components

Valued Ecosystem Component (VEC)		Magnitude	Geographic Extent	Duration	Frequency	Reversible / Irreversible	Limits of Confidence	Significance Level Post-Mitigation
Marine Mammals	Whales	LOW	LOW	MED	LOW	Reversible	MEDIUM	No Significant Residual Impact
	Seals	LOW	LOW	MED	LOW	Reversible	HIGH	No Significant Residual Impact
	Walrus	LOW	LOW	MED	LOW	Reversible	HIGH	No Significant Residual Impact
	Polar Bear	LOW	LOW	MED	LOW	Reversible	HIGH	No Significant Residual Impact
Sea Turtle		LOW	LOW	MED	LOW	Reversible	HIGH	No Significant Residual Impact
Birds		LOW	LOW	MED	LOW	Reversible	HIGH	No Significant Residual Impact
Fish		LOW	LOW	MED	LOW	Reversible	MEDIUM	No Significant Residual Impact
Fishing Gear Conflict		LOW	LOW	MED	LOW	Reversible	HIGH	No Significant Residual Impact

Key:

Magnitude	LOW	Within natural variation/less than one generation
	MEDIUM	Temporarily outside natural variation / 1 to 2 generations
	HIGH	Permanently outside natural variation / whole population affected
Geographic Extent	LOW	Localized
	MEDIUM	Sectoral
	HIGH	Widespread

Duration	LOW	Less than one month
	MEDIUM	One to two months
	HIGH	Greater than two months
Frequency	LOW	One time event
	MEDIUM	Several events low duration
	HIGH	Continuous
Reversible / Irreversible	Reversible	By natural processes and or mitigation
	Irreversible	Permanent regardless of mitigation
Limits of Confidence	LOW	High degree of scientific uncertainty
	MEDIUM	Medium degree of scientific uncertainty
	HIGH	Low degree of scientific uncertainty (conclusions are accurate)
Significance Level Post-Mitigation	No Significant Residual Impact	
	Significant Residual	
	Positive Residual Impact	

5.2.7 Fishing Gear Conflict

All proposed activity associated with this project will occurs offshore, fishing vessels and their associated in-sea gear represent the main group that could be potentially affected by the physical presence of the survey vessel and in-sea equipment. In order to manage this effectively, Fisheries Liaison Officers (FLO) familiar with the survey area's fisheries will be employed on the vessel during the proposed survey as means of facilitating inter-industry communications, advising on fisheries issues, and avoiding fishing / gear conflicts. It is anticipated that the FLO individuals will be hired based on the recommendation of the local fishing industry (FFAW), and personnel with experience working in the Arctic are appropriate for this type of project. The FLO will provide dedicated marine radio contact for all fishing vessels in the vicinity of the survey vessel to discuss potential interactions and solutions. These persons, knowledgeable about local fishing, will assist the vessel's bridge personnel with information about established fishing activities and harvesting methods.

As discussed in Section 4.9 of this report, commercial fish harvesting activities may occur throughout the survey period within some parts of the survey area, though the timing of specific fisheries varies. The fixed-gear (gill nets and long lines) of the turbot fishery poses the highest potential for gear conflict if they are concurrent and co-location with seismic survey operations. Historically, such gear conflicts have occurred in other areas, typically 2-3 times annually throughout Atlantic Canada. All incidents have involved fixed gear (typically crab or lobster pots, gill nets, or large pelagic long lines). When these events occur, they are assessed on a case-by-case basis and compensation paid for determined losses.

Mitigation plans to avoid active fishing areas are presented below. These focus on reducing the likelihood of conflicts. With precautions and compensation plans in place, the economic impacts on fishers would be negligible, and thus not significant.

5.2.8 Avoidance

As discussed above, potential impacts on fishing gear will be mitigated by avoiding active fixed gear fishing areas. The FLO, good at-sea communications, and mapping of fishing locations have proven effective in the past at preventing such conflicts.

5.2.9 Fisheries Liaison Officer (FLO)

As described above, the onboard fisheries industry FLO will provide a dedicated marine radio contact for all fishing vessels in the vicinity of the survey vessel to help identify gear locations, discuss potential interactions and find solutions, and provide essential guidance to the Bridge.

5.2.10 Communications with Fishing Industry

Good communications are the best way to minimize interference with fishing activities. Maintaining good communication with fishers is important before and during the survey.

The Operator (through its consultants) will communicate with appropriate fisheries organizations to inform them of planned survey activities and to facilitate information exchange with fisheries participants.

Relevant information about the survey will also be publicized using established communications mechanisms, such as the Notices to Shipping and CBC Radio's Fisheries Broadcast, as well as direct communications between the survey vessel and fishing vessels via marine radio at sea.

5.2.11 Single Point of Contact

The operator will arrange for the services of a Single Point of Contact (SPOC) with the fisheries industry. The SPOC role will include updating vessel personnel (i.e. the FLO, the Captain, and the Party Manager) about known fishing activities in the area, and will relay relevant information from Fisheries and Oceans Canada.

5.2.12 Fishing Gear Compensation

In case of accidental damage to fishing gear, the operator will have available a gear damage compensation contingency plan to provide appropriate and timely compensation to any affected fisheries participants. The Notices to Shipping filed by the vessel will also inform fishers that they may contact the SPOC, if they believe that they have sustained survey-related gear damage.

The Operator is familiar with the C-NLOPB / CNSOPB Compensation Guidelines Respecting Damages Related to Offshore Petroleum Activity (C-NLOPB / CNSOPB, 2002), and with programs developed jointly by the fisheries industry and offshore petroleum operators (e.g. by the Canadian Association of Petroleum Producers and other Operators) as alternatives to claims through the courts, to address all aspects of compensation for attributable gear damage. These programs include provisions for paying compensation for lost or damaged gear, and any additional financial loss that is demonstrated to be associated with the incident. The programs include mechanisms for claim payments and dispute resolution. The operator will implement similar procedures to settle claims promptly for any gear damage that may be caused by survey operations, including the replacement costs for lost or damaged gear, and any additional financial loss that is demonstrated to be associated with the damage, as recommended under the C-NLOPB Guidelines. The operator will provide the NEB with the details of any compensation to be paid.

By adopting the above mitigation measures it is unlikely that a significant impact on fishing gear will occur during the seismic program (Table 11).

5.3 MITIGATIONS

The operator will follow the 'Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment' developed by Fisheries and Oceans Canada in order to minimize the negative effects of its activity on the environment (Fisheries and Oceans Canada, 2004a). This document is available for review online:

http://www.dfo-mpo.gc.ca/oceans-habitat/oceans/im-gi/seismic-sismique/pdf/statement-enonce_e.pdf

This Statement of Canadian Practice was created to formalize and standardize the mitigation measures used in Canada with respect to the conduct of seismic surveys in the marine environment. Based on current knowledge and experience, seismic surveys conducted with the mitigation measures contained in the Statement of Canadian Practice are not expected to cause significant adverse environmental effects. A copy of this document is provided in Appendix A.

A scientific review on what is known regarding marine mammals and acoustic noise is also presented in Appendix I. (Fisheries and Oceans Canada, 2004b). This document, titled 'Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals', forms the basis of the 'Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment', and is also available on the Fisheries and Oceans Canada website:

http://www.dfo-mpo.gc.ca/csas/Csas/status/2004/HSR2004_002_E.pdf

No residual environmental impacts are expected on the marine resources in the survey area. A seismic energy source for this type of survey produces about 230 db re 1 μPa @ 1 m. Note this is a theoretical level and is not actually reached the array is not a point source. At a distance of about 1 kilometre from the sound source the received sound is in the order of 170 db re 1 μPa. The Department of Fisheries and Oceans has concluded that exposure to seismic sound is considered unlikely to result in direct fish or invertebrate mortality (Fisheries and Oceans Canada, 2004a).

For marine mammals a safety zone distance of 500 metres from the sound source will be established. At this distance the received sound level (180 dB re 1 μPa) is similar to the vocalization sounds made by Humpback, Bowhead, Right, Blue, Fin, as well as other large marine mammals (175-190 dB). Furthermore, vessel traffic in the area, such as commercial fishing, produces sound levels in the order of 154 dB (Richardson et al., 1995). As a note, rain will increase the background noise by up to 35 dB above ambient.

All standard and industrially related mitigation measures pertaining to the use of seismic airgun arrays for exploration will be adopted and followed. For marine mammals, especially whales, the safety radius or zone of 500 metres from the sound generating source will be adopted to reduce received sound levels in the order of 180 dB at the maximum (LGL, 2005). Note that this sound level is about the same sound production level that is produced by cracking and breaking pack ice that is prevalent in this high Arctic environment, and represents a background noise level. Further mitigation measures with respect to potential marine mammal interaction with the project will also be adopted. These include the following:

1) Alteration of vessel speed / course providing it will not compromise operational safety requirements.
2) Airguns will be shut down if any marine mammal enters or is anticipated to enter the 500 metres safety zone through observations by a trained marine mammal observer on the seismic vessel.
3) Airgun start-up procedures will not commence unless a full 500 metres safety zone is clear of any marine mammal by visual inspection by a trained marine mammal observer for a continuous period of at least 30 minutes.
4) The airgun array will be "powered down" during transit from one seismic line to another. All guns will be turned off except for one gun, which will function as a signal intended to alert marine mammals of the presence of the vessel.
5) Total shut down of all airgun activity will occur and not resume until all marine mammals have cleared the 500 metres safety zone.
6) Airgun start-up procedures will include a "ramping-up" period.
7) The location of the seismic activity associated with this project will not take place in the vicinity of any native harvest area.
8) Notice to mariners posting where and when surveying will occur.
9) Adherence to recent Fisheries and Oceans Canada guidelines for conducting seismic surveys in Canadian waters (Appendix A).

With respect to polar bears, it is highly unlikely that the sub-sea sound produced will impact bears if they are encountered. If seen by the trained marine mammal observer within the 500 metres safety zone, all of the above mitigation measures will be applied to ensure that no project interaction occurs.

For marine fish and invertebrates, federal Department of Fisheries and Oceans and other scientific studies have indicated that no fish kills have taken place that can be directly attributed to seismic exploration activity, and no measurable impact on populations of phytoplankton, zooplankton, as well as fish eggs, larvae, or juveniles have been reported at distances of 8 metres from the seismic sound source.

Overall, by adopting all industrial mitigation standards as well as more stringent measures discussed above, no anticipated measurable environmental impacts are predicted for this seismic exploration research field program in the Davis Strait project area.

5.3.1 Ramp-Up

"Ramping-up" (i.e. starting with low energy array components and slowly increasing the volume) will allow marine mammals to avoid the survey area if they choose to. The survey vessel will gradually ramp-up (soft-start) the energy of the airgun array to warn away marine mammals and finfish before they can be exposed to the full array energy.

As specified in the Statement of Canadian Practice, the ramp-up procedures will begin after a 30-minute observation period (see below), at least 20 minutes prior to the use of seismic equipment, and be continuous until recording starts. Ramp-up will begin with a single air-source unit firing singly followed by other source units in the array. The array will then increase intensity, either through adding units or increasing pressure (or both), at a planned rate until the full intensity of the array is achieved.

5.3.2 Start-Up and Shutdown Procedures

Guidelines for the mitigation of seismic noise in the marine environment established DFO in 2004 (Mitigation of Seismic Noise in the Marine Environment – Statement of Canadian Practice; Appendix A) will be adopted. A designated observer for the presence of marine mammals and/or sea turtles will conduct a visual inspection of the area 30 minutes prior to commencement of the soft start.

The operator undertakes not to commence the array start-up, or to recommence firing the array if stopped, if any marine mammal is sighted within 500 metres of the survey vessel during this period. During ramp-up, if a marine mammal is sighted within 500 metres of the array, the array will be shut down.

If for any reason the array is shut down, ramp-up procedures will be followed prior to recommencing survey operations. Outside daylight hours, or in periods of low visibility, visual observations may not be practicable. In these situations, a soft-start approach will still be employed, and the reasons for “no observations” will be recorded.

Employing these mitigation methods, no measurable impact is anticipated for the leatherback sea turtle that could potentially enter the area of seismic profiling (Table 11).

5.3.3 Mitigations with Respect to Seabirds

The array will be gradually ramped-up and the array will generate impulses approximately every 15 seconds. Seabirds will therefore be warned as they approach the ship and array, which will reduce the likelihood that birds will choose to come close enough to the vessel or array to experience any measurable deleterious interaction.

Onboard lights are known to attract birds, although the situation on the survey vessel is not expected to be any different than that for any other similar sized cargo vessel or fishing ship. Nevertheless, the measures adopted to address stranding of *Storm Petrels* as described by Williams and Chardine will be adopted. A copy of this document is provided within Appendix J.

5.4 ACCIDENTS AND MALFUNCTIONS

All safety measures established on the research vessel will be enforced while seismic data are collected. Dedicated safety officers and crew of the research vessel will be fully briefed on the procedures required by the scientific staff for deployment, data collection, and instrument retrieval. No instrument deployment / data collection will occur at any time without the knowledge of the vessel Captain or designate. The vessel carries trained personnel and applies specific protocols to deal with equipment malfunctions that may lead to the spill of toxic materials.

5.5 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

Sea and ice conditions are the primary sources of potential effects of the environment on the project. If sea states exceed a Beaufort wind scale value of 7, with sea waves in excess of 3-4 metres in height, seismic activity cannot take place. Additionally, if pack-ice is covering the proposed survey area, no seismic data can be acquired in that region and another ice-free survey area must be visited.

As described in detail in Section 5.3.2, airgun start-up procedures will not commence unless a full 500 metre safety zone is clear of any marine mammal by visual inspection by a trained marine mammal observer for a continuous period of at least 30 minutes. Outside of daylight hours, or in periods of low visibility, visual observations may not be practicable. In these situations, start-up procedures (including a soft-start approach, described below) will still be employed, and the reasons for “no observations” will be recorded.

This gradual ramp-up / soft-start of the seismic array commences by firing a single source (preferably the smallest source in terms of energy output and volume), and then continuing to active additional sources in ascending order of size over a 20 minute period until the desired operating level is attained.

5.6 CUMULATIVE ENVIRONMENTAL EFFECTS

Environmental effects resulting from individual projects may accumulate and interact within the environment to result in cumulative environmental effects. Potential cumulative effects due to accumulation and/or interaction of the seismic program’s activities are considered below. In this regard, the evaluation of cumulative environmental effects considers the nature and degree of change from baseline environmental conditions as they pertain to the proposed program, the program in combination with past and ongoing projects, and the program in combination with future planned projects and activities.

With regards to future activities, a critical step in the assessment process is determining what other projects or activities have reached a level of certainty (e.g. reasonable foreseeable) that they will be undertaken. Within the study area, other projects / activities that meet this level of certainty include: commercial fishing, commercial vessel / shipping (both domestic and international), scientific research surveys, and mineral resource exploration and development.

Seismic surveys are of particular interest since cumulative impacts from seismic impulses within the marine environment are significantly harder to quantify than effects attributed to other activities. This is because the acquisition of seismic data requires the temporary creation of sound / pressure waves (airgun-derived) that dissipate and soon disappear when the sound energy source is stopped. Unlike other mineral resource exploration / extraction activities that are tangible in nature, such as the production and deposition of drilling muds on the seafloor, or other industrial related cumulative impacts, such as deposition of mine tailings and contaminant loading, any cumulative impact that maybe attributed to a seismic energy source is intangible and can only be measured as impacts associated with organisms in the environment.

Specifically, the energy source produces sound / pressure that, in it, do not "accumulate" in the physical environment from one project to another. There is no bioaccumulation of sound / pressure within the food chain as there can be with contaminants and noxious materials. However, there may be a relatively temporary additive effect if sounds from one activity coincide and overlap spatially and temporally with another concurrent activity. In any case, the "added sound" dissipates and is removed from the receiving environment once one or the other sound-generating source ceases or passes out of the area of concern.

To our knowledge, there have been no historical or current documented measurable cumulative physical environmental effects on any marine organism that can be attributed to, in part, a seismic energy source operating within the survey region. Thus, any cumulative impacts from a seismic survey energy source would have to be measured as behavioural impacts caused by repeated exposure to the energy source in conjunction with other sound sources.

Within the study area there may be many sound generating sources present when the seismic energy source is active. Commercial fishing occurs within the proposed survey area. Concurrent with fishing activity is domestic and international shipping. Propeller noise from these vessels combines to make the ocean a very noisy place, especially near and at primary fishing and commercial ports. Since the proposed seismic survey will not be concentrating efforts in areas of major commercial shipping activity for any extended period of time, it is not anticipated that the relatively small seismic survey vessel, with its associated propeller noise, will contribute a significant addition to the overall domestic / international vessel traffic noise within the region. This conclusion also applies to government research survey vessels that may occur within the proposed seismic survey area.

The behaviour of marine mammals and birds may be influenced by noise. Existing marine activities within the study area that contribute to background noise include: commercial fishing, general marine traffic (domestic and international shipping), government research surveys, as well as recreational boaters. In addition, there is considerable naturally occurring background noise, such as that cause by the cracking and breaking of sea ice. When combined, this combination of routine and naturally occurring sounds make the underwater environment considerably noisy. It is anticipated that the additional noise generated as a result of the present proposed seismic survey activities will be minimal, in part due to the broad area that is to be surveyed over an extended sampling time, and not concentrated in a particular area over a short period of time. Mitigation measures are in place to protect marine mammals and reptiles thus reducing the potential for impacts.

As noted in Appendix C, a considerable number of seismic studies have been undertaken in the region (190 seismic reflection surveys (2D and 3D), seismic refraction surveys, and shallow seismic / seabed surveys) and no measurable cumulative impact on any fishery, nor other marine resource, has been identified that can be attributed to seismic exploration; therefore it is unlikely that cumulative impacts will result from the proposed program. Potential cumulative impact related to seabirds may primarily be related to accidents and malfunctions that may release hazardous materials, such as oils, into the marine environment that would combine with other materials already present. Mitigation methods are in place to address these issues. Furthermore, lights from several vessels operating in close proximity may cause cumulative impacts relating to stranding of birds on the vessels. However, due to the nature of the seismic survey method, where the seismic apparatus is towed up to several kilometres behind the survey vessel, no other vessel is likely to be in close proximity. Therefore, the likelihood of cumulative accidents / malfunctions releasing hazardous materials from the seismic survey vessel and another vessel is low, as is the attraction of seabirds to multiple vessels in close proximity to each other at night.

Commercial fishing and domestic / international shipping, as well as government research surveys, will continue to occur. However, no measurable cumulative impacts / effects associated with past or current activities have been identified despite over 1.5 million line kilometres of seismic survey data having been collected in the region. Overall, the proposed seismic survey is not projected to measurably contribute to residual cumulative environmental effects within the proposed survey area

5.7 CONSULTATIONS

As mentioned early in this document, in person meetings were held with HTO groups in the communities, meetings with Federal and territorial groups in Iqaluit prior to the commencement of the EA development. A copy of these meetings can be found in Appendix B. It is anticipated that RPS Energy will return to some communities for public meetings in late May 2011. These meetings were scheduled for May 1-6th but negative feedback due to it being election week, resulted in the decision to re-schedule.

Consultations with the fisheries industry have been conducted by the authors for marine 2D seismic reflection surveys in the Davis Strait in 2007 – '*Environmental Impact Assessment for Marine 2D Seismic Reflection Survey, Baffin Bay / Davis Strait / Labrador Sea, Offshore Canada* ' (LaPierre et al., 2007). The primary issues raised during these consultations were concerns regarding the potential impacts of seismic operations on the spawning of Greenland halibut in general, gear conflicts, and communications with the fisheries fleet in the field.

Spawning will not be impacted as there are no concentrated areas or timing of spawning to avoid in the survey area. Regardless, the commercial species of fish spawn at the ocean bottom, at depths well-removed from the surface where the sound could potentially result in temporary dispersal of fish. Science does not currently have sufficient data to identify a set period when spawning occurs in NAFO Divisions 0A and 0B; however, research on the Flemish Cap suggests that turbot do not have a peak spawning period, with some fish in spawning conditions year-round (Fisheries and Oceans Canada, 2005).

For fishing activity that takes place concurrently with the proposed geophysical program there is potential for gear interaction between the seismic and fishing vessels / gear;

however, the presence of a fisheries liaison officer (FLO) onboard the seismic vessel will ensure good communication at sea so that areas of fishing can be avoided when fishing is taking place. In practice seismic vessel yield to and/or avoid fixed gear locations, and work around fishing activity. It is routine for seismic vessels to break off survey lines in order to avoid fishing gear.

Since 1998, fishing effort restrictions have been in place to limit the time spent by vessels fishing for Greenland halibut (turbot) in this area, as the harvesting of this species is considered a potential impact on narwhal food supply. A fifteen-year rebuilding programme started in 2004 to attain a sustainable level of exploitable biomass. This issue will be closely monitored by the operator as it develops, and the onboard FLO and operator will be made aware of any developments related to the adoption of this policy in order to be fully aware of the potential fishing activity, and to facilitate appropriate communications with expected fishers. Effective communication between fishing vessels in the field and the survey vessel is recognized as a high priority for these operations.

As mentioned early in this document, in person meetings were held with HTO groups in the communities, meetings with Federal /Provincial groups in Iqaluit prior to the commencement of the EA development. A copy of these meetings can be found in Appendix B. It is anticipated that RPS Energy will return to some communities for public meetings in late May 2011. These meetings were scheduled for May 1-6th but negative feedback due to it being election week, resulted in the decision to cancel the meetings and reschedule.

5.8 FOLLOW-UP

No specific effects monitoring programs are indicated by this assessment. The survey provides a very good opportunity to collect environmental observation data related to some of the region's VEC's, specifically seabirds and marine mammals. After the survey the observation data will be submitted to the NEB (to pass onto Environment Canada and Fisheries and Oceans Canada), and will include a report on the results of the monitoring program.

Importance of ensuring the location of the survey activity is conveyed to the communities before the program begins. Onboard MMO will communicate this to the Hunters & Trappers Organization onshore, such that there is good awareness.

Further discussions will take place with the fishing fleet's to ensure exchange of contacts before survey work commences.

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Appendix A

Statement of Canadian Practice

Fisheries and Oceans Canada   Pêches et Océans Canada   Canada

Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment

Context

The Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment specifies the mitigation requirements that must be met during the planning and conduct of marine seismic surveys, in order to minimize impacts on life in the oceans. These requirements are set out as minimum standards, which will apply in all non-ice covered marine waters in Canada. The Statement complements existing environmental assessment processes, including those set out in settled land claims. The current regulatory system will continue to address protection of the health and safety of offshore workers and ensure that seismic activities are respectful of interactions with other ocean users.

Definitions

Cetacean: means a whale, dolphin or porpoise.

Critical habitat: means the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species.

Marine Mammal Observer: means an individual trained to identity different species of marine mammals and turtles that may reasonably be expected to be present in the area where the seismic survey will take place.

Marine mammals: means all cetaceans and pinnipeds.

Passive Acoustic Monitoring: means a technology that may be used to detect the subsea presence of vocalizing cetaceans.

Pinniped: means a seal, sea lion or walrus.

Ramp-up: means the gradual increase in emitted sound levels from a seismic air source array by systematically turning on the full complement of an array's air sources over a period of time.

Seismic air source: means an air source that is used to generate acoustic waves in a seismic survey.

Seismic air source array(s): means one or a series of devices designed to release compressed air into the water column in order to create an acoustical energy pulse to penetrate the seafloor.

Seismic survey: means a geophysical operation that uses a seismic air source to generate acoustic waves that propagate through the earth, are reflected from or refracted along subsurface layers of the earth, and are subsequently recorded.

"Statement": means the Statement of Canadian Practice for the Mitigation of Seismic Sound in the Marine Environment.

Whale: means a cetacean that is not a dolphin or porpoise.

Application

1. Unless otherwise provided, the mitigation measures set out in this Statement apply to all seismic surveys planned to be conducted in Canadian marine waters and which propose to use an air source array(s).

2. The mitigation measures set out in this Statement do not apply to seismic surveys conducted:
    a. on ice-covered marine waters; or
    b. in lakes or the non-estuarine portions of rivers.

Planning Seismic Surveys

Mitigation Measures

3. Each seismic survey must be planned to
    a. use the minimum amount of energy necessary to achieve operational objectives;
    b. minimize the proportion of the energy that propagates horizontally; and
    c. minimize the amount of energy at frequencies above those necessary for the purpose of the survey.

4. All seismic surveys must be planned to avoid:
    a. a significant adverse effect for an individual marine mammal or sea turtle of a species listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*; and
    b. a significant adverse population-level effect for any other marine species.

5. Each seismic survey must be planned to avoid:
    a. displacing an individual marine mammal or sea turtle of a species listed as endangered or threatened on Schedule 1 of the *Species at Risk Act* from breeding, feeding or nursing;
    b. diverting an individual migrating marine mammal or sea turtle of a species listed as endangered or threatened on Schedule 1 of the *Species at Risk Act* from a known migration route or corridor;
    c. dispersing aggregations of spawning fish from a known spawning area;
    d. displacing a group of breeding, feeding or nursing marine mammals, if it is known there are no alternate areas available to those marine mammals for those activities, or that if by using those alternate areas, those marine mammals would incur significant adverse effects; and
    e. diverting aggregations of fish or groups of marine mammals from known migration routes or corridors if it is known there are no alternate migration routes or corridors, or that if by using those alternate migration routes or corridors, the group of marine mammals or aggregations of fish would incur significant adverse effects.

Safety Zone and Start-up

Mitigation Measures

6. Each seismic survey must:
    a. establish a safety zone which is a circle with a radius of at least 500 metres as measured from the centre of the air source array(s); and
    b. for all times the safety zone is visible,
        i. a qualified Marine Mammal Observer must continuously observe the safety zone for a minimum period of 30 minutes prior to the start up of the air source array(s), and
        ii. maintain a regular watch of the safety zone at all other times if the proposed seismic survey is of a power that it would meet a threshold requirement for an assessment under the *Canadian Environmental Assessment Act*, regardless of whether the Act applies.

7. If the full extent of the safety zone is visible, before starting or restarting an air source array(s) after they have been shut-down for more than 30 minutes, the following conditions and processes apply:
    a. none of the following have been observed by the Marine Mammal Observer within the safety zone for at least 30 minutes:
        i. a cetacean or sea turtle,
        ii. a marine mammal listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*, or
        iii. based on the considerations set out in sub-section 4(b), any other marine mammal that has been identified in an environmental assessment process as a species for which there could be significant adverse effects; and
    b. a gradual ramp-up of the air source array(s) over a minimum of a 20 minute period beginning with the activation of a single source element of the air source array(s), preferably the smallest source element in terms of energy output and a gradual activation of additional source elements of the air source array(s) until the operating level is obtained.

Shut-down of Air Source Array(s)

Mitigation Measures

8. The air source array(s) must be shut down immediately if any of the following is observed by the Marine Mammal Observer in the safety zone:
    a. a marine mammal or sea turtle listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*; or
    b. based on the considerations set out in sub-section 4(b), any other marine mammal or sea turtle that has been identified in an environmental assessment process as a species for which there could be significant adverse effects.

Line Changes and Maintenance Shut-downs

Mitigation Measures

9. When seismic surveying (data collection) ceases during line changes, for maintenance or for other operational reasons, the air source array(s) must be:
    a. shut down completely; or
    b. reduced to a single source element.

10. If the air source array(s) is reduced to a single source element as per subsection 9(b), then:
    a. visual monitoring of the safety zone as set out in section 6 and shut-down requirements as set out in section 8 must be maintained; but
    b. ramp-up procedures as set out in section 7 will not be required when seismic surveying resumes.

Operations in Low Visibility

Mitigation Measures

11. Under the conditions set out in this section, cetacean detection technology, such as Passive Acoustic Monitoring, must be used prior to ramp-up for the same time period as for visual monitoring set out in section 6. Those conditions are as follows:
    a. the full extent of the safety zone is not visible; and
    b. the seismic survey is in an area that
        i. has been identified as critical habitat for a vocalizing cetacean listed as endangered or threatened on Schedule 1 of the *Species at Risk Act*, or
        ii. in keeping with the considerations set out in sub-section 4(b), has been identified through an environmental assessment process as an area where a vocalising cetacean is expected to be encountered if that vocalizing cetacean has been identified through the environmental assessment process as a species for which there could be significant adverse effects.

12. If Passive Acoustic Monitoring or similar cetacean detection technology is used in accordance with the provision of section 11, unless the species can be

identified by vocal signature or other recognition criteria:

a. all non-identified cetacean vocalizations must be assumed to be those of whales named in sections 8(a) or (b); and
b. unless it can be determined that the cetacean(s) is outside the safety zone, the ramp-up must not commence until non-identified cetacean vocalizations have not been detected for a period of at least 30 minutes.

Additional Mitigative Measures and Modifications

Mitigation Measures

13. Persons wishing to conduct seismic surveys in Canadian marine waters may be required to put in place additional or modified environmental mitigation measures, including modifications to the area of the safety zone and/or other measures as identified in the environmental assessment of the project to address:
    a. the potential for chronic or cumulative adverse environmental effects of
        i. multiple air source arrays (e.g., two vessels on one project; multiple projects), or
        ii. seismic surveys being carried out in combination with other activities adverse to marine environmental quality in the area affected by the proposed program or programs;
    b. variations in sound propagation levels within the water column, including factors such as seabed, geomorphologic, and oceanographic characteristics that affect sound propagation;
    c. sound levels from air source array(s) that are significantly lower or higher than average; and
    d. species identified in an environmental assessment process for which there is concern, including those described in sub-section 4b).

14. Variations to some or all of the measures set out in this Statement may be allowed provided the alternate mitigation or precautionary measures will achieve an equivalent or greater level of environmental protection to address the matters outlined in sections 6 through 13 inclusive. Where alternative methods or technologies are proposed, they should be evaluated as part of the environmental assessment of the project.

15. Where a single source element is used and the ramping up from an individual air source element to multiple elements is not applicable, the sound should still be introduced gradually whenever technically feasible.

Appendix B

Meeting Notes

To Support the

Environmental Assessment

Of

An Offshore Seismic Project

Baffin Bay Area 2011

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Table of Contents

1. Introduction

RPS Energy on behalf of Multi Klient Invest filed with the National Energy Board a Project Description for the potential 2D Seismic Survey offshore Baffin Bay within their jurisdiction.

NEB has issued a Section 5 Federal Coordination Notification (FCN) for the proposed TGS/PGS Northeastern 2D offshore seismic program in the Baffin Bay/Davis Strait area (MKI the operator an association of PGS). Federal coordination was initiated for this project in the spring of 2010, however the project was suspended until 2011 and the project area has since expanded.

They have request that stakeholders kindly respond to this Notification by 10 February 2011.

The following documents were attached.
- a Letter of Federal Coordination Notification
- a Response Form
- a Project Description received by the NEB for the project

A public registry for this was posted on the NEB website and an opportunity for public comment on the draft scope and draft environmental screening report will be provided when available.

RPS Energy is engaged by MKI to carry out the consultation program in support of the Environmental Assessment for the proposed Seismic Project to be conducted offshore Baffin Bay in 2011.

The consultation was planned to facilitate the consideration of stakeholders regarding public issues and concerns that are relevant to the overall project and that will need to be specifically addressed in the environmental assessment report.

These consults have enabled a much better understanding on the relationship between the peoples, land, sea, and wildlife. Safeguarding wildlife and habitats through the food chain was emphasised at the Qikiqtarjuaq meeting.

The consultations conducted as part of this study were the first in the field of marine seismic 2008, and again in 2011, as such there were many questions about how the survey was to be performed, why it being done, what were the potential impacts, and what were the safeguards. Some of the feedback which came early in the consults was how appreciative the communities were to receiving this knowledge in light of the fact that work has been performed in the past without similar consultations taking place.

Thus, from the standpoint of opening up lines of communication there was no substitute for these in-person presentations. In particular, the HTO's were very welcoming and provided facilities and their own time

The mitigation measures proposed for this survey, which follow the Statement of Canadian Practice on the Mitigation of Seismic Noise in the Marine Environment, will ensure that any potential interaction is kept to a minimum. As this survey is a single event and the lines are widely spaced, it is highly unlikely that any measurably impact will occur during the survey considering the mitigation methods adopted.

The proposed program is an exploration survey only, designed to map the sub-sea geology, and is a first step in the exploration cycle. The issues pertaining to drilling and development were not considered here, as they represent separate processes which would occur many years in the future, if at all.

An appreciation of the traditional knowledge was obtained by consulting two major studies: *The Nunavut Wildlife Harvest Study* (Nunavut Wildlife Management Board, August 2004), and the *Final Report of the Inuit Bowhead Knowledge Study* (Nunavut Wildlife Management Board, March 2000). And this knowledge was shared in the meetings.

2. Federal/Provincial Meetings

2.1 Nunavut Department of Development and Transportation

Date & Time of the meeting	Monday Jan. 10th, 2011 10:00 - 12:00 a.m. Tuesday Jan. 11th, 2011 2:00-3:00 Separate discussions on PAM with Dave Hedgeland-PGS.
Location	Iqualuit
Organization	Nunavut Department of Development and Transportation
Proponent Speaker	Tony LaPierre / Darlene Davis-RPS Energy PGS – Dave Hedgeland – Environmental Manager
Proponent Translator	None
Personnel	Peter Frampton Senior Petroleum Advisor Eric Prosh Director Minerals & Petroleum Resources Diane LaPierre Mgr, Environmental Assessments & Reg Janelle Kennedy BSc.Envs., MMM-Environment (Sr. Advisor, Aquatic Science, Fisheries and Sealing)
Advertisement for the meeting:	Direct e-mail contact / Telephone
Delivery of the meeting	PowerPoint Presentation
Duration of the meeting	2 hour
Issues /Concerns Expressed: - Support the program - Shared knowledge and discussion on how to consult with the communities - PAM (Passive Accoustic Monitoring) discussion on the possibility of using this and benefits of using this for the program - Source Discussion - Lancaster sound (Exact Area) discussion on this program in relation to NRCan survey in 2010	
Methods of Addressing Concerns: - Discussion and follow-up correspondence - Community Meetings	
Significance of impact	Not significant
Recommendations: -Very supportive of the Program -Observer should come from the communities -Photos (graphics) are great for community meetings -Animation of “Statement of Practice” -Translate as much as possible -Bring hard copies of the maps to leave with communities -“Don’t deny that Seismic can lead to development”	
Feedback / Future meeting	Separate presentation in the afternoon at 2:00 pm with Dave Hedgeland (PGS Environmental Mgr) as he couldn’t be in the a.m. meeting, late flight arrival. February 21st-Met with Diane LaPierre to discuss the facilitation of Pubic meetings in the communities and share information.

2.2 Department of Indian and Northern Affairs (INAC)

<table>
<tr><td>Date & Time of the meeting</td><td>Monday, January 11th, 2011
2:00-4:00 pm</td></tr>
<tr><td>Location</td><td>Iqualuit</td></tr>
<tr><td>Organization</td><td>Department of Indian and Northern Affairs</td></tr>
<tr><td>Proponent Speaker</td><td>Tony LaPierre / Darlene Davis –RPS Energy
Dave Hedgeland-PGS Environmental Manager</td></tr>
<tr><td>Proponent Translator</td><td>None</td></tr>
<tr><td>Personnel</td><td>Robynn Gillis Petroleum Advisor
Bernie McIsaac Director Operations Nunavut Regional
Karen Costello Mgr.Minerals Resources
Linda Ham Nunavut Development Corporation
Resource Development Advisor
(Telephone Conference)
Derek Moggy –Habitat Team Leader, Eastern Arctic -DFO
Gilles Norell-Oil & Gas INAC</td></tr>
<tr><td>Advertisement for the meeting</td><td>Direct e-mail contact/Telephone</td></tr>
<tr><td>Delivery of the meeting</td><td>PowerPoint Presentation</td></tr>
<tr><td>Duration of the meeting</td><td>2 hrs</td></tr>
<tr><td colspan="2">Issues /Concerns Expressed:
-Support to build a presentation for the communities and conversation on concerns
-Concerns: LanCaster Sounds, Seismic in the 70’s
-Need to build trust in the communities, need for several meetings in communities
-Robyn – Will participate in assisting to build information for the communities and travel with Darlene Davis & Tony LaPierre
-Bernie McIssac expressed that there is a huge concern in the communities on “Impacts of Wildlife”, migration as it is their livelihood.
-Discussions on Air Gun Sound;
-Gilles brought up the possibility to clearly graphically displace the attenuation of sound away from the source, what it means? Modeling diagrams have been created to explain this clearly and can be found within the EA. (Figure 4 & 5).
-Discussion on Passive Accoustic Monitoring, will it be used?
-Benefits plan for the northern communities / -People want to be part of the planning</td></tr>
<tr><td colspan="2">Methods of Addressing Concerns:
- Prepare the proposed benefits plan by the operator in consultation with aboriginals and northern communities in the vicinity of the proposed exploration (i.e. coastal communities)
- Look into further the possibility of using Passive Accoustic Monitoring</td></tr>
<tr><td>Significance of impact</td><td>Not significant</td></tr>
<tr><td colspan="2">Recommendations
- Advised consulting with northern communities; also to use diagrams while explaining issues while avoiding graphs and technical language
- Explain how low the sound from the seismic is and the response of marine mammals
- Adhere to the requirement of the Northern Benefits Requirements for New Exploration Programs
- More than one visit to the communities
- Passive Accoustic Monitoring should be a mitigation if possible
- Marine Mammal Observers from the communities
-</td></tr>
</table>

Feedback / Future meeting	**Darlene Davis met with Robynn Jan 11th** – afternoon for further discussion. Robynn will travel to community meetings (mid Feb). **April 4, 2011 Spoke with George McCormick and Ursela Beddoes (**INAC) who travelled last week to the communities to talk with them about the possibility of opening lease blocks. They felt the overall of their meetings was positive. That Inuit were not opposed to Exploration buy in turn don't want Harvesting affected and have concerns about spills and commercial fishery. In our consultation work, we continue to explain "The Canadian Statement of Practice and the role of the Marine Mammal Observer and Fisheries Liaison Officer onboard the vessel

2.3 Consultation with Nunavut Development Corporation

Date & Time of the meeting	Jan 10th, 2011
Location	Office of INAC
Organization	Nunavut Development Corporation
Proponent Speaker	Tony LaPierre
Proponent Translator	None
Personnel	Linda Ham
Advertisement for the meeting	Direct e-mail contact / Linda Ham came to the meeting in the Boardroom of INAC
Delivery of the meeting	Presentation given using MS PowerPoint for 1 hour.
Duration of the meeting	2.0 hours
Issues /Concerns Expressed: Participated in the conversations as above -	
Methods of Addressing Concerns: - Complete consultations prior to the survey start - Involve community members as fisheries representatives or environment observer roles on the project	
Significance of impact	Not significant
Recommendations - Complete consultations with coastal communities	
Feedback / Future meeting	Progress feedback to be sent during and after the survey

2.4 Derrick Moggy –Habitat Team Leader, Eastern Arctic Area -DFO

Date & Time of the meeting	Wednesday January 12th, 2011 Noon – 1:00 pm
Location	Iqualuit-DFO Tumit Plaza
Organization	Department Fisheries & Oceans
Proponent Speaker	Tony LaPierre RPS Energy Dave Hedgeland PGS Environmental Mgr
Proponent Translator	None
Personnel	Derrick Moggy-Habitat Leader Eastern Arctic Area DFO
Advertisement for the meeting	Direct e-mail derrick.moggy@dfo-mpo.gc.ca Telephone (705) 522-9909 Cell: (705) 919.6255
Delivery of the meeting	Powerpoint
Duration of the meeting	1 Hr
Issues /Concerns Expressed: Tony LaPierre and Dave Hedgeland met in-person with Derrick Moggy for further discussions on the project. -	
Methods of Addressing Concerns: Consultation in the communities Mitigation Measures Observers from the communities -	
Significance of impact	Not significant
Recommendations -	
Feedback / Future meeting	

2.5 Consultation with Baffin Fisheries Coalition

Date & Time of the meeting	Tuesday January 11th 2:00pm.
Location	Iqualuit
Organization	Baffin Fisheries Coalition
Proponent Speaker	Darlene Davis
Proponent Translator	None
Personnel	Jerry Ward
Advertisement for the meeting	Direct e-mail contact / Telephone
Delivery of the meeting	Meeting cancelled.
Duration of the meeting	
Issues /Concerns Expressed: Jerry was unable to be in Iqaluit at this time as he travels back and forth to Newfoundland. Tried to re-schedule and Jerry would be in Halifax on March 30th, schedules did not allow. Darlene to try to facilitate a meeting with Jerry when back in Newfoundland if possible. -	
Methods of Addressing Concerns: -	
Significance of impact	Not significant
Recommendations -	
Feedback / Future meeting	Will be advised of Public Meeting

2.6 Consultation with Nunavut Wildlife Management Board

Date & Time of the meeting	November 30, 2011
Location	Iqaluit
Organization	Nunavut Wildlife Management Board
Proponent Speaker	Tony LaPierre / Darlene Davis
Proponent Translator	None
Personnel	Robert Kidd-Director of Wildlife Management
Advertisement for the meeting	Direct e-mail contact /Telephone
Delivery of the meeting	
Duration of the meeting	
Issues /Concerns Expressed: In order to meet with NWMB you must send a letter in both languages and ask permission to make a presentation. There next scheduled meeting is in March 2011. -	
Methods of Addressing Concerns: RPS Energy will be returning to Iqaluit first week in May for a public meeting. The meeting will be posted and on the radio. This will give members of NWMB and opportunity to attend if they want information on the project. Due to election meeting in Iqaluit is to be re-scheduled. This will be a public meeting. -	
Significance of impact	Not significant
Recommendations -	
Feedback / Future meeting	Public Meeting

2.7 Consultation with Nunavut Research Institution

Date & Time of the meeting	Tuesday, January 11th 10:00 a.m.
Location	Iqualuit-Frobisher Inn
Organization	Nunavut Research Institution
Proponent Speaker	Tony LaPierre/Darlene Davis/Dave Hedgeland
Proponent Translator	None
Personnel	Mary Ellen Thomas Senior Research Officer
Advertisement for the meeting	Direct e-mail contact
Delivery of the meeting	Brief ½ hour meeting in her office.
Duration of the meeting	.30 hours

Issues /Concerns Expressed:

- Review the need for Fisheries Liaison Officers and Environmental Observers for the seismic program
- Two year Environmental tech program
- 15 first year students, 10 second year
- Don't see a lot of support from the communities
- Bowhead hunt in Iqaluit area will bring discussions
- Lancaster Sound, makes "Seismic a Dangerous word in Baffin"
- Don't expect a positive reaction in communities
- Pond Inlet the only community with an Environmental Program
-

Methods of Addressing Concerns:

- Candidates with offshore safety training and with data collection ability would be good for the MMO role
- Six candidates recently completed the Fisheries Observer program
- Their primary role, onboard fishing vessels, is monitoring catches and observations on marine mammals
- Recommended a translator though Simone (phone: 867-473-2653) for community visits

Significance of impact	Not significant

Recommendations

-Public meeting will be held (Appendix A)
-Two Marine Mammal and one Fisheries Liaison Officer will be onboard at all times
-Canadian Statement of Practice to be followed

Feedback / Future meeting	Public Meeting in Iqaluit May 1, 2011 Re-scheduled end May, early June 2011.

2.8 Consultation with Qikiqtani Inuit Association (QIA)

Date & Time of the meeting	January 11th, 2011 10:00 am -12:00 noon
Location	Iqaluit
Organization	Qikiqtani Inuit Association
Proponent Speaker	Tony LaPierre
Proponent Translator	None
Personnel	Okalik Eegeesiak — President Sal Shoo — Director of Lands Matthew Akavak — Lands Officer Evie Eegeesiak — Implementation Co-ordinator Joanasie Akumalik — CLO co-ordinator Nigel Qaumariaq — Env. & Regulary Affairs Advisor
Advertisement for meeting	Direct e-mail contact/Telephone
Delivery of the meeting	PowerPoint Presentation
Duration of the meeting	2 hours
Issues /Concerns Expressed: -Time of year for the project -Mitigation Measures -Community Meetings, how much time we are willing to devote? -Passive Accoustic Monitoring (PAM)? -Possibility of Nigel/president attending the community meetings -details on the vessel -Supply vessel, remaining after the survey to monitor the area for several days after -Marine Mammal Observer training, candidates from the communities -Add Artic Bay to consultation list of another communities to consult -If the communities are not happy the program will not proceed -Science says the mammals leave the area, how do you know they are gone? -	
Methods of Addressing Concerns: -Discussions -Follow /up conference call on Jan. 17/2011 at 3:00 pm Atlantic Time. (QIA advises they do not have time/resources to support the project in 2010, but they advise they would in 2011. -Attendees: Darlene Davis, Dave Hedgeland (TGS Nopec), Tony LaPierre -Nigel invited to attend community meeting in Pond Inlet. -Nigel sent his community Liaison officer to community meeting in Clyde River -	
Significance of impact	Significant
Recommendations -Passive Accoustic Monitoring -Supply vessel remain to observe after the program -Marine Mammal Observers from the communities -Several meetings with the communities, listen to their concerns and make them feel they are being asked and participating in the program -Consult information for the communities pictures and as much translated documentation as possible should be with you	
Feedback / Future meeting	Conf. Call Jan 17th at 3 pm Atlantic for further discussions. Attend Meeting Pond Inlet February 16th, 2011, Meeting Feb. 18th – Iqaluit (Nigel cancelled), Meeting Feb. 21st – Iqaluit (cancelled), Conf. call March 17th, advice on Public Meeting.

2.9 Consultation with Nunavut Tunngavik Inc.

Date & Time of the meeting	Contacted via email Nov 29th, 2011
Location	Iqaluit
Organization	Nunavat Tunngavik Inc
Proponent Speaker	Darlene Davis
Proponent Translator	None
Personnel	Jeffrey Maurice, Inuit Rights Fisheries Advisor (phone: 867-975-4734)
Advertisement for the meeting	Direct e-mail contact /telephone
Delivery of the meeting	N/A
Duration of the meeting	N//a
Issues /Concerns Expressed: - Consultation with the communities - Sent consultation note from previous project in 2008 for review	
Methods of Addressing Concerns: -	
Significance of impact	Not significant
Recommendations -	
Feedback / Future meeting	None/ Public Meeting will be advertised.

2.10 Nunavut Planning Commission

Date & Time Contact *Via Email*	January 19th, 2011
Location	Via Email
Organization	Nunavut Planning Commission (NPC)
Contact Initiated by	Darlene Davis, Marine Project Coordinator
Delivery	Full Project Description Summary on Meetings in Iqaluit & Planned HTO Meetings
Issues /Concerns Expressed: Good morning Darlene; Email is to confirm that the above noted/attached proposal falls outside the boundaries of the North Baffin Regional Land Use Plan. Therefore no conformity review with the approved plan is required. Any questions concerns, please do not hesitate. Brian Aglukark, NPC Arviat -	
Methods of Addressing Concerns: - Via Email sent Project Description.	
Significance of impact	Not significant
Recommendations Not within their Jurisdiction	

2.11 Parks Canada

Date & Time Contact Via Email	January 17th, 2011
Location	Via Email
Organization	Parks Canada Doug Yurick Chief Marine Program Coordinator
Contact Initiated by	Darlene Davis, Marine Project Coordinator
Delivery	Full Project Description
Issues /Concerns Expressed: Email from Doug Yurick: *I understand that you are aware of the controversy generated last year by the proposed Canada - Germany Eastern Canadian Arctic Seismic Experiment in the Baffin Bay - Lancaster Sound region.* *As you likely know, several ministers of the Government of Canada announced jointly, on December 6, 2010, the federal position regarding the boundary of the proposed NMCA. I am attaching the press release of that date, and the mapped boundary. My understanding from the petroleum regulatory affairs group in Indian and Northern Affairs Canada is that the project you are contemplating is entirely beyond the limits of territorial sea ofCanada. Nowhere does the eastern limit of the presently proposed NMCA boundary extend beyond the territorial sea.* *Please contact me directly at Parks Canada should you require additional information about the NMCA.* *Best wishes,* -	
Methods of Addressing Concerns: Via Fisheries and Oceans Canada to obtain a map indicting the limits of the proposed national marine conservation area (NMCA) in Lancaster Sound.	
Significance of impact	Not significant
Recommendations	

2.12 World Wildlife Federation (Peter Ewan)

Date & Time Contact *Via Email*	January 19th, 2011 Peter Ewans, D. Phil Senior Officer, Species
Location	Via Email
Organization	WWF
Contact Initiated by	Darlene Davis, Marine Project Coordinator
Delivery	Full Project Description via email

Issues /Concerns Expressed:
Email Response Peter Ewan:
many thanks Darlene. I will consult with some key colleagues on this one, especially in light of the current NEB offshore review underway, and now that the US Gulf incident report is out. Hope to get back to you soon.

best wishes

Pete

-

Methods of Addressing Concerns

NEB has placed the project description for Federal Coordination along with opportunity for public comment.
See Email:
Please find attached a Section 5 Federal Coordination Notification (FCN) for the proposed TGS/PGS Northeastern 2D offshore seismic program in the Baffin Bay/Davis Strait area. Federal coordination was initiated for this project in the spring of 2010, however the project was suspended until 2011 and the project area has since expanded.

I am requesting that you kindly respond to this Notification by 10 February 2011.

Attached are the following documents:
- a Letter of Federal Coordination Notification
- a Response Form
- a Project Description received by the NEB for the project

A public registry for this file will be posted on the NEB website shortly, and an opportunity for public comment on the draft scope and draft environmental screening report will be provided when available. Should anyone included in this notification be addressed incorrectly, or should you have any questions, please do not hesitate to contact me at the address below.

Significance of impact	Not significant

Recommendations

-

3. Communities Meetings

3.1 Consultation with Baffin HTO's (Clyde River)

Date & Time of the meeting	February 14th, Monday 7:00pm-10:00 pm
Location	Office of HTO
Organization	Baffin HTO, Clyde River Email: cedo@clyderiver.ca (Billy) Rebecca HTO Manager htoclyde@qiniq.com 867-924-6202
Proponent Speaker	Tony LaPierre Geologist Darlene Davis – Project Manager
Proponent Translator	
Personnel	HTO Manager - Rebecca Lizzy Palituq – Community Liason Officer Jayko Asheuak – Chariman Anasic Audlakiak – Vice Chairman Leah Arreak – Secretary Treasurer Tommy Kumiliusie - Director Joanasic Apak – Director Jaycopic Iqaukjuak – Director Jayko Apak (member) Deckhand Certificate INAC – Robynn Aberney Gillis
Advertisement for the meeting	Direct e-mail contact
Delivery of the meeting	Presentation given using MS PowerPoint during Meeting
Duration of the meeting	7:00 pm-9:45 pm

Issues /Concerns Expressed:
- Opportunities for local persons on the project
- How much company is looking at benefiting Clyde River?
- In the past surveyors don't give benefit to the community
- Mine further North – Is not giving them opportunities?
- Concerned that they have no birth certificates or passports, and how this will effect the ability for someone to ride onboard the vessel to be involved in project
- Wanted to know if we have approval (NEB)?
- Want to have a public meeting, $100 hour to rent community centre, give door prized to get people to attend or they won't come out, they suggest 45 gal of fuel and 45 gal of heating oil, cash prize
- HTO will set up public meeting for April 1st or 2nd and communicate with Darlene Davis on details
- Overall very concerned about Marine Mammals./harvesting/Migration and effects from seismic activity

Methods of Addressing Concerns:
- Conduct public meeting
- Keep them informed
- Notify them when the vessel starts work and is in the area
- Select MMO from their community
- Look into Transport Canada would they need passport to ride vessel in Canada
- Involve community members as fisheries representatives or environment observer roles on the project

While in Clyde River, Tony LaPierre (Geologist) taught two classes in Geology to grade 10

students and told then about the project.	
Significance of impact	Not significant
Recommendations -	
Feedback / Future meeting	Public Meeting April 1st or 2nd, follow up meeting Provide copies of Marine Mammal reports after survey. -RPS follow-up with an email upon return, no meeting was set up by HTO, RPS has proceeded to schedule meetings via meeting notice for return visits Appendix A. Due to negative feedback from HTO Manager Clyde river, the meeting is being re-scheduled due to election week.

3.2 Consultation with Baffin HTO's (Pond Inlet)

Date & Time of the meeting	February 16th (Wednesday) 2011 1:00 pm
Location	Office of HTO
Organization	Baffin HTO, Pond Inlet
Proponent Speaker	Tony LaPierre – Geologist / Project Darlene Davis – Project Manager
Proponent Translator	
Personnel	James – Acting Vice Chairman Charmin and Vice Chairmen out of town to another meeting QIA-Nigel Qaumariaq INAC-Robyn Aberney Gillis
Advertisement for the meeting	Direct e-mail contact
Delivery of the meeting	Presentation given using MS PowerPoint for 1 hour.
Duration of the meeting	1.5 hours
Issues /Concerns Expressed: - Ships spilling into the water, happened last year? - Will it bother the whales? - Narwhales start migrating June – August ? - Ice is always going through this area - Very concerned about are whales and sensitive about are food supply - While we are here, we are protective of our animals and are way of life - How loud is the sound? - Will you have a public meeting? - Concerned about the Narwhales - Are you coming back? - QIA (Nigel attended meeting) advised he would be back for Public meeting - QIA advised possible two other projects, he would return to speak about this - Robyn – INAC would return to speak to them about their opinions on opening up lease blocks?	
Methods of Addressing Concerns: - This marine wildlife area extends from the coast to 12 nautical miles, however as the survey area does not commence until the 12 nautical mile limit, the project area does not encroach into this area. - Involve community members as fisheries representatives or environment observer roles on the project - Conduct Public Meeting	
Significance of impact	Not significant
Recommendations -	
Feedback / Future meeting	Public Meeting, as per Appendix A. Meeting re-scheduled due to election.

3.3 Consultation with Baffin HTO's (Qikiqtarjuaq)

<table>
<tr><td>Date & Time of the meeting</td><td>February 17th (Thursday) 2011-02-20
7:00 pm – 9:30 pm</td></tr>
<tr><td>Location</td><td>Office of HTO</td></tr>
<tr><td>Organization</td><td>Baffin HTO, Qikiqtarjuaq</td></tr>
<tr><td>Proponent Speaker</td><td>Darlene Davis – Project Manager</td></tr>
<tr><td>Proponent Translator</td><td></td></tr>
<tr><td>Personnel</td><td>HTO Manager – Harry Alookie
Samuel Nuqingaq – Secretary-Treasurer
Board Members
Robyn Aberthy Gillis - INAC</td></tr>
<tr><td>Advertisement for the meeting</td><td>Direct e-mail contact</td></tr>
<tr><td>Delivery of the meeting</td><td>Presentation given using MS PowerPoint during meeting.
Minutes of the meeting were kept by the General Secretary.</td></tr>
<tr><td>Duration of the meeting</td><td>2.5 hrs</td></tr>
<tr><td colspan="2">Issues /Concerns Expressed:
- Harvesting activities are very important, very concerned about the whales and their way of life;
- They know that seismic will hurt the whales, they will be dead and not float to the surface for three months because they are heavy
- Concerned about sedimentary areas for the turbot fish live their
- Concerned about Corel zone and how airguns will affect this?
- Concerned about Trophy Week, fishing trip they make to take people to catch a whale in Baffin Bay in July August time, they make $2500 per trip, Will this affect them catching whales?
- Will you get approval whether we agree or not?
- Do you have permission?
- We want to be informed
- We will work with you
- Government doesn't listen to us
- Will you do a public meeting
- What did the other communities think of this project? We are certain they would not agree
-</td></tr>
<tr><td colspan="2">Methods of Addressing Concerns:
- Hold a public meeting
- Deal with HTO Manager to share information and keep them informed
- Stay in contact
- Share information via email</td></tr>
<tr><td>Significance of impact</td><td>Not significant</td></tr>
<tr><td colspan="2">Recommendations
-</td></tr>
<tr><td>Feedback / Future meeting</td><td>Public Meeting as per Appendix A.
Meeting being re-scheduled due to election.</td></tr>
</table>

3.4 Consultation with Baffin HTO's (Iqaluit)

<table>
<tr><td>Date & Time of the meeting</td><td>February 21st, 2011 (Monday)
4:00-4:30 pm</td></tr>
<tr><td>Location</td><td>Office of HTO
Jose – HTO Manager amrok@qiniq.com
Phone: 867-979-3066</td></tr>
<tr><td>Organization</td><td>Iqaluit HTO Chairman</td></tr>
<tr><td>Proponent Speaker</td><td>Darlene Davis Project Manager</td></tr>
<tr><td>Proponent Translator</td><td>Not necessary</td></tr>
<tr><td>Personnel</td><td>David Alexander
Baffin Fisheries Coalition Manager
Chairman for HTO</td></tr>
<tr><td>Advertisement for the meeting</td><td>Contacted while in Iqaluit to set up a short meeting to introduce myself and RPS Energy role in the permit process.</td></tr>
<tr><td>Delivery of the meeting</td><td>Conversation.</td></tr>
<tr><td>Duration of the meeting</td><td>30 min</td></tr>
<tr><td colspan="2">Issues /Concerns Expressed:
- Introduced myself, told him about the proposed program offshore Baffin Bay.
- Asked him to set up a meeting with HTO members and public meeting for a return visit end of March 2011-02-21
- He expressed if we want their approval they would need support letters from other communities, supporting the project
- Expressed he is concerned with commercial fisheries as he works with
- Baffin Fisheries Coalition
- Left him a copy of the program
- Left him a copy of the Canadian Statement of Practice both in English and Inuktitut</td></tr>
<tr><td colspan="2">Methods of Addressing Concerns:
- Left him a copy of Canadian Statement of Practice both in English and Inuktitut
- Will send follow up information via email
- Will hold a public meeting, and meeting with all HTO and follow up meeting when they have been completed to address additional questions
-</td></tr>
<tr><td>Significance of impact</td><td>Not significant</td></tr>
<tr><td colspan="2">Recommendations
- Share information about the proposed project, and have representatives from the communities onboard as environmental observers</td></tr>
<tr><td>Feedback / Future meeting</td><td>Public meeting as per Appendix A.
Meeting will be re-scheduled due to election week.</td></tr>
</table>

3.5 Consultation with Baffin HTO's (Pangnirtung)

Date & Time of the meeting	No Meeting
Location	
Organization	Baffin HTO, Pangnirtung
Proponent Speaker	Darlene Davis
Proponent Translator	
Personnel	
Advertisement for the meeting	Direct e-mail contact Contracted Eric Joamie from Pang to set up meeting.
Delivery of the meeting	
Duration of the meeting	
-We were unable to get a scheduled meeting unfortunately in Pang on this visit. They were in the process of changing HTO managers and this meeting did not come together. -Upon arrival for the other communities, the contracted translator (Eric Joamie) did not show. This made the task much more difficult in each community. -March 3th – Eric Joamie advised he had worked with council and mentioned the matter to the new HTO Manager. (Jackie Maniapik new HTO Manager) -March 7th – HTO board to hold meeting -March 8th – Provide Jacki with information (Project Description sent via email) -March 10th – Advised best dates for meeting approximately April 3 or 4th -April 7th – Sent RPS schedule for meetings in communities to include Pang in both languages.	
Significance of impact	Not significant
Recommendations : Include Pang in the public meeting notice (Appendix A). -	
Feedback / Future meeting	Public meeting being re-scheduled due to the election week.

4. Baffin Bay Public Meetings

Upon completion of the initial meetings with Hunters and Trappers Associations in the communities, it was apparent that a need for public meetings would be adhered to.

Upon completion of the in-person meetings with the HTO groups it was understood that HTO Managers would set up public meetings by communicating and working together to do so. Unfortunately time did not allow for this to come together.

In a conference call meeting with QIA on March 17, 2011 it was recommended that RPS Energy take the following steps to set-up public meetings:

- Select Dates Translate
- Send to SAO of Hamlet
- Advertise on the Radio
- Rent meeting Hall

A copy of the meeting notice can be located in Appendix A.

The meetings have been re-scheduled, due to negative feedback based on the timing being election week. RPS is making efforts currently to make arrangements to re-schedule and get notices out to the communities for tentatively late May, early June 2011.

Appendix A.

A representative of RPS Energy of Behalf of Multi Klient Invest (MKI) will be in your community on the following dates for Public Meeting to share information on a potential 2D Seismic Survey offshore Baffin Bay for the 2011 season.

Community	Date	Location	Time
I			
Iqaluit	May 1/11	Frobisher Inn	7:00 pm
Clyde River	May 2/11	Community Centre	7:00 pm
Pond Inlet	May 3/11	Community Centre	7:00 pm
Quik	May 4/11	Community Centre	7:00 pm
Pangnirtung	May 5/11	Community Centre	2:00 pm

Please listen to your local Radio Station for further updates or you may contact:

Darlene Davis
1545 Birmingham Street
Halifax, Nova Scotia, B3J 2J6
Tel: (902) 492-0281
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Appendix C

Natural Resources Canada, Geological Survey of Canada, Geoscience Data Repository, BASIN Database
Date: April 27, 2011, 10:01 am EDT

Project	Company	Year	Area
BB09	TGS-NOPEC	2009	BAFFIN BAY/DAVIS STRAIT/W GREENLAND SHELF
ULAM09	TGS-NOPEC	2009	DAVIS STRAIT/LABRADOR SEA/W GREENLAND SHELF
5552841	TGS-NOPEC	2008	BAFFIN BAY/DAVIS STRAIT
5554046	HUSKY OIL	2008	DAVIS STRAIT/W GREENLAND SHELF
5554118	ENCANA	2008	DAVIS STRAIT
BB08	TGS-NOPEC	2008	BAFFIN BAY/DAVIS STRAIT/W GREENLAND SHELF
ULAM08	TGS-NOPEC	2008	DAVIS STRAIT/LABRADOR SEA/W GREENLAND SHELF
BLF03	TGS-NOPEC	2003	DAVIS STRAIT/W GREENLAND SHELF
FBSE03	TGS-NOPEC	2003	DAVIS STRAIT/W GREENLAND SHELF
GREEN03	TGS-NOPEC	2003	DAVIS STRAIT/W GREENLAND SHELF
KW03	TGS-NOPEC	2003	DAVIS STRAIT/W GREENLAND SHELF
9724-T063	TGS-NOPEC	2002	DAVIS STRAIT
9724-T063	TGS-NOPEC	2002	DAVIS STRAIT
DW02	TGS-NOPEC	2002	DAVIS STRAIT/W GREENLAND SHELF
GRC02	TGS-NOPEC	2002	DAVIS STRAIT/W GREENLAND SHELF
GREEN02	TGS-NOPEC	2002	DAVIS STRAIT/W GREENLAND SHELF
9724-T063	TGS-NOPEC	2001	DAVIS STRAIT
9728-C138	CANNAT RESOURC	2001	DAVIS STRAIT
GRC01	TGS-NOPEC	2001	DAVIS STRAIT/W GREENLAND SHELF
GREEN01	TGS-NOPEC	2001	DAVIS STRAIT/W GREENLAND SHELF
9724-P055	PHILLIPS/TGS-NOP	2000	DAVIS STRAIT
GEUS 200	GEUS	2000	DAVIS STRAIT/W GREENLAND SHELF
GREEN00	TGS-NOPEC	2000	DAVIS STRAIT/W GREENLAND SHELF
KR00	TGS-NOPEC	2000	DAVIS STRAIT/W GREENLAND SHELF
NUNAOIL 2	NUNAOIL	2000	DAVIS STRAIT/W GREENLAND SHELF
SW00	TGS-NOPEC	2000	DAVIS STRAIT/W GREENLAND SHELF
GREEN99	TGS-NOPEC	1999	DAVIS STRAIT/W GREENLAND SHELF
FUGRO-G	FUGRO-GEOTEAM	1998	DAVIS STRAIT/W GREENLAND SHELF
NUNAOIL	NUNAOIL	1998	DAVIS STRAIT/W GREENLAND SHELF
NUNAOIL	NUNAOIL	1998	DAVIS STRAIT/W GREENLAND SHELF
NUNAOIL	NUNAOIL	1998	DAVIS STRAIT/W GREENLAND SHELF
NUNAOIL	NUNAOIL	1997	DAVIS STRAIT/W GREENLAND SHELF
NUNAOIL	NUNAOIL	1997	DAVIS STRAIT/W GREENLAND SHELF
GEUS	GEUS	1995	DAVIS STRAIT/W GREENLAND SHELF
NUNAOIL	NUNAOIL	1994	DAVIS STRAIT/W GREENLAND SHELF
WESTERN	WESTERN GEOPHY	1990	DAVIS STRAIT/W GREENLAND SHELF
8624-G005	GSI	1982	E NFLD SHELF/LABRADOR SHELF/DAVIS STRAIT
8624-P028	PETRO-CANADA	1982	LABRADOR SHELF/DAVIS STRAIT
9720-C055	CANTERRA ENERG	1982	LABRADOR SHELF/DAVIS STRAIT
9726-C055	CANTERRA ENERG	1982	DAVIS STRAIT
673-09-12-	AQUITAINE	1981	DAVIS STRAIT/FROBISHER BAY
8624-P028	PETRO-CANADA	1981	LABRADOR SHELF/DAVIS STRAIT
8624-P028	PETRO-CANADA	1981	LABRADOR SHELF/DAVIS STRAIT
037-09-12-	SHELL CANADA	1980	DAVIS STRAIT
673-09-12-	AQUITAINE	1980	DAVIS STRAIT/CUMBERLAND SOUND
673-09-12-	AQUITAINE	1980	DAVIS STRAIT/BAFFIN BAY

8624-J001-	ESSO RESOURCES	1980	LABRADOR SHELF/DAVIS STRAIT
8624-P028	PETRO-CANADA	1980	LABRADOR SHELF/DAVIS STRAIT
8624-P028	PETRO-CANADA	1980	LABRADOR SHELF/DAVIS STRAIT
007-09-12-	ESSO RESOURCES	1979	DAVIS STRAIT/BAFFIN BAY
007-09-12-	ESSO RESOURCES	1979	DAVIS STRAIT
007-09-12-	ESSO RESOURCES	1979	DAVIS STRAIT
007-09-12-	ESSO RESOURCES	1979	DAVIS STRAIT/BAFFIN BAY
007-09-12-	ESSO RESOURCES	1979	DAVIS STRAIT/CUMBERLAND SOUND
246-09-12-	PETRO-CANADA	1979	DAVIS STRAIT/BAFFIN BAY
246-09-12-	PETRO-CANADA	1979	DAVIS STRAIT/BAFFIN BAY
673-09-12-	AQUITAINE	1979	DAVIS STRAIT/BAFFIN BAY
673-09-12-	AQUITAINE	1979	DAVIS STRAIT
673-09-12-	AQUITAINE	1979	DAVIS STRAIT
8620-J001-	ESSO RESOURCES	1979	FLEMISH PASS/LABRADOR SHELF/DAVIS STRAIT
037-09-12-	SHELL CANADA	1978	LABRADOR SEA/DAVIS STRAIT
246-09-12-	PETRO-CANADA	1978	DAVIS STRAIT/BAFFIN BAY/LANCASTER SOUND
246-09-12-	PETRO-CANADA	1978	DAVIS STRAIT/BAFFIN BAY
673-09-12-	AQUITAINE	1978	DAVIS STRAIT/FROBISHER BAY
8627-A011	AQUITAINE	1978	LABRADOR SHELF/DAVIS STRAIT
007-09-12-	ESSO RESOURCES	1977	DAVIS STRAIT/CUMBERLAND SOUND
039-09-12-	BRITISH PETROLEU	1977	LABRADOR SHELF/DAVIS STRAIT/CUMBERLAND SOUN
673-09-12-	AQUITAINE	1977	LABRADOR SHELF/DAVIS STRAIT/FROBISHER BAY
8620-A011	AQUITAINE	1977	LABRADOR SHELF/DAVIS STRAIT
BGR 1977	B.G.R.	1977	LABRADOR SHELF/LABRADOR SEA/DAVIS STRAIT/W G
007-09-12-	ESSO RESOURCES	1976	LABRADOR SHELF/DAVIS STRAIT
037-09-12-	SHELL CANADA	1976	DAVIS STRAIT
039-09-12-	BRITISH PETROLEU	1976	DAVIS STRAIT/CUMBERLAND SOUND
062-21-12-	CANADA CITIES SE	1976	DAVIS STRAIT
547-03-12-	AQUA-TERRA	1976	BAFFIN BAY/DAVIS STRAIT
673-09-12-	AQUITAINE	1976	LABRADOR SHELF/DAVIS STRAIT/CUMBERLAND SOUN
834-09-12-	RAM PETROLEUMS	1976	LABRADOR SHELF/DAVIS STRAIT/CUMBERLAND SOUN
8624-A011	AQUITAINE	1976	LABRADOR SHELF/DAVIS STRAIT
8627-T022	TRICENTROL OILS	1976	LABRADOR SHELF/DAVIS STRAIT
007-09-12-	ESSO RESOURCES	1975	DAVIS STRAIT
037-09-12-	SHELL CANADA	1975	DAVIS STRAIT
037-09-12-	SHELL CANADA	1975	DAVIS STRAIT
037-09-12-	SHELL CANADA	1975	DAVIS STRAIT
037-09-12-	SHELL CANADA	1975	DAVIS STRAIT
037-09-12-	SHELL CANADA	1975	DAVIS STRAIT
038-09-12-	HUDSONS BAY OIL	1975	DAVIS STRAIT
039-09-12-	BRITISH PETROLEU	1975	DAVIS STRAIT/CUMBERLAND SOUND
062-09-12-	CANADA CITIES SE	1975	DAVIS STRAIT
528-09-12-	EUREKA EXPLORA	1975	DAVIS STRAIT/BAFFIN BAY/LANCASTER SOUND
528-09-12-	EUREKA EXPLORA	1975	LABRADOR SHELF/DAVIS STRAIT/BAFFIN BAY
528-09-12-	EUREKA EXPLORA	1975	DAVIS STRAIT/BAFFIN BAY
673-09-12-	AQUITAINE	1975	LABRADOR SHELF/DAVIS STRAIT/FROBISHER BAY
8620-A011	AQUITAINE	1975	LABRADOR SHELF/DAVIS STRAIT
8620-J001-	IMPERIAL OIL	1975	SCOTIAN SHELF/SCOTIAN SLOPE/GRAND BANKS/FLEM
8620-P011	PACIFIC PETROLEU	1975	LABRADOR SHELF/DAVIS STRAIT
8624-A011	AQUITAINE	1975	LABRADOR SHELF/DAVIS STRAIT
8627-W002	WEST COAST PET	1975	LABRADOR SHELF/DAVIS STRAIT
8627-W006	WESTERN DECALT	1975	LABRADOR SHELF/DAVIS STRAIT

007-08-12-	ESSO RESOURCES	1974	LABRADOR SHELF/DAVIS STRAIT/CUMBERLAND SOUN
007-09-12-	ESSO RESOURCES	1974	LABRADOR SHELF/DAVIS STRAIT/CUMBERLAND SOUN
528-09-12-	EUREKA EXPLORA	1974	DAVIS STRAIT/BAFFIN BAY/HOME BAY
673-09-12-	AQUITAINE	1974	DAVIS STRAIT/CUMBERLAND SOUND/FROBISHER BAY
8620-J001-	IMPERIAL OIL	1974	E NFLD SHELF/LABRADOR SHELF/DAVIS STRAIT
002-09-12-	GULF CANADA	1973	DAVIS STRAIT/CUMBERLAND SOUND
007-09-12-	ESSO RESOURCES	1973	DAVIS STRAIT/CUMBERLAND SOUND
038-08-12-	HUDSONS BAY OIL	1973	DAVIS STRAIT
038-09-12-	HUDSONS BAY OIL	1973	DAVIS STRAIT
062-09-12-	CANADA CITIES SE	1973	LABRADOR SHELF/DAVIS STRAIT
528-09-12-	EUREKA EXPLORA	1973	DAVIS STRAIT/BAFFIN BAY
626-09-12-	CGG	1973	DAVIS STRAIT
626-09-12-	CGG	1973	LABRADOR SEA/DAVIS STRAIT/BAFFIN BAY
733-09-12-	GETTY OIL	1973	DAVIS STRAIT
838-09-12-	GSI	1973	LABRADOR SHELF/DAVIS STRAIT/BAFFIN BAY
8620-G005	GSI	1973	LABRADOR SHELF/DAVIS STRAIT
8620-J001-	IMPERIAL OIL	1973	SCOTIAN SHELF/SCOTIAN SLOPE/LAURENTIAN SUBBA
8627-A011	AQUITAINE	1973	LABRADOR SHELF/DAVIS STRAIT
8627-A011	AQUITAINE	1973	LABRADOR SHELF/DAVIS STRAIT
8627-M003	MOBIL OIL CANADA	1973	E NFLD SHELF/LABRADOR SHELF/DAVIS STRAIT
007-07-12-	ESSO RESOURCES	1972	DAVIS STRAIT/BAFFIN BAY
007-09-12-	ESSO RESOURCES	1972	DAVIS STRAIT/CUMBERLAND SOUND
039-07-12-	BRITISH PETROLEU	1972	DAVIS STRAIT/BAFFIN BAY
039-09-12-	BRITISH PETROLEU	1972	DAVIS STRAIT/CUMBERLAND SOUND
039-09-12-	BRITISH PETROLEU	1972	DAVIS STRAIT
062-09-12-	CANADA CITIES SE	1972	DAVIS STRAIT/BAFFIN BAY
528-09-12-	EUREKA EXPLORA	1972	DAVIS STRAIT/BAFFIN BAY/LANCASTER SOUND
733-09-12-	GETTY OIL	1972	DAVIS STRAIT/BAFFIN BAY
745-09-12-	PAN NORTHERN	1972	LABRADOR SEA/DAVIS STRAIT
8620-A011	AQUITAINE	1972	LABRADOR SHELF/DAVIS STRAIT
8620-J001-	IMPERIAL OIL	1972	SCOTIAN SHELF/SCOTIAN SLOPE/LAURENTIAN SUBBA
8624-E002	EASTCAN	1972	E NFLD SHELF/LABRADOR SHELF/DAVIS STRAIT
058-09-12-	TEXACO CANADA	1971	DAVIS STRAIT/FROBISHER BAY
062-09-12-	CANADA CITIES SE	1971	DAVIS STRAIT/CUMBERLAND SOUND
062-09-12-	CANADA CITIES SE	1971	DAVIS STRAIT/BAFFIN BAY
673-09-12-	AQUITAINE	1971	DAVIS STRAIT/CUMBERLAND SOUND
693-09-12-	KENTING EXPLORA	1971	DAVIS STRAIT/BAFFIN BAY/LANCASTER SOUND
829-09-12-	HIGH COUNTRY	1971	LABRADOR SHELF/DAVIS STRAIT
829-09-12-	HIGH COUNTRY	1971	LABRADOR SHELF/DAVIS STRAIT
838-09-12-	GSI	1971	DAVIS STRAIT
8620-G005	GSI	1971	LABRADOR SHELF/DAVIS STRAIT
GREENLA	VARIOUS	1971	DAVIS STRAIT/BAFFIN BAY
8624-A011	AQUITAINE	1970	LABRADOR SHELF/DAVIS STRAIT
BAFFIN BA	EUREKA EXPLORA	1969	DAVIS STRAIT

Status	Geophysical Type	Approx. Release Date	Nav	Digital Data
COMPLETED	SEISMIC REFLECTION SURVEY (2	ial status, release date	N	
COMPLETED	AEROMAGNETIC SURVEY	ial status, release date	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	26-Apr-19	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	06-Apr-14	N	
COMPLETED	GRAVITY SURVEY	27-Dec-13	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	ial status, release date	N	
COMPLETED	AEROMAGNETIC SURVEY	ial status, release date	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-13	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-13	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-13	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-13	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	03-Mar-13	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	05-Feb-13	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-12	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-12	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-12	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	26-Feb-12	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-11	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-11	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-10	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-10	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	31-Dec-10	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	N	

COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	N	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	N	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	N	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	D	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	D	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	N	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	D	
COMPLETED	REPROCESSING/REINTERPRETA	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	REPROCESSING/REINTERPRETA	released	N	
COMPLETED	REPROCESS/REINTERPRET OF A	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SHALLOW SEISMIC, SEABED SUR	released	D	
COMPLETED	GEOLOGICAL/GEOPHYSICAL RES	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	REPROCESS/REINTERPRET OF A	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	REPROCESSING/REINTERPRETA	released	N	
COMPLETED	REPROCESS/REINTERPRET OF A	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	digital data availa
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	REPROCESS/REINTERPRET OF A	released	D	
COMPLETED	REPROCESS/REINTERPRET OF A	released	D	

COMPLETED	GRAVITY SURVEY	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	GRAVITY SURVEY	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	REPROCESSING/REINTERPRETA	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	digital data availa
COMPLETED	REPROCESS/REINTERPRET OF A	released	D	
COMPLETED	REPROCESS/REINTERPRET OF A	released	D	
COMPLETED	REPROCESS/REINTERPRET OF A	released	D	
COMPLETED	AEROMAGNETIC SURVEY	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	AEROMAGNETIC SURVEY	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	D	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	Y	digital data availa
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION/REFRACTI	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	D	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	COMBINED GEOPHYSICAL SURVI	released	N	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	
COMPLETED	SEISMIC REFLECTION SURVEY (2	released	Y	

Description
9600 KMS? OF 2-D SEISMICS (AN INFILL OF PREVIOUS TGS SURVEYS) COMPLETED? 2009
41000 KM OFFSHORE SOUTHWEST GREENLAND AEROMAG AND GRAVITY SURVEY (UNGAVA
2704 KM 2-D SEISMIC SURVEY (BAFFIN BAY AND DAVIS STRAIT) COMPLETED 26-OCT-2008 (CA
591 KM 2-D SEISMIC AND GRAVITY SURVEY COMPLETED 06-OCT-2008 (CANADIAN SECTION O
85.3 KM MARINE GRAVITY AND MAGNETIC SURVEY (LADY FRANKLIN BLOCK?) COMPLETED 27
7108 KMS OF 2-D SEISMICS (AN INFILL OF THE BB2D07 SURVEY ALONG WITH A REGIONAL GR
75000 KM OFFSHORE SOUTHWEST GREENLAND AEROMAG AND GRAVITY SURVEY (UNGAVA
2016 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (BASIN OF LADY FRANKLIN 2003)
634 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (FYLLA BASIN SOUTH EAST 2003)
3078 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (GREENLAND 2003)
435 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (KANGAMIUT WEST 2003)
260 KMS OF 2-D SEISMICS COMPLETED 31-AUG-2002
200 KMS OF 2-D SEISMICS COMPLETED 05-AUG-2002
2235 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (DISKO WEST 2002)
1791 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (GREENLAND-CANADA 2002)
2417 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY DESIGNED TO INFILL EARLIER TGS-NOPEC SU
1288.15 KMS OF 2-D SEISMICS COMPLETED 26-AUG-2001 (PART OF GREEN 2001 SURVEY)
SURVEY STARTED 15-SEP-2001
2828 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY TYING DAVIS STRAIT CANADIAN WELLS TO OI
904 KM 2-D SEISMIC SURVEY CONDUCTED NORTH OF 68 DEGREES
630 KM 2-D & (800 KM 3-D ?) SEISMIC SURVEY COMPLETED 22-OCT-2000 (PART OF GREEN 200
2700 KM SEISMIC SURVEY CONDUCTED BY THE GEOLOGICAL SURVEY OF DENMARK & GREE
4526 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - BETWEEN THE FYLLA AND SISIMIUT WEST A
1104 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (KANGAMIUT RIDGE 2000)
1200 KM 2-D SEISMIC SURVEY - SISIMIUT WEST AREA
584 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY (SISSIMIUT RIDGE 2000)
2897 KM NON-EXCLUSIVE REGIONAL 2-D SEISMIC SURVEY
3098 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - NORTH & SOUTH OF THE FLYYA AREA
367 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - SISIMIUT WEST AREA
534 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - SISIMIUT WEST AREA
709 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - SISIMIUT WEST AREA
2115 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - HECLA RISE AREA
194 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - SISIMIUT WEST AREA
9460 KM REGIONAL SEISMIC SURVEYS CONDUCTED BY THE GEOLOGICAL SURVEY OF DENM
1708 KM NON-EXCLUSIVE 2-D SEISMIC SURVEY - FYLLA AREA
1915 KM NON-EXCLUSIVE REGIONAL SEISMIC SURVEY
REGIONAL NON-EXCLUSIVE SURVEY
CAPE CHIDLEY BLOCKS
MARINE SEISMIC SURVEY
WELLSITE SURVEY FOR RALEGH N-18
SEISMIC SURVEY - FROBISHER BAY
ASSOCIATED WITH 8624-P028-008E (PETRO-CANADA 1980)
ASSOCIATED WITH 8624-P028-008E (PETRO-CANADA 1980)
SEISMIC REFLECTION - DAVIS STRAIT
SEISMIC REFLECTION SURVEY - CUMBERLAND SOUND
SIDE SCAN SONAR & BATHYMETRY SURVEY

CUMBERLAND AREA
SAGLEK & CAPE CHIDLEY BLOCKS
SAGLEK & CAPE CHIDLEY BLOCKS
WELLSITE HIGH RESOLUTION SURVEY FOR C-92
WELLSITE SURVEY FOR C-5 (RESOLUTION ISLAND)
WELLSITE SURVEY FOR GJOA G-37
WELLSITE SURVEY FOR SITE C-76
SEISMIC SURVEY - CUMBERLAND
BAFFIN BAY SEISMIC SURVEY
BAFFIN BAY SURVEY
WELLSITE HIGH RESOLUTION SURVEY FOR FINNBOGI
WELLSITE HIGH RESOLUTION SURVEY FOR RALEGH & HEKJA
WELLSITE HIGH RESOLUTION SURVEY FOR RALEGH & HEKJA
FLEMISH PASS AREA AND CUMBERLAND & NORTH LABRADOR BLOCKS
SEISMIC INTERPRETATION - DAVIS STRAIT & LABRADOR
REGIONAL SEISMIC SURVEY - BAFFIN BAY
GEOLOGICAL FIELD OPERATIONS
REPROCESSING OF 1977 FROBISHER BAY SEISMIC
INTERPRETATION OF AVAILABLE GRAVITY & MAGNETIC DATA
1977 SEISMIC SURVEY - CUMBERLAND
TIE LINE FROM EASTCAN KARLSEFNI TO BP CUMBERLAND SOUND
SAME AS PROJECT 8620-A011-003E
HEKJA AND FINNBOGI STRUCTURES
SURVEY INCLUDES AREAS OFFSHORE WEST GREENLAND
SEISMIC SURVEY - ESSO & HBOG BLOCKS
MARINE SEISMIC - DAVIS STRAIT
MARINE REFLECTION SURVEY - CUMBERLAND SOUND
SITE SURVEY - DAVIS STRAIT
MAGNETIC SURVEY - BAFFIN BAY & DAVIS STRAIT
SEISMIC REFLECTION SURVEY - FROBISHER & CUMBERLAND (SAME AS 8624-A011-004E)
SEISMIC SURVEY - CUMBERLAND & NORTH LABRADOR
LABRADOR AND CUMBERLAND BLOCKS (SAME AS 673-09-12-00077)
PURCHASE OF GEOLOGICAL & GEOPHYSICAL REPORTS, 8627-A014-003P (AQUA-TERRA 1975)
REGIONAL SEISMIC SURVEY
MARINE SEISMIC - DAVIS STRAIT
SEISMIC SURVEY - DAVIS STRAIT
MARINE SEISMIC REPROCESSING - DAVIS STRAIT
INTERPRETATION OF TRADE DATA - DAVIS STRAIT
MARINE SEISMIC - DAVIS STRAIT
SEISMIC SURVEY - DAVIS STRAIT
SEISMIC SURVEY OFFSHORE BAFFIN ISLAND - CUMBERLAND SOUND
MARINE SEISMIC SURVEY - OFFSHORE BAFFIN ISLAND
SEISMIC SURVEY - LANCASTER SOUND, BAFFIN BAY & DAVIS STRAIT
SEISMIC SURVEY - NORTHERN LABRADOR SHELF, BAFFIN BAY & DAVIS STRAIT
BAFFIN BAY SURVEY
SAME AS PROJECT 8620-A011-002E
NORTH LABRADOR AND CUMBERLAND BLOCKS
1975 GEOPHYSICAL SURVEYS: FLEMISH PASS, SOUTH LABRADOR, ORPHAN BLOCK AND NOR
LABRADOR SHELF SURVEY
LABRADOR SHELF AND SLOPE
PURCHASE OF GEOLOGICAL AND GEOPHYSICAL REPORTS, 8627-A014-003P (AQUA TERRA 19
PURCHASE OF GEOLOGICAL AND GEOPHYSICAL EVALUATION OF LABRADOR SHELF, 8627-A(

GRAVITY SURVEY - CUMBERLAND & NORTH LABRADOR
MARINE SEISMIC SURVEY - CUMBERLAND & NORTH LABRADOR
BAFFIN BAY SURVEY
MARINE SEISMIC SURVEY - CUMBERLAND SOUND & FROBISHER BAY
CUMBERLAND, NORTH & SOUTH LABRADOR AND ORPHAN BLOCKS
MARINE SEISMIC & GRAVITY SURVEY - CUMBERLAND (SOUTHEAST BAFFIN ISLAND)
DAVIS STRAIT PORTION OF PROJECT 8620-J001-002E
MARINE SEISMIC & SHIPBORNE GRAVITY - DAVIS STRAIT
MARINE SEISMIC SURVEY - DAVIS STRAIT
REINTERPRETATION - LABRADOR & DAVIS STRAIT
SEISMIC SURVEY - BAFFIN BAY & DAVIS STRAIT
MARINE SEISMIC SURVEY - DAVIS STRAIT
MARINE SEISMIC SURVEY - BAFFIN & LABRADOR (SAME AS PROJECT 8624-C010-001P)
MARINE SEISMIC SURVEY - OFFSHORE BAFFIN ISLAND
SAME AS PROJECT 8620-G005-005P
REGIONAL NON-EXCLUSIVE SURVEY
REGIONAL SURVEY: LAURENTIAN FAN, ORPHAN BLOCK AND NORTH & SOUTH LABRADOR
PURCHASE OF GSI LINE
HIGH SENSITIVITY AEROMAGNETIC SURVEY
PURCHASE OF REGIONAL DATA FROM DELTA
SENSITIVITY MAGNETOMETER SURVEY
DAVIS STRAIT PORTION OF PROJECT 8620-J001-001E
AEROMAG SURVEY - SOUTHEAST BAFFIN & DAVIS STRAIT
MARINE SEISMIC SURVEY - CUMBERLAND SOUND
MARINE SEISMIC SURVEY - DAVIS STRAIT
BAFFIN BAY & DAVIS STRAIT SURVEY
SEISMIC SURVEY - BAFFIN BAY, LANCASTER SOUND & DAVIS STRAIT
SEISMIC SURVEY - OFFSHORE BAFFIN ISLAND
SEISMIC SURVEY - BAFFIN ISLAND & LABRADOR SEA
LABRADOR SHELF SURVEY
LAURENTIAN CONE, CUMBERLAND, NORTH & SOUTH LABRADOR AND ORPHAN BLOCKS
RECONNAISSANCE OVER SAGLEK, NAIN, HARRISON, DOMINO & SAGLEK AREAS
MARINE SEISMIC SURVEY - FROBISHER BAY
MARINE SEISMIC SURVEY - OFFSHORE BAFFIN ISLAND
STRUCTURAL MAPS ONLY
MARINE SEISMIC SURVEY - CUMBERLAND SOUND
MARINE SEISMIC REFLECTION & REFRACTION SURVEY
SEISMIC SURVEY - BAFFIN ISLAND & LABRADOR OFFSHORE
SEISMIC SURVEY - BAFFIN ISLAND & LABRADOR OFFSHORE
MARINE SEISMIC SURVEY - DAVIS STRAIT
SAME AS PROJECT 838-09-12-00001
BAFFIN BAY SURVEY
3 RECONNAISSANCE LINES
DAVIS STRAIT SURVEY

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Marine Seismic Operations

An Overview

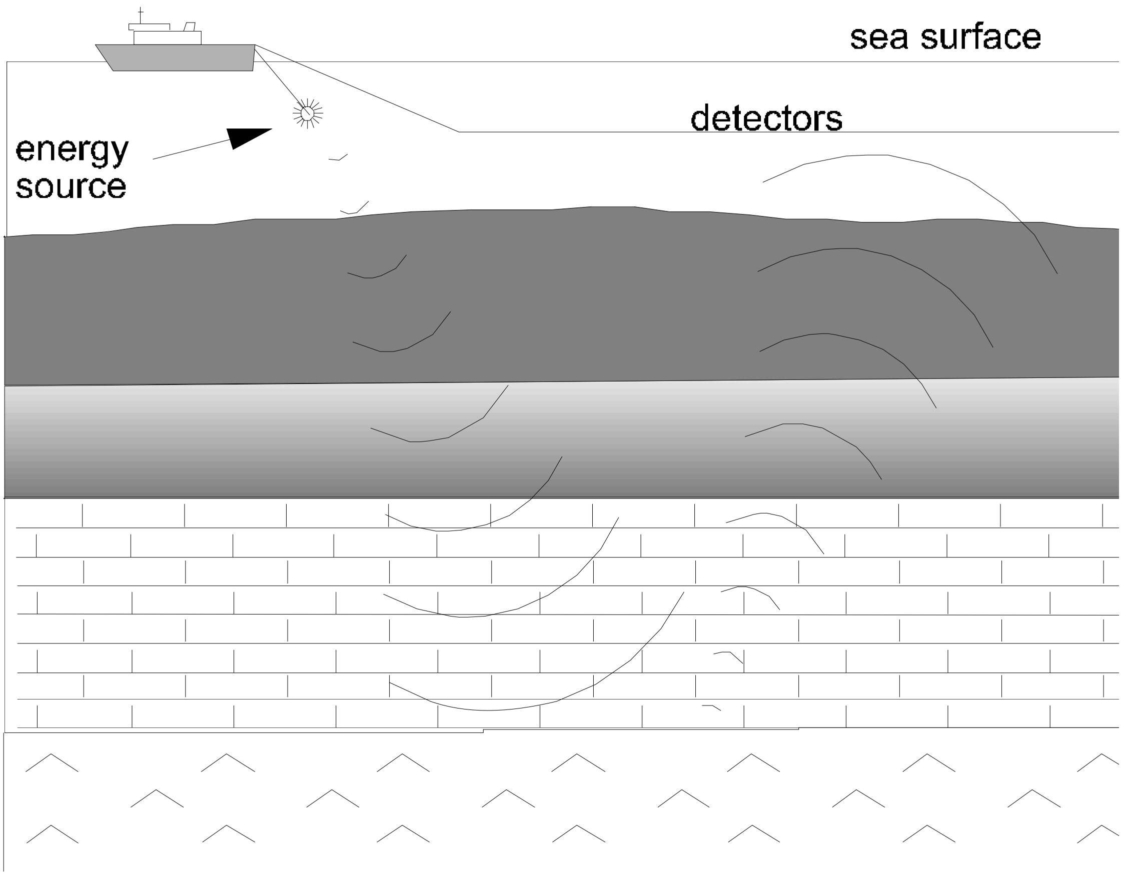
Produced by IAGC to provide a reference to other marine operations in general and the fishing industry in particular.

Underlying Principles

The dictionary definition for the word seismic means "of or relating to an earthquake" and indeed it comes from the Greek word seismos meaning an earthquake. In its broad scholarly or teaching sense this is what seismic study is about. It involves earthquake measurement, monitoring and prediction. What is measured are the energy waves created by the earthquakes and the effect of these waves close to where the earth's crust actually moved.

Basic Seismic Reflection

In seismic surveying, geophysicists use the same basic physical properties as the earthquake seismologists. Relatively low energy waves are mechanically generated and directed into the earth. Some of the energy is reflected back to the surface from the different layers of rock below the surface. The returning waves are detected with sensitive measuring devices that accurately record the strength of the wave and the time it has taken to travel through the various layers in the earth's crust and back to the surface. These recordings are then taken and, after various adjustments, done mostly by computers, transformed into visual images that give a picture of what the subsurface of the earth is like beneath the seismic survey area. To summarise, although geophysicists cannot see directly beneath the ground, they can use seismic surveying to get a picture of the structure and nature of the rock layers indirectly.



There are many reasons for doing seismic surveys. They are used to check foundations for roads, buildings or large structures such as bridges. They can help to detect ground water. They can be used to assess where coal and minerals are. One of the most common uses is in the search for hydrocarbon resources, gas and oil, and most commercial seismic surveying is carried out in this energy sector.

Oil and gas exploration takes place all over the Earth's surface. It can be generally considered as falling into the two main categories:

- Onshore or Land Exploration
- Offshore or Marine Exploration.

There is a third zone, which is currently of lesser commercial significance. This is commonly called Shallow Water Exploration, but is also sometimes referred to as Transition Zone Exploration (TZ). This involves shallow water areas such as tidal zones, river estuaries or swamplands. Exploration activities in these areas can be very complex.

This document will focus on marine seismic exploration.

2D and 3D Seismic Methodology

The complexity of the seismic survey operation can vary enormously. There are, however, two main types of seismic surveying. These are Two Dimensional or 2D Exploration and Three Dimensional or 3D Exploration. 2D can be described as a fairly basic and inexpensive survey method, which although somewhat simplistic in its method, has been and still is used very effectively to find oil and gas. 3D surveying on the other hand is a much more complex and accurate method of seismic surveying, which involves greater investment and much more sophisticated equipment than 2D surveying. Until the beginning of the 1980's, 2D work predominated in oil and gas exploration but now 3D is the dominant exploration tool.

2D Acquisition

In the 2D method, a single seismic cable or streamer is towed behind the seismic vessel, together with a single source. The reflections from the subsurface are assumed to lie directly below the sail line that the seismic vessel traverses – hence the name 2D. The processing of the data is, by nature of the method, less sophisticated than that employed for 3D surveys. 2D lines are typically acquired several kilometres apart, on a broad grid of lines, over a large area. The method is generally used today in frontier exploration areas before drilling is undertaken, to produce a general understanding of the regional geological structure.

3D Acquisition

A 3D survey covers a specific area, generally with known geological targets generated by previous 2D exploration. Prior to the survey, careful planning will be undertaken to ensure that the survey area is precisely defined, usually carried out by the Oil Company or by specialist contractor personnel. Since much time, money and effort will be put into the acquisition, processing and interpretation of the survey, it is very important that it is designed to achieve the survey objectives. The result of the detailed planning will be a map defining the survey boundaries and the direction of the survey lines. Specific acquisition parameters such as energy source, firing and receiver station intervals, together with the seismic listening time, will also be defined. In 3D surveying, groups of sail lines (or swathes) are acquired with the same orientation, unlike 2D where there is a requirement for orthogonal or oblique lines to the prominent acquisition direction. Simplistically, 3D acquisition is the acquisition of many 2D lines spaced in parallel close together over the area.

The 3D sail line separation is normally of the order of 200 to 400 metres. By utilising more than one source and many parallel streamers towed by the seismic vessel, the acquisition of many closely spaced sub-surface 2D lines, typically between 25 and 50 metres apart, can be achieved by a single sail line. A 3D survey is therefore much more efficient in that many times more data is generated than for 2D. The size of a 3D survey is usually referred to in square kilometres or sometimes the number of line kilometres to be acquired. A small 3D survey size is of the order of 300 square kilometres or 1000 sail line kilometres or 12000 sub-surface 2D kilometres.

3D surveys are typically acquired with a racetrack pattern being employed, to allow adjacent sail lines to be recorded in the same direction (swathe), whilst reducing the time necessary to turn the vessel in the opposite direction. This increases the efficiency of acquiring the data and minimises processing discontinuities, which could adversely affect the interpretation of the data.

With the number of sail line kilometres involved, 3D surveys can take many months to complete. The way in which the data is acquired greatly affects the efficiency of the acquisition and considerable planning goes into this aspect. Whilst a racetrack approach is the favoured one, size and shape of the survey, obstructions, tides, wind, weather, fishing vessels and client specifications amongst others, will clearly affect the efficiency and design of the operations. Usually, a survey is broken into areas and swathes of lines are completed in phases or individual racetracks, but there is no rigid procedure which is followed.

Powerful computers are required to process the large volume of data acquired into a three-dimensional image of the subsurface – hence the term 3D seismic. 3D surveys have now become the preferred method for providing the geological interpreter with subsurface information and account for more than 95% of marine seismic data acquired worldwide. 3D surveys are used in all phases of hydrocarbon exploitation from identifying geological structures which are considered likely to contain hydrocarbons to, in areas of established production, establishing those portions of the reservoir which are not being drained by existing wells. Increasingly, 3D surveys are being repeated regularly on established production fields to monitor the reservoir characteristics and depletion rates, so-called Time Lapse surveys.

Seismic Survey Vessel

Now days, seismic vessels are purpose built with many special features, including accommodation for the seismic crew, the instruments, helideck and quiet engines and propellers. The Captain, is responsible for the safety of the seismic vessel and he has the final say in how the seismic vessel is operated and manouvered.

A recently built seismic vessel has the following specifications:
Length: 84 m
Beam: 18.5 m
Draft: 6.2 m
Displacement: 5600 metric tons
Cruising speed: 13.5 Knots
Berths: 50
Endurance at sea: 50 days

Courtesy of Veritas DGC

The instrument room

This is where the main seismic instrumentation is located and operated. The position of the instrument room varies from vessel to vessel but normally is located centrally, somewhere below the bridge and forward of the back deck. It contains the main seismic instruments for recording seismic data and controlling the seismic streamer(s) and energy source firing. The main navigation system is also here with its links to satellite, radio systems, compasses and all the various positioning control devices and monitors. There is usually a working area for instrument testing and repair.

The back deck

This is an area, which although in detail can vary from vessel to vessel, has the same basic purpose – storage, retrieval and deployment of the seismic equipment that is placed in the sea. The seismic streamers are stored here on large reels and when acquisition is ongoing, they are deployed over the back and/or sides of the vessel and towed directly behind the vessel, subject to feather. The number of streamers varies depending on the vessel but can be as many as sixteen for 3D surveys. All the wiring from the streamers is fed through special connectors to the instrument room. Most vessels have a small streamer repair area on the back deck. The seismic streamers are under control of the geophysical observer section of the crew.

The back deck is also the location of the energy source equipment. The energy source is usually made up of airguns, which are fed with high-pressure air. Each source is made up of an array of many different sizes of airguns, linked together with special harnesses and fed with airlines and electronic control cables. When not in use, these cables are stored on reels usually at the forward end of the back deck. During deployment, they are put to sea through a slipway at the rear of the deck. The air feed from the seismic vessel compressors to the arrays is monitored from a control panel, which is housed in a small work shack where airgun repairs can also be done.

In association with the streamers and source arrays is the towing equipment. This is a complex, carefully designed arrangement of specialised gear that enables the multiple streamers and source arrays to be positioned accurately behind the seismic vessel and allows different source and streamer separations depending on the survey design. The airgun system and the towing equipment are the main responsibilities of the mechanical section of the seismic crew.

Finally on the back deck is the navigation or positioning equipment. This usually involves buoy systems containing navigation instruments. Tail buoys are attached to the end of each of the streamers furthest from the vessel. Additional buoys can be attached to the source arrays and towing equipment for example. These are not the only buoys in the system however, and in complex multi streamer/ source/ boat arrangements, the navigators need a lot of other control and monitoring systems on sources, streamers and any other vessels so that the relative positions of all the equipment can be recorded.

Compressor room

This contains the compressor engines and compressors, which supply high pressure (nominally 2000 psi) air to the source arrays. The compressors are capable of recharging the airguns rapidly and continuously, enabling the airgun arrays to be fired, typically every ten seconds or so during acquisition of data and for periods of up to 12 hours continuous firing, depending on the length of the sail line. This room is under the mechanics' control and is usually situated in proximity to the back deck.

Seismic Streamer

It is worth noting that due to the action of wind, tides and currents, the seismic streamer does not normally tow directly behind the seismic vessel, but lies in an arc offset from the nominal sail line. This is referred to as feathering and whilst such lateral displacements are not typically crucial to the success of 2D data surveys, they are critically important in 3D, where accurate knowledge of the positions of all sources and receivers is fundamental to the successful application of the technique.

The seismic cable or streamer detects the very low level of reflection energy that travels from the seismic source, through the water layer down through the earth and back up to the surface, using pressure sensitive devices called hydrophones. The hydrophones convert the reflected pressure signals into electrical energy, that is digitised and transmitted along the seismic streamer to the recording system on board the seismic vessel, where the data is recorded on magnetic tape.

The sensitivity and robustness of the streamers is remarkable. Normal noise levels in calm weather conditions are of the order of 2-3 μbar and it is quite common for streamers to remain operating in the water for months at a time.

The streamer itself is made up of five principal components:
- hydrophones, usually spaced one metre apart, but electrically coupled in groups of 12.5 or 25 metres in length.
- electronic modules, which digitise and transmit the seismic data.
- stress members, steel or kevlar, that provide the physical strength required, allowing the streamer to be towed in the roughest of weather. Each streamer may be subjected to several tonnes of towing strain.
- an electrical transmission system, for power to the streamer electronic modules and peripheral devices, and for data telemetry.
- the skin of the streamer in which all the above are housed.

The streamer is divided into sections, each 50-100 metres in length, to allow modular replacement of damaged components. Each section is terminated with a connector unit, which houses the electronic modules. Each section is filled with electrical isolating fluid, which has a specific gravity of less than one, to make the overall streamer neutrally buoyant. Although historically, this fluid was an organic compound, more recently a purely synthetic material has been used.

Recent advances in cable technology have led to a new generation of seismic streamers, moving away from the traditional fluid filled cable to a solid cable, constructed of extruded foam, where the requirement for fluid is minimised or removed entirely. This generation of streamers has many advantages in that they are more robust and resistant to damage, do not leak when damaged either on the vessel or in the sea, and are less sensitive to weather and wave noise. This has been achieved without reducing the sensitivity of the cable to the reflection energy.

Streamer lengths have increased over time with improving technology. The streamer length utilised is dependent on the depth and type of the geological target for a given survey. Recent surveys have seen streamer lengths typically in the order of 5000 to 6000 metres, with some detailed surveys using streamers up to 12000 metres in length. This increase in length, coupled with the increasing number of deployed streamers, has resulted in a marked increase in the quantity of streamers in the water, with seismic vessels deploying 40 to 50 kilometres of streamer becoming more prevalent.

Streamer tow depths are a compromise between the requirement to operate these sensitive devices away from the surface weather and wave noise, which limits the usability of the recorded data, and other technical requirements. The deeper the tow depth, the quieter the streamer and the greater the immunity to weather noise, but also unfortunately, the narrower the bandwidth of the data.

Typically the range of operating depths varies from 4 to 5 metres for shallow, high resolution surveys in relatively good weather areas to 8 to 10 metres for deeper penetration, lower frequency targets in more open waters.

In addition to the internal components of the streamer, there are three types of external device, which are attached to the streamer:

- depth control units or birds.
- magnetic compasses.
- acoustic positioning units.

Power for these systems is provided both through the streamer itself, inductively coupled, and by batteries in each external device.

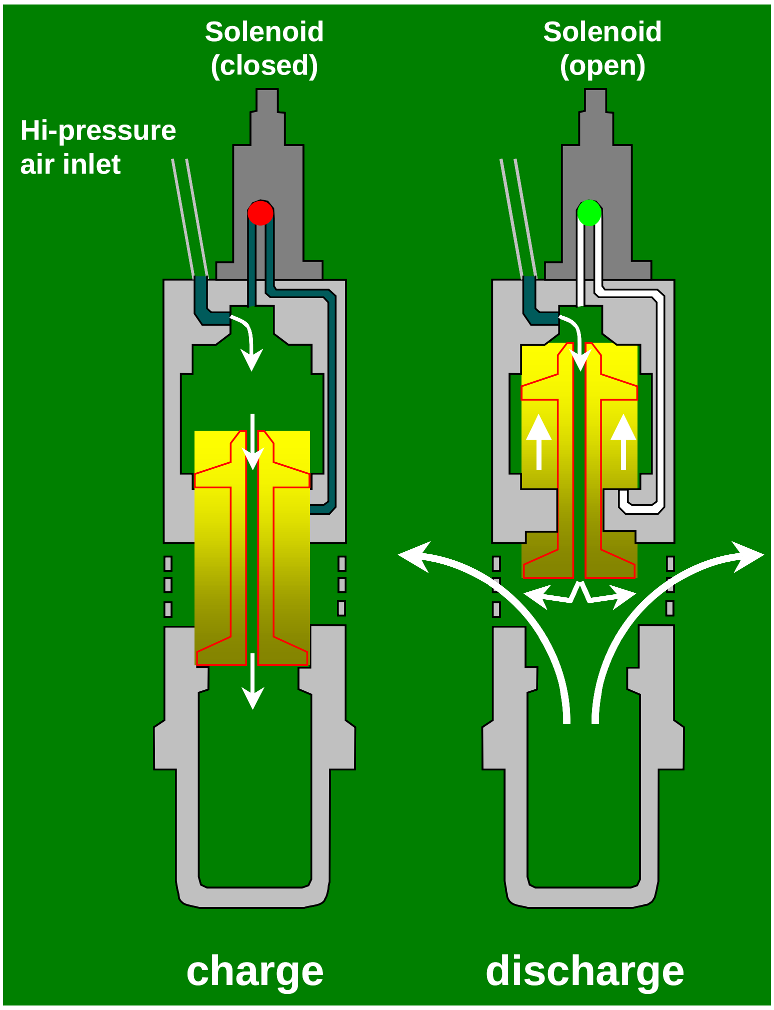
In addition, a tailbuoy is connected to the far end of each streamer to provide both hazard warning of the submerged towed streamer, especially important at night, and positional information.

The Seismic Source

Although there are now three types of seismic source, airguns, waterguns and vibrators, that can be utilised, almost all surveys conducted world-wide use airguns. Explosives are an historic source, and are not used in present day operations.

The airgun, comprises two high pressure air chambers; an upper control chamber and a discharge chamber. High pressure air, at typically 2000 to 2500 psi, is supplied to the upper control chamber from the compressor onboard the seismic vessel via an air hose and bleeds into the lower firing chamber through an orifice in the shank of the shuttle. The airgun is actuated by sending an electrical pulse to the solenoid valve which opens, allowing high pressure air to flow to the underside of the triggering piston. The high pressure air in the lower (firing) chamber is

discharged into the surrounding water through the airgun ports. The air from these ports forms a bubble, which oscillates according to the operating pressure, the depth of operation, the temperature and the volume of air vented into the water.
The shuttle is forced back down to its original position by the high-pressure air in the



control chamber, so that once the discharge chamber is fully charged with high-pressure air, the airgun can be fired again. The opening of the shuttle is very rapid, taking only a few milliseconds, which allows the high-pressure air to be discharged very rapidly.

Total energy source volumes vary from survey to survey and are designed to provide sufficient seismic energy to illuminate the geological objective of the survey, whilst minimising environmental disturbance.

An airgun array is made up of sub-arrays or strings, which are suspended from floatation devices to maintain the specified operating depth. Array dimensions are usually of the order of 25 metres wide by 15 to 20 metres long.

Typical source outputs in use today will output approximately 220 dB relative to 1µ Pascal/Hz at 1 metre. In pressure terms the zero-peak output of an array is of the order of 40 bar-metres.

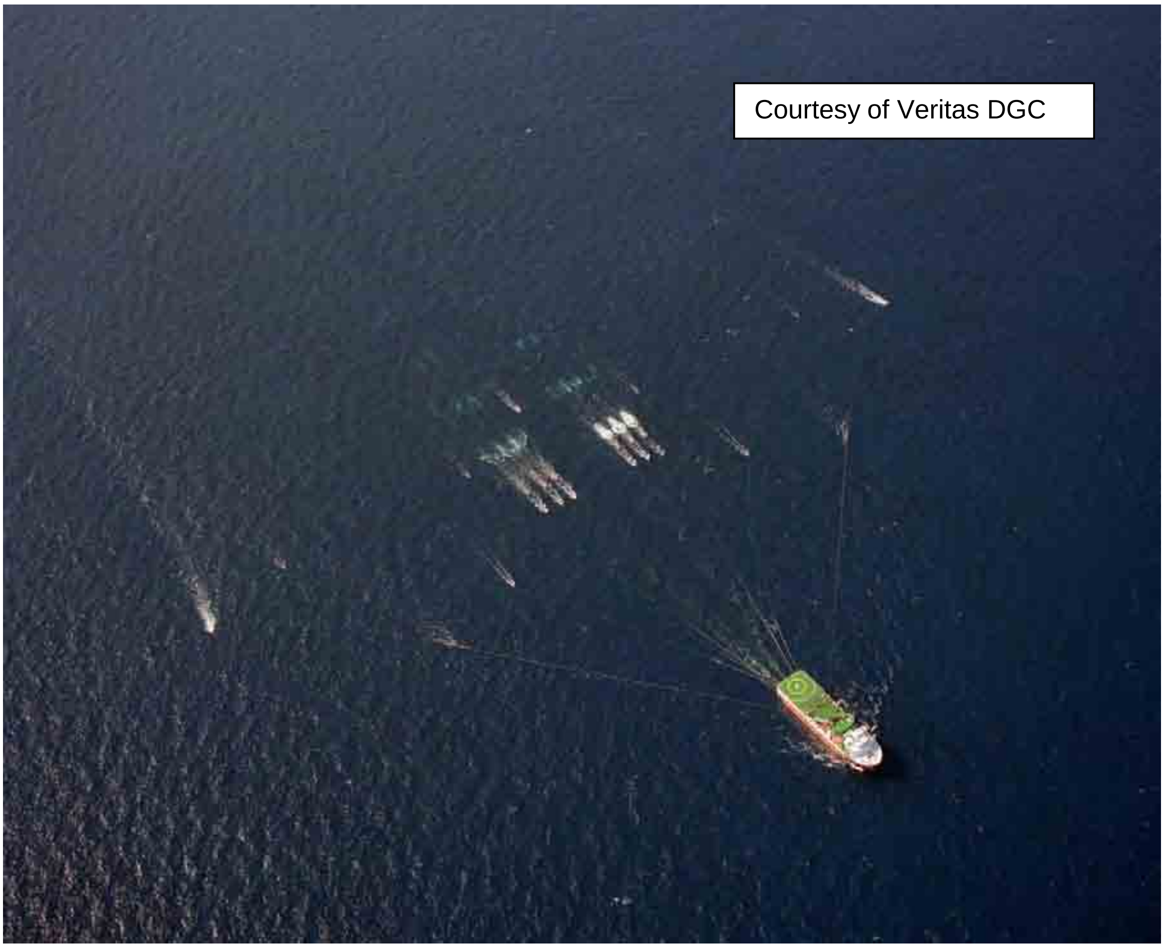
Source arrays are designed to focus energy downward into the subsurface.

Operations

The first stage of normal operations is that the seismic vessel should be fully supplied with all necessary fuel, water, food, seismic equipment and crew. It will then transit to the designated survey site. The seismic vessel will have been provided in advance with all necessary details regarding the survey layout and design and what and how much equipment will be deployed. The navigators will have information, which specifies where each seismic line must start and finish, and what the energy source firing, or shooting, interval must be. This information will have been fed into the onboard integrated navigation system.

On the bridge, the captain will ensure that while the seismic vessel is under normal manual control, he will be navigating as agreed to the first line start position. The seismic vessel will maintain a constant speed of around 5 Knots. He and the seismic crew (party) manager will be closely monitoring wind, weather and any incoming reports.

As the survey area is approached, the geophysical observers will deploy and check the streamers, attaching depth monitor and control devices (birds) as they go. The mechanics will start the compressors and prepare and check the required airgun arrays. These will be launched when necessary but after the streamers. The navigators will work with both mechanics and observers to attach the necessary buoys for positioning.


Courtesy of Veritas DGC

In the instrument room, all equipment will be powered up, tested and checked for trouble free operation. Test records (no airguns operating) for insea noise will be made. The streamer, airgun and buoy links will all be checked and tested and the whole system confirmed as OK and ready to go.

As the seismic vessel approaches the line start or first firing point, it is said to be on the run in. This is the stage where it is very close to the agreed start position and the seismic vessel has the correct heading and the streamers are as much in line behind the seismic vessel as conditions will allow. The seismic vessel by this point is steered according to the input from the navigation system. Around the seismic vessel all involved crew members will be monitoring the seismic vessel's position from information screens in their areas. The navigator will be at his desk keeping a close eye on his console, where he can monitor in detail the approach to line start in terms of distance to go, heading and speed and can ensure that no positioning problems arise at the last moment. The mechanics will be keeping a close eye on the compressor monitors and will make a last minute visual inspection of the airgun equipment that can be seen from the vessel. The observers will take final test records and record the system noise for future reference and will check out the airgun control system.

It is during the approach to the line start, that environmental protection procedures may be applicable. Depending on the country of operations and the area specific environmental controls in place, a visual watch for marine mammals from the seismic vessel may be ongoing for at least 30 minutes before the first firing of the airguns. On some surveys, acoustic methods may additionally be utilised to identify the presence of marine mammals within the vicinity of the airgun array. It is only when the crew has been informed that no marine mammals are present, that the survey line can proceed with the firing of the airguns. A 20 minute run-in is required in some regions where the airgun array energy output is slowly increased to full power.

All systems are now ready to go and at the first predetermined position, the first shot is fired from the airgun array and data recorded. At successive intervals, as determined by the navigation system programme, the recording process is repeated and so on, to the end of the line. Throughout the recording period, all personnel involved perform detailed prescribed tasks. The navigator monitors the system output, checking for any discrepancies and completes the line paperwork and prepares plans for moving to the next line to be recorded. The mechanic watches the compressor performance, checks the back deck towing systems and is ready to deal with any hose or airgun problems. The geophysical observer monitors each shot, keeps an eye on insea noise, changes recording media and fills in the line log as the line progresses.

When the line is complete, all systems stop recording. The ship is now in line change mode. The navigator has planned how the vessel should manoeuvre to get into the run in for the next line. The line change time varies according to the layout of the survey and the configuration of the equipment but is usually between one and three hours. During the changeover period, all the crew involved work quickly to resolve any problems and make modifications or repairs in readiness for the next line. The run in is then started, all equipment is readied, and the cycle repeats.

Infrequently, technical failures occur and line starts are delayed or lines are terminated early.

Other types of Seismic Source

Waterguns

Waterguns operate in a similar manner to airguns, but in place of air being vented into the water when the gun is triggered, a volume of water is used. The advantage of this is that as there is no air in the water, there is consequently no air bubble to oscillate, so the need to use differing volumes of guns is removed.

The disadvantage is that the low frequency bandwidth of the signal generated by forcing water under high pressure into the surrounding water, is much less than that provided by an equivalent airgun and thus the signal is unable to penetrate as deeply into the subsurface. Water guns were briefly popular in the 1980s but are not used commercially today.

Marine Vibrators

A marine vibrator operates by using either hydraulic or electrical power to drive an actuating plate, that is immersed in the sea, in a controlled manner.

The advantage of this is that a very precise signal can be injected into the subsurface. The signal usually employed is a sweep of frequencies, say 10-80 Hz for example, over a 10-second interval. The instantaneous sound pressure level is much lower than that from an airgun. The recorded data is then correlated against the input sweep to recover the reflection record.

The control of these devices is very complex. The output from a single vibrator is comparable to that from an airgun sub-array but suffers the disadvantage, like waterguns, that its low frequency response has historically been poor, so that deep penetration into the subsurface has not been possible. The vibrator has also suffered poorly in comparison with airguns with regards to mechanical failure, having a much higher failure rate.

Other insea equipment

Depth control birds are used to control the depth of the streamer to an accuracy of typically plus or minus 1 metre. The wings on the bird are electronically controlled to pivot in response to the hydrostatic pressure (depth) measured by a pressure transducer inside each bird. As the streamer is weighted to be neutrally buoyant, the birds are used to counteract depth variations in the streamers introduced by seismic vessel pitching movements in heavy weather or when different currents are experienced, with corresponding fluctuations in density and/or temperature of the sea water.

Birds are normally spaced approximately 300 metres apart on each streamer.

Positioning

One of the most critical elements in the 3D seismic method is the positioning of the in-sea equipment. The tailbuoy is used to house Differential Global Positioning System (DGPS) receivers that are used in the positioning solution for the hydrophone groups in the streamers. Compasses, and acoustic ranging units are fitted along each streamer which contribute to the location accuracy of 3 to 8 metres absolute, with which seismic surveys are normally conducted. Differential GPS is the standard system used for positioning the seismic vessel itself and Relative


Courtesy of Veritas DGC

DGPS is used to position both source floats and tailbuoys.

Vessel Configurations

The 2D method involves the use of a single source and a single streamer from which one subsurface data is generated. In 1984, the first twin streamer operation was undertaken, which effectively doubled the efficiency of the seismic vessel by generating two subsurface lines per vessel traverse. By moving to twin source/twin streamer configurations in 1985, the output was increased to four lines per pass. The next logical step of towing three streamers and two sources behind a single vessel, six lines per pass, was not achieved until 1990, but thereafter the rate of progress has been very rapid.

Multi-Vessel Operations

In addition to the single vessel geometries described above, the industry has been using a number of multi-vessel operations.

By using two three streamer seismic vessels side-by-side, with two sources deployed from one vessel, twelve subsurface lines per traverse can be achieved.

There are many variations in the numbers of vessels, streamers and configurations, and the techniques to acquire data.

The system used for a particular survey will best match the objectives of the survey and the conditions found at the survey site.

Other Marine Seismic Techniques

Seabed Recording Systems

There are three principal types of seabed recording systems used in marine seismic; Ocean Bottom Seismometers (OBS), Dragged Array (DA) and Ocean Bottom Cables (OBC). Of these, OBS and DA are used in multi-component (sensor) acquisition and OBC is used in both dual component and multi-component data acquisition. The term multi-component refers to the use of three component geophones in addition to a hydrophone for each seismic receiver location. The term dual component refers to the use of just a single geophone in addition to a hydrophone. A geophone measures particle displacement velocity in contrast to pressure which a hydrophone detects. The use of geophones, which must be in contact with the sea floor, sense particle motion along three orthogonal axes, allowing the geophysicist to infer more information concerning the subsurface geological layers from which the reflections occur. This has particular application in producing reservoirs, where multi-component techniques have the potential to enhance hydrocarbon recovery.

Of the three techniques, OBC is by far the most prevalent technique in use in world-wide marine acquisition.

Ocean Bottom Seismometers

Such systems have been historically used by university research groups to provide large-scale information for crustal studies and lithospheric investigations. They are battery powered individual units, which contain both the three-component geophones and hydrophone detectors, in addition to the associated recording system. The electronics are placed in a pressure housing, which also includes a flotation collar and navigation pinger. The unit, with an anchor system attached, is deployed onto the sea floor, typically in fairly deep water. The unit is then used to record data internally from a seismic energy source operating near the sea surface as in conventional marine seismic. Once this has been accomplished, the unit is released from its anchor to float up to the sea surface to be recovered. The data recorded on the internal tape drive is then removed from the buoy for subsequent processing and analysis, the batteries replaced or recharged and the whole operation repeated.

Buoys are typically deployed several kilometres apart for crustal investigations, but more recently have been used in areas like the Atlantic Margin for oil related projects in a closely spaced configuration. The interest here has been to see if the OBS method can assist in enabling geophysicists to “look through” the basalt rocks which cover much of the subsurface area and which are opaque to conventional towed streamer seismic techniques.

The fact that the buoys are physically separate and their positions are not, especially in deep water, sufficiently accurately known for 3D means that this technology is unlikely to see large volume commercial usage.

Dragged Array

In this system, a number of multi-component sensors are connected together by a short length of streamer that is electrically connected to a recording vessel. The equipment, which can comprise no more than 16-24 individual sensor stations, is lowered onto the seabed and a separate seismic source vessel used to conduct a 2D shot line over the seabed deployed sensors. The data is transmitted to the recording vessel, which is usually dynamically positioned off to one side of the survey line. Once this line has been acquired, the recording vessel repositions itself online and moves forward along this line, carrying the seabed deployed equipment with it, the so-called dragging operation. The system is moved forward to provide continuous coverage of the subsurface and the shot line re-acquired by the source vessel. The system used has operational capability down to 2000 metres of water depth.

Dual Component/Multi-Component Ocean Bottom Cable

The dual component or multi-component OBC technique utilises both geophones and hydrophones in a combined cable that is deployed from a cable/recording vessel down to the seabed. Existing equipment design has limited the depth to which these sensors can be used to less than 200 metres, although newer generations of cables are being used in deeper waters. Unlike the dragged array, the equipment is laid out or dropped on the seabed and data recorded using a separate source vessel.

The principal difference between OBC and dragged array operations is that as much as 72 kilometres of ocean bottom cables can be laid or deployed on the seabed, compared to less than one kilometre for the dragged array. This allows the OBC method to be used for 3D surveys.

The separations of source and recording vessel allow for different acquisition approaches to be used in ocean bottom cable 3D surveys. Two different methods are typically used: swath, where the source and seabed receiver lines are oriented along the same direction, and patch where they are oriented at right angles.

Vertical Cable

A rarely used technique, closely related to VSP. Only one survey has been conducted in the North Sea so far. This involves the use of hydrophone cables set out vertically in the water column across the survey area.

Each cable typically comprises single hydrophones spaced at intervals, together with a concrete anchor block, subsurface flotation buoys and a surface buoy, which houses the recording and radio telemetry systems.

The vertical cables are deployed at pre-determined locations by a dynamically positioned cable-laying vessel. The separation of the cables is determined by both the water depth and the geological objective. A separate source vessel fires its airguns into the 2D source lines producing a regular grid of shot point locations. The cable vessel replaces batteries and recovers the recorded data. The source technology is identical to that used for conventional towed streamer.

Survey duration will depend on the specific target objective for the survey but the method is more focussed towards reservoir imaging rather than general exploration.

Vertical Seismic Profiling (VSP)

In this technique, a number of geophones are lowered into a well and used to record data from a seismic source deployed from the well platform itself, called zero offset VSP, or from a source vessel which travels away from the well, known as offset VSP.

The main advantage of this method is that the seismic energy only has to travel one way through the earth. The reflected signal only has to travel a short way from the reflector to reach the downhole geophones. This results in higher bandwidth data being recorded, since there is less absorption of the higher frequency energy due to the shorter ray path lengths.

Source volumes are generally smaller than for conventional data but larger than for site surveys. The duration of these surveys is typically short, one or two days at most.

There have been a number of 3D VSPs recorded but these are relatively expensive to acquire. Much like the dragged array system, they require many passes of the source vessel to achieve complete 3D coverage and are hence relatively expensive, especially when the cost of the well time is included.

Site Surveys

Before a well is drilled, there is both a legal and operational need to have detailed information about the seabed in the area immediately surrounding the well location and the geological layers immediately below the subsurface.

The information about the nature of the seabed is needed to ensure that the rig legs and/or anchors will not encounter any problems when they are lowered to the seafloor and will provide the necessary stability for the structure. If the well is successful, this information will also be needed for any platform or subsea completion systems that would be installed.

The near subsurface data is needed to ensure that there are no unforeseen hazards, such as shallow gas pockets or buried river channels, that could have catastrophic effects when penetrated during the drilling process. The sudden release of gas below a drill rig could result in a catastrophic loss of life.

The resolution from conventional seismic is not sufficient for these purposes and a high resolution or site survey is undertaken. This technique is identical in principle to conventional 2D marine, except that the energy source is much smaller, and the streamer is much shorter at between 600 to 1200 metres. The source and streamer are towed at a depth of only two or three metres, corresponding to the much shallower depth of investigation. This limits operations to very good weather conditions only, to avoid wave noise.

Survey durations are short, depending on weather, but are usually of the order of four or five days. Other equipment may be deployed from the survey vessel during the course of the site survey. This may include side scan sonar fish for seabed profiling and the dropping of coring equipment to determine the seabed conditions.

Transition Zone Acquisition

This is by far the most complex and challenging area of seismic acquisition.

Shallow shelving waters are the most common problem, for they often require small, shallow draft, specialised vessels to move cables, sources, people and equipment around. With bad surf conditions it is very difficult to deploy, retrieve or operate equipment in a flat-bottomed boat.

Source types may have to be varied across an area. Where water is deep enough, it might be possible to deploy the source from the back of a barge for example, but where it is shallow, the use of explosives might be required, which are jetted or pushed into the mud or sand of the sea bottom.

Providing reliable recording sensors is also problematic. Marine hydrophones are suitable, provided they are located in deep enough water to enable them to operate properly, They are unreliable when the tide goes out for example. An additional problem involves placing the cable at a reasonable depth in the deeper water. In these environments, the streamer is not being pulled through the water with depth controlling devices. Personnel are often required to weight the cable to the sea bottom with chains and anchor blocks. With active surf or current conditions, it is likely that the cables will move and then subsequently have to be manhandled back into position.

One form of cable that can be used very successfully in transition areas is called a bay cable. It is effectively a very well sealed land cable with geophones on gimbals so that they remain upright. Some variants of these cables can contain hydrophones as well. This cable is lighter and easier to handle than a marine type of cable, but it is still not either straightforward or effortless in its use.

Another method of recording data in these zones is to integrate the sensors with electronics, creating rugged sensor stations that radio transmit the received earth signal back to an instrument position, either continuously or on command from the observer. In some areas this is often the only equipment that can be effectively used, but these units still need to be positioned and anchored appropriately and this is seldom easy.

Positioning of the equipment can be complicated. Close inshore areas are usually less problematic, but the highly variable mid zone complete with fast currents, drifting cables, wandering shots, big tides and lots of mud can make it a navigator's nightmare.

Transition zone surveys conducted in UK waters are limited in number and are unlikely to become more numerous in the future.

Operational Performance

The rate of progress for a seismic survey is constrained by many factors but the most dominant is usually the weather. Other issues that affect the duration of a specific survey are:

- Survey Location
- Time of Year
- Survey Size, particularly Sail Line Length
- Technical Acquisition Parameters
- Vessel Configuration
- Line Orientation and Prevailing Current Direction
- Fishing and Shipping Activity in the Survey Area – trawling especially
- Other Seismic Operations nearby
- Marine Mammal Activity
- Drilling and Subsea Equipment Maintenance, including diving
- Technical Equipment Downtime

The net effect of all of these factors is to limit the time actually spent acquiring seismic data to just 35-40% of the available time.

The reason the weather is so important is that the signal levels that are recorded by the seismic streamer are very small. Because there is a requirement to record data with as wide a bandwidth as possible, to improve the resolution with which geologic features in the subsurface can be identified and mapped, the streamers are towed at quite shallow depths to avoid technical problems. Thus any wave action, which is directly proportional to weather conditions, causes noise that degrades the quality of the recorded data.

The location of the survey dictates the weather environment for the survey, as does the time of year the survey is being conducted. Offshore West Africa, for example, the weather is much better than in the North Sea, and thus two identically sized surveys in these two regions would have significantly different durations.

Activity Levels – Historical - Europe

The first 2D seismic was acquired in the Dutch sector of the North Sea in 1959. Activity started in the UK sector some three years later, Norway two years after that. A steady increase in exploration saw a peak in the mid seventies, followed by a lull until the late eighties. 2D activities have been trailing off since then apart from the UK non North Sea area, namely the Atlantic Margin area, which has seen a major upturn in activity since 1993.

The decline in 2D acquisition has been matched by a rapid increase in the use of the 3D technique. This is a result of the reduction in unit costs for 3D, following the rapid increase in the capabilities of seismic vessels to tow more streamers. From just two streamers towed in 1989, 8 to 10 streamers in 1998, up to the current maximum of 16 in 2001. 3D seismic acquisition therefore, has changed from being just a tool to appraise discoveries and fine tune production, to being used for exploration purposes in frontier areas.

The sharp peaks and troughs in seismic acquisition operations can be traced to a number of factors. Exploration seismic is usually acquired in the period immediate before and after Licencing Rounds issued by the governments, originally annually in the UK but now every two years or so. Oil company budgets are subject to the vagaries of the oil price; downturns in the oil price have led historically to reductions in exploration.

Other Marine Operations

If the survey is in an area of high shipping activity or other marine operations, seismic operations can be difficult. A seismic vessel is limited in its manoeuvrability due to the streamers deployed from the stern, which may be several kilometres long. The seismic vessel itself is in little danger, but with lots of vessels in close proximity, the streamers may well be fouled or cut. Trawl fishing can be a particular hazard. With very high towing strain (may be several tonnes) on the insea equipment cables, there is a danger of both a safety and environmental accident. Aside from the large financial loss from the value of the streamers themselves this can mean a serious loss of earnings through disrupted operations. In difficult areas, chase or escort boats are employed. These are smaller vessels, usually ex-fishing boats, which contact potentially threatening shipping traffic and direct them away from possible contact with the streamers.

Legislative Environment - UK

Under the terms of the Petroleum (Production) Act of 1934 and the 1964 Continental Shelf Act, the Exploration Companies (oil companies) of all surveys conducted in the UKCS to search for petroleum in the strata in the islands and in the sea and subsoil require a license from the UK Department of Trade and Industry (DTI). These exploration licenses have a three year term, are renewable, and have no specific geographical reference.

Production licences for specific blocks or areas are usually applied for in response to invitations issued by the DTI or national equivalent, in respect of blocks or areas specified in the invitation or ‘Round of Licencing’. The licence grants the holder exclusive rights to explore for, and produce petroleum, in the block covered by the licence. The duration of the licence has varied with each Round. Blocks or areas may on occasion be offered for Licencing between Rounds (out-of-Round).

The conditions for each licensed area have evolved over time.

JNCC Requirements

All seismic surveys in designated areas in the UK are subject to the JNCC (Joint Nature Conservation Committee) Guidelines for Minimising Acoustic Disturbance to Marine Mammals. These guidelines have been in place, and formed part of licence conditions, since 1995. These guidelines cover:

1) Before starting a survey line, seismic company personnel should carefully make a visual check to see if there are any cetaceans within 500 metres

   If cetaceans are present, the start of the survey should be delayed until the cetaceans have moved away, allowing adequate time after the last sighting (30 minutes) for the animals to move well out of range. Hydrophones may also be useful in determining when cetaceans have moved out of range.

2) Airgun energy should be built up slowly from low energy to operating level over 30 minutes, to give adequate time for cetaceans to leave the vicinity.

3) Throughout the survey, the lowest practicable energy levels should be used.

4) Reporting of sightings and details of watches (using standard forms)

All seismic acquisition contractors have agreed to conduct survey operations in the UK in accordance with these guidelines and have employed marine mammal observers on their vessels. The JNCC have reported that the data that has been gathered from seismic vessels in the Atlantic margin in recent years has added significantly to their knowledge of cetacean population distributions in the area.

Future Trends

3D survey sizes have historically been increasing due to a variety of economic and technical factors. This trend is likely to be maintained for exploration 3D, but the areas covered in the mature UKCS in recent years are very large and there is a finite limit to the acreage to be surveyed. This does not, however, take into account the potential for reacquiring older 3D surveys in the light of new acquisition and processing technology when it becomes available.

Reservoir specific 3D surveys, which are designed to maximise hydrocarbon recovery from a given reservoir, are necessarily much smaller than exploration 3Ds, since almost all reservoirs in the North Sea are much less than 100 square kilometres in extent. With increased subsurface imaging potentially available from multi-component data, it is probable that there will be a number of geographically small, but geophysically intense, production 3D surveys in the coming years. The exact configurations and techniques employed will be very specific to each particular reservoir, but will involve combinations of most, if not all, the methods described in this booklet.

The complexity of the equipment deployed in the water has dramatically increased in the last decade and whilst there are geophysical limits to how many streamers can be used to image a specific geological target, it is certain that this trend will continue.

The use of seabed receivers, especially multi-component systems, will increase for both 3D surveys and the newly emerging 4D or time lapse 3D technique. In this method, successive 3D surveys acquired months or years apart depending on the characteristics of reservoir production, are compared to determine where fluid movement has occurred (or not) in the reservoir itself.

Research into how improvements to both the quality and productivity of the seismic method will continue as will investigations into how best to quantify and minimise any environmental impact that seismic surveys may have.

Marine seismic surveys have experienced strong growth in the last ten years and it is likely that this growth will continue well into the next millennium. However activity levels will always reflect the economic conditions in which the oil companies are working.

Worldwide there are presently a total of some 80 seismic vessels available. In the past a maximum of about 120 seismic vessels were operating.

Appendix E
Sanco Spirit Maritime and Seismic Specification

Maritime Specification Summary

Name	**Sanco Spirit**
IMO number	9429936
Owner	Sanco Shipping AS
Maritime operator	Jon Aklestad (Sanco Shipping AS)
Flag	GIBRALTAR
Port of registry	Gjerdsvika, Norway
Call sign	ZDJN 3
Builder	Vaaggland Båtbggeri AS, Norway
Built	2009
Classification society and notations to class	DNV + 1A1, ICE-C, HELDK-SH, RP, EO, DYNPOS-AUTR.

Vessel Dimensions

Length	86 M
Breadth	16,00 M
Draft	5,80 Loaded . 4,50 M in Ballast

Vessel Tonnage

Gross (IMO-69)	4396
Net	1319

Vessel Capacities

Fuel	1100m3
Maximum endurance (shooting/transit)	Transit = 27m3/day..Shooting endurance..?10 m3.day,when not towing cables
Vessel Cruising Speed Knots	13 kts
Vessel Speed Knots	13
Maximum Transit Speed Knots	15 kts
Power Plant	4 x 1593 kW, ABC Diesel, 8 DZC, 900 RPM
Propulsion type	2 x Stadt Stascho 2500 KW
Pumps	[Pumps]
Fresh water maker capacity	117m3
Accomodation	47 (13 x Single cabins and 17 double cabins)
Helideck	Diameter 20 m, 11 ton

Communications Systems

Inmarsat B	+870764946968 (69)
Direct Phones	[Direct Phones]
Norsat	+31107130612 (13) (14)

Navigational Aids

Radar	3 cm Furuno FR 2117 and 10 cm Furuno FR 2137 S, Arpa
Auto pilot	Kongsberg with track steering
Heading sensor	Kongsberg Seapath
Echosounder	Furuno FE-700
Water speed log	Furuno DA-80

Vessel Fire Fighting Equipment

Fire detection system	
Pumps	Allweiler
Portable Fire Extinguishers	[Portable Fire Extinguishers]
Hydrants and hoses	[Hydrants And Hoses]

Inert gas and other fixed systems	CO2.Flexifog/ Water mist
Foam deluge system	Foamsystem for helideck ,

Vessel Safety and Survival

Fireman's outfits	4
Breathing apparatus	[Breathing Apparatus Spares] spares
Life boats	n/a
Life rafts	6 x 25 persons
MOB raft	n/a
Life jackets	99
Survival suits	52
Life buoys	10

HSE

[Vessel HSE]

Seismic Specifications

Streamer Systems

Manufacture and type	PGS GeoStreamer® Solid
Skin material	Polyurethane
Outside diameter	62mm cm
Length of each group	12.5m m
Streamer set-up	Typical 1 x 10050m
Manufacture and type of hydrophones	Hydrophones: Teledyne T-2BX or equivalent, Velocity Sensors: PGS confidential (MarkIII)
Type of array (e.g. linear, binomial)	Linear
Number of hydrophones per group/distance apart	Hydrophones: 12 per 12.5m, Velocity Sensors: PGS confidential
Coupling between phones and pre-amp	Capacitive
Sensitivity of near group at 1/P to recorder	20V/Bar
Sensitivity of far group at 1/P to recorder	20V/Bar
Bandwidth over which above sensitivities apply	Specified at 100Hz
Availability of shoreside spares if required	Pool system
Manufacturer and type of depth controller	ION DigiCourse 5011
Manufacturer and type of compass	ION DigiCourse 5011

Recording System

Manufacturer, type	Acquisition System: PGS GeoStreamer 24bit, Recording System: PGS gAS
Number of seismic and auxiliary channels	Typical 1 x 804 + 48
Format(s) available	SEG-D revision 1.0 and 2.1
Tape drives	IBM 3592
Sample rates	1ms, 2ms, 4ms
High cut filter	428Hz, 214Hz, 107Hz @ 341dB/oct
Low cut filter	Hydrophones: 3.04Hz @ 7.5dB/oct, 4.4Hz @ 12dB/oct, Velocity Sensors: PGS confidential
Auxiliary channels allocation	Recorded as separate streamer or appended to streamer 1
Telemetry systems array forming capabilities	Optional

Energy Source

Manufacturer and type	Sercel – G Gun 2
Effective volume of standard array(s)	3111 ci
Maximum number of sub-arrays	6
Standard array depth(s)	7 M
Position of depth transducers	Front and tail of sub-array
Working pressure	2000 psi psi
Type of firing sensors	Pressure activated
Position of firing sensors	Mounted directly on the gun.
Type of firing synchroniser unit	RTS BigShot
Timing resolution	0.1ms ms
Timing accuracy	+/- 1.0ms
Position of near field phones	1 mounted on each gun hang frame.
Air compressors capacity	Neuman & Esser, 2200 cfm each
Number of air compressors	2

Navigation and Positioning Systems

Differential GPS

Standard system	Starfix XP and HP
Subcontractor	[Subcontractor Differential GPS]
Processing software	[Processing Software Differential GPS]

Relative GPS

Standard system	Fugro Seatrack RGPS
Processing software	[Processing Software Relative GPS]

Vessel Heading Sensors

GPS heading reference	[GPS Heading Reference]
Survey gyrocompasses, No/Make/Model	SGBrown Meridien

Acoustic Ranging System

Manufacturer/Model	n/a
Frequency	n/a
Type of units	n/a

Sound Velocity Meters	[Sound Velocity Meters]

Echosounder

Manufacturer, type and model number	Kongsberg EA-600
Frequencies	18 Khz and 32kHz to be confirmed
Maximum sounding depth	[Maximum Sounding Depth M] m

Integrated Navigation Computer System

Type	ORCA
Supplier	Concept - ORCA
Hardware description	[Hardware Description Integrated Navigation Computer System]
Tape drives	[Tape Drives Integrated Navigation Computer System]

Binning System

Type	n/a
Supplier	Concept System, Limited
Hardware description	Reflex

Navigation Post Processing System

Type	[Type Navigation Post Processing System]
Supplier	Concept - ORCA
Software Version	[Software Version Navigation Post Processing System]
Hardware description	Concept Sprint
Plotter	HP-4550..?

Onboard Seismic Data Processing

Standard hardware configuration	N/A
Secondary hardware configuration	2 x IBM x3650 server, 1 x EonStor RAID disk array (9TB), 1 x HP z800 visualisation terminal, 1 x HP xw6600 visualisation terminal, 4 x IBM 3592 tape drive
Standard hardware capacity	N/A

Secondary hardware capacity	[Secondary hardware capacity Onboard Seismic Data Processing]

Appendix F.

List of Phytoplankton Species found in the Study Area. Ocean Biogeographic Information System. www.iobis.org

Scientificname
Ceratium furca
Actiniscus pentasterias
Bacteriastrum spp.
Ceratium arcticum
Ceratium bucephalum
Ceratium carriense
Ceratium extensum
Ceratium fusus
Ceratium hexacanthum
Ceratium horridum
Ceratium lineatum
Ceratium longipes
Ceratium macroceros
Ceratium massiliense
Ceratium minutum
Ceratium trichoceros
Ceratium tripos
Chaetoceros(phaeoceros) spp.
Cladopyxis spp.
Coccolithaceae
Corethron criophilum
Coscinodiscus concinnus
Coscinodiscus wailesii
Cylindrotheca closterium
Dactyliosolen antarcticus
Dactyliosolen mediterraneus
Detonula confervacea
Dictyocysta spp.
Dinoflagellate cysts
Dinophysis spp.
Eucampia zodiacus
Exuviaella spp.
Favella serrata
Fragilaria spp.
Glenodinium spp.
Gonyaulax spp.
Gyrosigma spp.
Halosphaera spp.
Lauderia borealis
Leptocylindrus danicus

Navicula planamembranacea
Navicula spp.
Neodenticula seminae
Nitzschia delicatissima
Nitzschia seriata
Odontella aurita
Odontella sinensis
Oscillatoria spp.
Oxytoxum spp.
Parafavella gigantea
Paralia sulcata
Phaeocystis pouchetii
Phalacroma spp.
Pinus pollen
Podolampas spp.
Prorocentrum spp.
Protoperidinium spp.
Pterosperma spp.
Ptychocylis spp.
Radiolaria
Rhizosolenia acuminata
Rhizosolenia alata alata
Rhizosolenia alata curvirostris
Rhizosolenia alata indica
Rhizosolenia alata inermis
Rhizosolenia bergonii
Rhizosolenia delicatula
Rhizosolenia hebetata semispina
Rhizosolenia imbrica. shrubsolei
Rhizosolenia stolterfothii
Rhizosolenia styliformis
Schroederella delicatula
Scrippsiella spp.
Silicoflagellatae
Skeletonema costatum
Stellate body (land plant hair)
Stephanopyxis spp.
Thalassionema nitzschioides
Thalassiothrix longissima
Tintinnidae
Unidentified coscinodiscus spp.
Unidentified nitzschia spp.
Zoothamnium pelagicum
Foraminifera
Chaetoceros(hyalochaete) spp.
Thalassiosira spp.

Appendix G:

List of Zoooplankton Species found in the Study Area. Ocean Biogeographic Information System. www.iobis.org

Scientificname

Euphausiacea adult
Echinoderm larvae
Decapoda larvae
Copepod nauplii
Copepod eggs
Coelenterata tissue
Chaetognatha traverse
Chaetognatha eyecount
Total copepods
Calanus fin. finmarchicus
Calanus i-iv
Unidentified pleuromamma spp.
Unidentified heterorhabdus spp.
Unidentified gymnosomata
Unidentified euchaeta spp.
Unidentified centropages spp.
Undeuchaeta plumosa
Calanus total traverse
Acartia longiremis
Acartia spp.
Aetideus armatus
Anomalocera patersoni
Atlanta spp.
Calanus fin. glacialis
Calanus helgolandicus
Unidentified pneumodermopsis spp
Calanus hyperboreus
Calanus tenuicornis
Calanus v-vi total
Calocalanus spp.
Candacia armata
Candacia i-iv
Centropages bradyi
Centropages hamatus
Centropages typicus
Cephalopoda larvae
Cirripede larvae
Clausocalanus spp.
Clio spp.

Clione limacina
Cyphonautes larvae
Echinoderm post-larvae
Eucalanus elongatus
Euchaeta acuta
Euchaeta glacialis
Euchaeta norvegica
Euchirella rostrata
Euphausiacea calyptopis
Euphausiacea eggs
Euphausiacea juvenile
Euphausiacea nauplii
Euphausiacea total
Evadne spp.
Fish eggs
Fish larvae
Gaidius spp.
Gammaridea
Harpacticoida total
Heterorhabdus abyssalis
Heterorhabdus norvegicus
Heterorhabdus papilliger
Hyperiidea
Lamellibranchia larvae
Larvacea
Limacina retroversa
Lucicutia spp.
Mecynocera clausi
Metridia i-iv
Metridia longa
Metridia lucens
Metridia total traverse
Microcalanus spp.
Nannocalanus minor
Neocalanus gracilis
Oithona spp.
Oncaea spp.
Ostracoda
Parasites of the plankton
Parasitic nematoda
Parathalestris croni
Pleuromamma abdominalis
Pleuromamma borealis
Pleuromamma gracilis
Pleuromamma piseki
Pleuromamma robusta
Pleuromamma xiphias
Pneumodermopsis paucidens

Podon spp.
Polychaeta larvae
Pseudocalanus elongatus adult
Rhincalanus nasutus
Rotifer eggs
Salpidae
Sapphirina spp.
Scolecithricella spp.
Sergestidae
Siphonophora
Temora longicornis
Temora stylifera
Thaliacea
Tomopteris spp.
Para-pseudocalanus spp.

Appendix H: Marine Fish from the region

Source:

Coad, B.W. and J.D. Reist. 2004. Annotated list of the Arctic Marine Fishes of Canada. Can. MS Rep. Fish. Aquat. Sci. 2674: iv + 112 p.

Acantholumpenus mackayi
Alepocephalus agassizii
Alepocephalus bairdii
Amblyraja hyperborea
Amblyraja jenseni
Amblyraja radiata
Ammodytes dubius
Ammodytes hexapterus
Anarhichas denticulatus
Anarhichas lupus
Anarhichas minor
Anarhichas orientalis
Anoplogaster cornuta
Anotopterus pharao
Antimora rostrata
Aphanopus carbo
Arctogadus glacialis
Arctozenus risso
Argentina silus
Artediellus atlanticus
Artediellus scaber
Artediellus uncinatus
Aspidophoroides monopterygius
Astronesthes cf. *richardsoni*
Bajacalifornia megalops
Bathylagus euryops
Bathyraja sp.
Bathyraja spinicauda
Benthosema glacialis
Boreogadus saida
Borostomias antarcticus
Bythites fuscus
Careproctus longipinnis
Careproctus reinhardti
Caristius sp.
Centroscyllium fabricii

Chaenophryne longiceps
Chauliodus sloani
Chiasmodon niger
Chirolophis ascanii
Clupea harengus
Clupea pallasii
Coregonus artedi
Coregonus autumnalis
Coregonus clupeaformis
Coregonus laurettae[1]
Coregonus nasus
Coregonus sardinella
Coryphaenoides brevibarbis
Coryphaenoides guentheri
Coryphaenoides rupestris
Cottunculus microps
Cottunculus thomsonii
Cyclopteropsis jordani
Cyclopterus lumpus
Cyclothone microdon
Dipturus linteus
Eleginus gracilis
Eumesogrammus praecisus
Eumicrotremus derjugini
Eumicrotremus spinosus
Eurypharynx pelecanoides
Gadus morhua
Gadus ogac
Gaidropsarus argentatus
Gaidropsarus ensis
Gasterosteus aculeatus
Glyptocephalus cynoglossus
Gonostoma bathyphilum
Gymnelus barsukovi
Gymnelus bilabrus
Gymnelus knipowitschi
Gymnelus retrodorsalis
Gymnelus viridis
Gymnocanthus tricuspis
Halargyreus johnsonii
hippoglossoides
Hippoglossoides platessoides
Hippoglossoides robustus
Hippoglossus hippoglossus
Holtbyrnia sp.
Hydrolagus affinis

Icelus bicornis
Icelus spatula
Lampanyctus crocodilus
Lampanyctus intricarius
Lampanyctus macdonaldi
Lampetra camtschatica
Lepidion eques
Leptagonus decagonus
Limanda proboscidea
Lionurus carapinus
Liparis atlanticus
Liparis fabricii
Liparis gibbus
Liparis tunicatus
Lota lota
Lumpenus
Lumpenus fabricii
Lumpenus maculatus
Lumpenus medius
lumpretaeformis
Lycenchelys kolthoffi
Lycenchelys muraena
Lycenchelys paxillus
Lycenchelys sarsii
Lycodes adolfi
Lycodes esmarkii
Lycodes eudipleurostictus
Lycodes frigidus
Lycodes jugoricus
Lycodes lavalaei
Lycodes luetkenii
Lycodes marisalbi
Lycodes mcallisteri
Lycodes mucosus
Lycodes paamiuti
Lycodes pallidus
Lycodes polaris
Lycodes reticulatus
Lycodes rossi
Lycodes sagittarius
Lycodes seminudus
Lycodes terraenovae
Lycodes vahlii
Lycodonus mirabilis
Macrourus berglax
Magnisudis atlantica

Malacoraja spinacidermis
Malacosteus niger
Mallotus villosus
Melanostigma atlanticum
Myoxocephalus aenaeas
Myoxocephalus octodecemspinosus
Myoxocephalus quadricornis
Myoxocephalus scorpioides
Myoxocephalus scorpius
Myxine glutinosa
Nematonurus armatus
Nemichthys scolopaceus
Nezumia bairdii
Notacanthus chemnitzii
Notoscopelus kroeyerii
Oncorhynchus gorbuscha
Oncorhynchus keta
Oncorhynchus kisutch
Oncorhynchus nerka
Oncorhynchus tshawytscha
Oneirodes sp.
Osmerus mordax
Paralepis coregonoides
Paraliparis bathybius
Paraliparis copei
Paraliparis garmani
Peprilus triacanthus
Pholis fasciata
Platichthys stellatus
Pleuronectes glacialis
Pleuronectes putnami
Polyacanthonotus rissoanus
Prosopium cylindraceum
Protomyctophum arcticum
Pungitius pungitius
Rajella fyllae
Reinhardtius
Rhadinesthes decimus
Rhodichthys regina
Saccopharynx ampullaceus
Salmo salar
Salvelinus alpinus
Salvelinus fontinalis
Salvelinus malma
Scopelosaurus lepidus
Sebastes mentella

Sebastes norvegicus
Serrivomer beanii
Somniosus microcephalus
Spiniphryne gladisfenae
Stenodus leucichthys
Stichaeus punctatus
Stomias boa
Symbolophorus veranyi
Synaphobranchus kaupii
Trachyrincus murrayi
Triglops murrayi
Triglops nybelini
Triglops pingelii
Ulcina olrikii
Urophycis chesteri
Xenodermichthys copei
Zoarces americanus

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Science | Sciences

Review of Scientific Information on Impacts of Seismic Sound on Fish, Invertebrates, Marine Turtles and Marine Mammals

Background

A Workshop to develop a "Decision Framework for Seismic Survey Referrals" held in March 2003 produced an inventory of ecological factors that DFO should consider when dealing with referrals for seismic surveys in Canadian waters. The workshop also discussed the sources of uncertainty about effects of seismic sounds on those ecological factors, and ways that the uncertainty could be presented in science documents evaluating possible impacts. The workshop did not attempt to review critically the scientific literature on impacts of seismic sounds or effectiveness of mitigation options. Consequently the meeting did not address tolerances for ecological impacts, if any, or operational standards for respecting such tolerances.

Following that Workshop, teams of scientists prepared major literature reviews of the primary and secondary literature that reports on experimental studies and field monitoring of effects of sound, particularly seismic sound, on marine organisms. Reviews were also contracted of the standards and mitigation methods applied by other national and international bodies which regulate seismic surveys in marine ecosystems, and of the strengths and problems with various sound propagation models in marine environments. These papers were reviewed at a National Advisory Process meeting on Seismic Impact Evaluation Framework in May 2004, although time did not allow a detailed critical review of the paper on standards and mitigation methods.

Figure 1: Map of Canada

Summary

- From the evidence available, it can be concluded that seismic sounds in the marine environment are neither completely without consequences nor are they certain to result in serious and irreversible harm to the environment. In the huge range of effects between those extremes, however there are many *potential* detrimental consequences. In general risks of these consequences are poorly quantified, often unknown, and likely to be variable with both conditions of the environment and of the organisms exposed to the sounds. The long and widespread history of seismic surveys globally in marine environments with no documented fish or invertebrate kills, and only circumstantial evidence of associations with infrequent strandings of marine mammals and giant squid, suggest that seismic surveys with fairly routine mitigation measures in place are unlikely to pose high risk of mortality of marine organisms. However, this suggestion must be qualified, because sublethal or longer-term effects could have occurred and not have been detected by the monitoring programs typically in place.

- Immediate behavioral reactions to exposure to seismic sound have been widely documented in marine organisms, especially marine mammals; particularly behaviors which would result in avoiding the immediate area where the sounds are being produced, or reducing vocalisations. The possible longer-term consequences of these short-term behavioral changes are debated among experts. The debate is largely speculative and there is little empirical basis to determine the likelihood of the full chain of events which would lead to serious longer-term consequences of the short-term behavioral reactions. However, the risk to be managed would be the combined probability of all the events in the chain occurring.

- Whatever the absolute level of risk posed by seismic sounds, there are mitigation measures available which the evidence available suggests can reduce the risk by varying, but sometimes substantial, amounts. The effectiveness of specific mitigation measures was not reviewed in detail at the meeting, but was generally agreed likely to depend on the effect of concern and how the measures are implemented. The impact on the seismic operations of application of some mitigation methods, such as not conducting surveys in critical times and places, will also vary with many factors, but sometimes also could be large. Clearly much more research and monitoring are needed to better clarify and quantify the unknown risks and uncertain effects, if they occur, and the effectiveness of mitigation measures to a wider range of potential effects. Towards that end, some key research needs are listed below.

Introduction

Literature reviews of the primary and secondary literature that reports on experimental studies and field monitoring of effects of sound, particularly seismic sound, on marine organisms were evaluated in May 2004, by a group of scientists from DFO, other federal and international agencies, the hydrocarbon exploration industry and environmental groups. The review indicated that information was incomplete to varying degrees in essentially all areas related to impacts of seismic sound on marine ecosystems. Nonetheless, the background papers and scientific deliberations resulted in a body of information that allowed the following conclusions to be reached.

These conclusions provide a science basis for developing a regulatory framework for use of sound in aquatic environments, at least in the frequencies used for seismic surveys. Some of the conclusions based on the laboratory studies reviewed may generalise to higher frequencies as well, but the review focused on scientific studies directly applicable to seismic sound. The conclusions also contribute to the scientific basis for an integrated approach to managing human impacts on marine ecosystems, and for dealing with referrals of applications for seismic surveys at the regional to national level within DFO.

Habitat Concern

The issue of concern was the effects of sound, particularly seismic sound, on marine organisms. Advice was sought to provide a scientific basis for developing a regulatory framework for use of sound in aquatic environments, at least in the frequencies used for seismic surveys.

Management Considerations

Overall Considerations:

1) The following statements and conclusions are based on information available and presented at the time of the Seismic Impacts Evaluation Framework workshop. Additional research is needed in many areas, and a number of these are identified in the meeting proceedings. These statements and conclusions

should be re-evaluated as new information becomes available.

2) When considering the possible impacts of seismic sounds on the marine ecosystem, it makes sense to embed these considerations within the larger framework of the impact of all anthropogenic noise on the ecosystem. The major anthropogenic sources of noise that might be appropriate to consider in a holistic view would include seismic sounds, shipping, explosives, construction, and low-frequency SONAR. Moreover, the significance of impacts of sound in the environment, if any, should be evaluated in the context of other uses of ecosystem.

3) The dearth of scientific information, especially concerning field experiments on fish, invertebrates, and the larger marine mammals, makes it extremely difficult to evaluate the impact of a particular type of seismic sound, or more generally noise, on a particular species. Restricting our consideration to only seismic sound impacts would have reduced the already-sparse information base to one that would not have supported any conclusions with an acceptable level of confidence, so we have looked more widely for relevant information.

4) If was not just for convenience that we looked for information more widely than just considering publications on effects of seismic sound on marine species. Given the scarcity of hard information on so many facets of this multi-dimensional problem, it is likely that a meaningful appreciation of risk can only be obtained by taking an integrated view of all the sources of information available.

5) Many conclusions refer to the likelihood of various biological effects, if animals were exposed to seismic sound. Likelihood is used in a relative sense, and not as the product of quantitative risk assessments, which are not possible with the information available. Saying that an event has a "high likelihood" does not mean we necessarily expect to see it in nine out of every ten animals exposed to the sound, or even in nine out of ten replicates of the same experiment. Rather, it means that compared to the expectation of the event in the absence of seismic sound, the likelihood of the event has increased substantially, and it would be observed if sought with due diligence. However, it still may not be the typical event. Where quantification of the probability of an event is possible, we use the term "probability" rather than "likelihood".

6) The conclusions that follow often refer to "seismic sound" and "field operating conditions". These terms are used colloquially and are not defined prescriptively. In this document "seismic sound" refers generally to that produced by the types of airguns and arrays normally used at present in Canadian waters. "Field operating conditions" refers to 2-D and 3-D seismic surveys using measures such as ramp-up of sound level at onset, and ceasing sound emissions when cetaceans are known to be in the proximity of the operations.

7) Both the likelihood and severity of biological effects that may result from seismic surveys are likely to vary with local conditions of the environment (ice coverage, bottom topography, sea state, etc.) and conditions of the organisms (breeding state, nutritive condition, etc.). These conditions should not be ignored when evaluating risks and the potential for mitigation, however regulatory frameworks do not need complex rules to be effective.

Limitations for quantitative conclusions:

8) It was agreed that the biologically meaningful aspect of seismic sound is the "received sound" by the organism(s) potentially being affected. However, "received sound" is multi-dimensional. Seismic sound (or noise in general) can be characterised by its frequency spectrum (acoustic energy or pressure as a function of acoustic frequencies), peak pressure (a time domain concept, referring to the maximum instantaneous amplitude of the pressure signal), rms pressure (mean pressure averages over a time interval), Sound Exposure Level (a measure of the “dosage” of sound energy received over a time interval), and in other ways.

9) The mechanisms by which exposure to seismic sound could result in biological impacts are sufficiently varied that no one metric may be sufficient to describe the risk of impact from a particular type of seismic sound. Some mechanisms may be well characterised by one or two of these metrics; others may not be well characterised by any of them. For example, peak pressure may be the most relevant parameter for risk of trauma, whereas rms pressure may be the most relevant parameter for non-trauma effects such as Temporary Threshold Shifts [TTS]. The frequency band, intensity, and duration of exposure all contribute to auditory effects, because although the impact must occur within the frequency band of exposure, we anticipate that auditory impact is greater within the hearing range of a species, and will decline towards the margins of its hearing threshold.

10) Many studies of the impacts of seismic sound on marine animals reduce the information about the sound used or received to a few numbers. This practice often discards important information, and makes inter-comparison of results across studies very difficult.

11) Although careful experimentation ought to be able to determine which feature(s) of the sound stimulus caused the observed reactions (when they occurred), the existing literature on experiments with marine fish and invertebrates rarely describes completely enough the characteristics of the sounds used to allow biological observations to be interpreted with confidence.

12) The literature on experiments and field observations of marine mammals exposed to sound stimuli is more extensive than the literature on effects on other types of marine organisms, and therefore likely to provide a more complete (but still partial) basis for setting thresholds. However the results, taken together, were complex and inconsistent and were an insufficient basis for agreement on quantitative thresholds for impacts on marine mammals, even from those studies where there were adequate descriptions of the sound characteristics. The major review by the NMFS Acoustic Criteria Panel is devoting much more time to this information, and may contain a quantitative synthesis of stimulus-response relationships from the information available at present. That review, when released, may comprise a useful source of information for defining regulatory tolerances. Where sensitivities of marine turtles, fish, or invertebrates are documented to be greater than sensitivities of marine mammals those factors should be taken into account in the Canada standards, guidelines and/or regulations. It was conjectured that sedentary species that cannot leave an area may experience higher levels of exposure to seismic sound than mobile animals, and this factor may be taken into account in management as well.

13) Ecological “significance” can be a value-laden term, although in these conclusions “significant” is used only in the context of DFO’s areas of responsibility. Specifically, DFO has a responsibility for conservation of aquatic species (except birds) and ecosystems, and where detrimental population-scale impacts are considered likely, DFO must ensure that the impacts are mitigated or remediated. Likewise, for aquatic species protected under Schedule 1 of SARA, if deaths, harm or harassment of individuals is considered likely to occur, DFO must

either act to ensure the impacts are ameliorated, or issue permits under the provisions of Section 73 of SARA.

Other limitations:

14) A number of studies reported sub-lethal effects on marine organisms, such as elevated stress-related chemicals, and damage to ears or other morphological structures. The dearth of long-term studies of marine organisms exposed to seismic sounds means that the long-term consequences of these effects, when they occur, are unknown.

15) The severity of impact at the population level may be higher for an effect like auditory masking, if it occurs, because masking has the potential to affect a very large geographical area for low frequency sounds. Masking also may have few immediately observable signs that impacts are occurring, so mitigation may be less likely to be triggered than with individual mortalities due to trauma, (which have limited geographical extent and are more easily observable).

Conclusions Regarding Fish

Physical Effects

1) There are no documented cases of fish mortality upon exposure to seismic sound under field operating conditions. With regard to the detectability of fish kills, if they occurred, it was noted that in Canada seismic surveys have frequently, but not always, included follow-on vessels instructed to watch for fish kills, and none have been observed. It was also noted that fish kills are not necessarily cryptic events, and kills caused by anoxic events, toxic spills etc are often readily detected. However, it was also argued that the efficiency of detecting fish kills by the follow-on vessels was not tested independently, so the possibility of undetected fish kills cannot be eliminated.

2) Under experimental conditions one study found that some subjects from three of four species tested suffered lethal effects from low-frequency (<500 Hz) tonal sounds, under exposure levels of 24 h at >170 dB. Participants noted that the experimental regime differed greatly from field operating conditions of seismic surveys, so extrapolation of the results to seismic surveys was not warranted. However some participants argued that the result indicates that risk of direct fish mortality from sounds with some characteristics of seismic sound cannot be discounted completely.

3) One anecdotal report of fish mortality upon exposure to an airgun less than 2 m away was discussed and found to be inconclusive when considered relative to field operating conditions. Overall, exposure to seismic sound is considered *unlikely* to result in direct fish mortality.

4) Under experimental conditions, sub-lethal and/or physiological effects, including effects on hearing, have sometimes been observed in fish exposed to an airgun. The experimental design made it impossible to determine to the satisfaction of all experts what intensity of sound was responsible for the observed damage to ear structures, nor the biological significance of the damage that was observed. Simulated field experiments attempting to study such effects have been inconclusive. Currently, information is inadequate to evaluate the likelihood of sub-lethal or physiological effects under field operating conditions. The ecological significance of sub-lethal or physiological effects, were they occur, could range from trivial to important depending on their nature.

Behavioral Effects

5) There is high likelihood of obtaining the following effects in some fish exposed to seismic sound:

- startle response,

- change in swimming patterns (potentially including change in swimming speed, and directional orientation), and
- change in vertical distribution.

6) These effects are expected to be short-term, with duration of effect less than or equal to the duration of exposure, are expected to vary between species and individuals, and be dependant on properties of received sound. The ecological significance of such effects is expected to be low, except where they influence reproductive activity.

7) Several scientific studies have investigated other behavioral effects on fish during seismic surveys. Some have found the effects listed below and some have not:

- Change in horizontal distribution of fish not closely associated with habitat structures such as a reefs or pinnacles,
- Change in catchability of fish possibly related to changes in behavior. Differences in experimental regimes and lack of adequate controls in some of the experiments means that the published results are an insufficient basis to predict the nature of any change that may occur, or even if a change will occur.

8) The duration of these effects may or may not extend beyond the duration of exposure, are expected to vary between species and individuals, and be dependant on the properties of received sound. The ecological significance of such effects is expected to be low, except when they may lead to a dispersion of spawning aggregations or deflection from migration paths. The magnitude of effect in these cases will depend on the biology of the species and the extent of the dispersion or deflection.

Functional Uses of Sound

9) The potential for seismic sound to disrupt communication, detection of predators/prey, navigation and other functional uses of sound by fish has not been studied. There is speculation that the discontinuous nature of seismic signals may allow these functions to occur between sound "pulses". There is also speculation that behavioral responses may include cessation of sound production by fish. If it were to occur, hearing damage would also be expected to impact these functions. Ecological significance of such effects is unknown.

Conclusions Regarding Invertebrates

Physical Effects

1) There are no documented cases of invertebrate mortality upon exposure to seismic sound under field operating conditions. An anecdotal report of beachings of giant squid on two occasions, which corresponded to periods of seismic activity, was discussed and found to be inconclusive.

2) Under experimental conditions, lethal and/or sub-lethal effects, including effects on external structure, have sometimes been observed in invertebrates exposed close to (less than 5 m) an airgun.

3) Therefore, exposure to seismic sound is considered *unlikely* to result in direct invertebrate mortality.

Physiological Effects

4) There is a series of publications showing effects of extended exposure to non-seismic sounds on the physiology of crustacean under experimental conditions. Effects include reduced growth and reproduction rates and behavioral changes, which indicate the

sensitivity of some invertebrates to noise. In a gastropod (mollusc) the physiological effects (sign of stress) were reported under field seismic operating conditions. In other species such effects were rarely present, except for some sign of excitation of ensonified crabs compared to control crabs.

5) Currently, information is lacking to evaluate the likelihood of sub-lethal or physiological effects on crustaceans during pre-molt, molting and post-molt periods.

6) The ecological significance of sub-lethal or physiological effects, were they occur, could range from trivial to important depending on their nature.

Behavioral Effects

7) There is high likelihood of obtaining the following effects in some invertebrates exposed to seismic sound:

    - startle response,
    - change in swimming/movement patterns (potentially including change in swimming/movement speed, and directional orientation).

8) Both increases and decreases in catch rates of commercially exploited species have been documented, but changes do not occur consistently.

9) These effects are expected to be short-term, with duration of effect often less than the duration of exposure, are expected to vary between species and individuals, and be dependent on properties of received sound.

10) Some invertebrates are sedentary or have limited locomotive capacity. Therefore their capacity to avoid seismic sound is extremely limited compared to many fish and marine mammals. This may increase their exposure to seismic sounds, but there is no basis on which to assume that increased exposure makes such species inherently more or less sensitive to those sounds.

11) The ecological significance of the effects is expected to be low, except if effects of exposure to seismic sounds were to influence reproductive or growth (molting) activities, or lead to a dispersion of spawning aggregations or deflection from migration paths. The magnitude of effect in these cases will depend on the biology of the species and the extent of the dispersion or deflection.

Functional Uses of Sound

12) The potential for seismic sound to disrupt communication, orientation, detection of predators/prey, locomotion and other functional uses of sound by invertebrates has not been studied. Loud sounds will reduce the efficiency of communication and other functional uses of sounds, but the severity and conditions under which this occurs with invertebrates are unknown. It is not known if invertebrates can communicate acoustically during the inter-pulse intervals that occur between seismic transmissions. Ecological significance of such effects, if they occur, is unknown.

Conclusions about Zooplankton, Eggs and Larvae of Fish and Invertebrates

1) Few studies of the effects of seismic sound on eggs and larvae or on zooplankton were found. A number of these provided inadequate description of experiment design, properties of the sound applied as treatments, or had methodological shortcomings.

2) Data are generally insufficient to evaluate the potential damage to eggs and larvae of fish and shellfish (or other planktonic organisms) that might be caused by seismic sound under field operating conditions.

3) From the experiments reported to date, results do show that exposure to sound may arrest development of eggs, and cause developmental anomalies in a small proportion of exposed eggs and/or larvae; however these results occurred at numbers of exposures much higher than are likely to occur during field operation conditions, and at sound intensities that only occur within a few meters of the sound source.

4) Effects of seismic sounds on behavioral functions and sensory perception of fish and invertebrate eggs and larvae are unknown;

5) In general, the magnitude of mortality of eggs or larvae that models predict could result from exposure to seismic sound would be far below that which would be expected to affect populations. However, special life history characteristics such as extreme patchiness in distribution and timing of key life history events in relation to the duration and coverage of seismic surveys may require case by case assessment.

6) No studies were found which specifically investigated the role of seismic sounds in recruitment variation of marine fish or invertebrates. There have been a large number of research studies on causes of variation in recruitment of marine fish or invertebrates, and none has considered that there are recruitment anomalies (positive or negative) which might be linked in space or time to seismic survey operations. This negative evidence applies at the scale of stocks, but does not provide information about the potential for effects on local-scale recruitment dynamics.

Conclusions Regarding Marine Turtles

1) Auditory studies suggest that sea turtles, specifically loggerhead and green turtles, are able to hear and respond to low frequency sound, but their hearing threshold appears to be high.

2) In three studies, the following behavioral responses of sea turtles in enclosures exposed to airgun sounds were sometimes observed:

   - increased swimming speed,
   - increased activity,
   - change in swimming direction, and
   - avoidance.

3) Sea turtles may become accustomed to seismic sound over time, but results of three studies were inconclusive on this matter.

4) Loss of hearing sensitivity and physiological stress response has also been considered as a possible consequence of exposure of sea turtles to seismic sound, but the one study reviewed was inconclusive.

5) The response, if any, of free-ranging sea turtles to seismic sound conducted under field operating conditions is unknown.

6) Based on studies that have been conducted to date, it is considered *unlikely* that sea turtles are more sensitive to seismic operations than cetaceans or some fish. Therefore, mitigation measures designed to reduce risk or severity of exposure of cetaceans to seismic sounds may be informative about measures to reduce risk or severity of exposure of sea turtles to seismic sounds. However sea turtles are harder to detect both visually and acoustically than are many species of cetaceans, so mitigation strategies based on sightings or acoustic detection of turtles, are expected to be less effective for turtles than for cetaceans.

Conclusions Regarding Marine Mammals

Mortality and Physical Effects

1. There are no documented cases of marine mammal mortality upon exposure to oil and gas exploration seismic surveys. There is one case of a stranding event involving two whales coincident in space and time with a research vessel conducting seismic operations. There is one stranding event involving the same vessel and whales, coincident in time but not space, with no obvious mechanism that could bridge the distance between the vessel and the stranding site. In both cases the research vessel was also operating mid-frequency airgun systems that produce sound significantly more similar in character to the tactical mid-frequency sonar implicated in whale mass stranding events, than is seismic sound. The role of the different sound sources in the stranding events could not be resolved by the study. Therefore, although whale strandings have been linked to exposure to anthropogenic sound, exposure to seismic sound is considered *unlikely* to cause direct marine mammal mortality.

2. Under experimental conditions, sub-lethal, temporary elevations in hearing thresholds (TTS) have sometimes been observed in captive marine mammals exposed to pulsed sounds. Currently, the likelihood of these effects have not been evaluated under field operating conditions; for some species of marine mammals the levels and types of sounds which may produce TTS can be predicted, so such evaluations may be possible. The significance of such TTS effects, were they occur, are likely to be unimportant, unless:

   a. the threshold was elevated repeatedly or for an extended period of time, which could result in a Permanent Threshold Shift [PTS]; or

   b. other threats were present at the same time as the temporary elevations in hearing thresholds, and the threats were ones normally avoided by acoustic means, such as predators or entanglements in fishing gear.

3. There are no documented cases of a marine mammal experiencing damage to non-auditory body tissues upon exposure to seismic surveys under field operating conditions. Therefore, exposure to seismic sound under field operating conditions is considered *unlikely* to result in such types of tissue damage to marine mammals, but the presence of other sound sources operating simultaneously with seismic operations should be taken into account when proposals are evaluated.

Direct Behavioral Effects

Displacement and Migratory Diversion:

4) There is documented displacement and migratory diversion in some marine mammal species exposed to seismic sound. The duration of these effects may or may not extend beyond the duration of exposure. The effects are expected to vary between contexts, species, gender and age class, and individuals, and be dependant on the properties of received sound. The ecological significance of such effects is expected to be low, but may be higher if they:

   - displace feeding marine mammals from areas where there are no alternates,
   - displace marine mammals from resting areas where there are no alternates,
   - displace marine mammals from breeding or nursery areas, or
   - divert migrating animals from routes for which their alternate routes either do not exist or would incur substantially greater costs to traverse.

5) The magnitude of effect in these cases will depend on the biology of the species and the extent and duration of the dispersion or deflection. Also, there is a risk that a seismic project occurring in another area could cause incursion of displaced competitors into the critical habitat or area of high biological productivity occupied by other species.

6) In summary, exposure to seismic sound can result in displacement and/or migratory diversion in some marine mammals, but this effect is species, individual, and contextually-related. The ecological significance of such effects is *unknown*, but there are conditions under which the worst-case scenarios could be high.

Changes in Dive and Respiratory Patterns

7) There are documented changes in dive and respiratory patterns in some marine mammal species (e.g., bowhead whales, harbour and grey seals) exposed to seismic sound. There are records of the duration of these effects extending beyond the duration of exposure. The effects are expected to vary between contexts, species and individuals, and be dependant on the properties of received sound. The ecological significance of such effects is expected to be low, except if such effects:

- interfere with feeding, or
- incur substantial energetic costs;

The magnitude of effect in these cases will depend on the biology of the species and the extent and duration of the dispersion or deflection.

8) In summary, exposure to seismic sound can result in changes in dive and respiratory patterns in some marine mammals, but this effect is expected to vary with species, individual, and context. The ecological significance of such effects is *unknown*, but there are conditions under which the worst-case scenarios could be high.

Changes in Social Behavior

9) Social behavior can include a wide variety of activities such as mating, cooperative feeding, play, aggressive interactions, and communication (see below). Studies of behavioral changes in other subsections of this summary describe effects on some of the activities that could be considered “social”. However, there have been no directed studies of the effects of seismic sounds on mating, cooperative feeding, play, or aggressive interactions.

10) In summary, it is *unknown* if exposure to seismic sound can result in changes in marine mammal social behavior, but if it were to occur there are conditions under which the worst-case consequences of such changes could be highly significant.

Changes in Vocalisation Patterns

11) There have been direct studies of the potential for anthropogenic sound to cause changes in the vocalisation patterns of marine mammals. For most cetacean species studied, there were measurable changes in vocalisation patterns, but these studies were not conducted during seismic operations. In the UK, Norway, and the Sable Gully, sperm whales did not stop calling when exposed to seismic sounds. A study off Heard Island, found that sperm whales did not call during distant (690-1070 km away) seismic transmissions in some parts of the study, but did call during seismic transmissions during another part of the study. Blue whales in the NE Pacific stopped calling for approximately one hour when within 10 kilometers of a small (1600 in^3) seismic array; they resumed calling as they swam away from the array.

12) There is evidence that exposure specifically to seismic sounds has sometimes caused changes in vocalisation patterns in marine mammals. However, it has not been possible to measure the functional consequences of

these changes (such as loss of contact between individuals or reduced ability to coordinate social behaviors), if any, nor the percent of time which they would occur.

13) In summary, it is *known* that exposure to seismic sound can result in changes in marine mammal vocal behavior, and when it occurs there are conditions under which the worst-case consequences could be highly significant.

Functional Consequences of Physical and Behavioral Effects

Reduced Communication Efficiency

14) Many species of marine mammals both produce and respond to sounds. Studies have shown these vocalisations to sometimes communicate information that is functionally important for feeding, breeding, parental care, predator avoidance, or maintenance of social groupings. Studies have also found vocalisations can occur when there are no observable functional consequences, although in such cases it is unclear if the vocalisations had no consequences, or if the effects were longer term or farther afield than the studies. Hence it is difficult for research to produce conclusive results about the frequency of occurrence and consequences of disruption of communication by anthropogenic activities, including seismic sounds.

15) There have been no published studies of the potential for seismic sound to reduce the efficiency of communication in marine mammals. Loud sounds will reduce the efficiency of communication but the severity and conditions under which this occurs with marine mammals are poorly known. When seismic sounds are produced there are inter-pulse intervals which present the opportunity for cetaceans to place vocal communication signals, but cetaceans have not been shown to use this mechanism in the field. Moreover, there is unpublished information that when multi-path echoes occur, such as in areas of complex bathymetry, the pulses of the seismic sound may smear over distance and time, such that the quieter inter-pulse intervals may be reduced or eliminated. This creates the potential for calls of cetaceans such as blue whales to be masked by seismic sounds although the distances over which the masking would be effective, if it were to occur, are unknown. It is unknown if whales could reduce the effects of masking through processes such as changes in their calling patterns, and the consequences of these changes (if they occur) are unknown. This facultative response has been documented in some other marine mammal species exposed to loud manmade sounds. Therefore, it is *unknown* if exposure to seismic sound can result in such reduced communication efficiency in marine mammals.

Reduced Echolocation Efficiency

16) There have been no direct studies of the potential for seismic sound to reduce the efficiency of echolocation in marine mammals. Therefore, it is *unknown* if exposure to seismic sound can result in reduced echolocation efficiency in marine mammals.

<u>Hampered Passive Acoustic Detection of Prey</u>

17) There have been no direct studies of the potential for seismic sound to hamper the passive acoustic detection of prey by marine mammals. In a published study on the effects of whale watching vessels on killer whale behavior, it was postulated that sounds from these vessels could reduce the ability of killer whales to detect their prey. It is not known if such an effect could result during exposure to seismic sounds, or even which species of marine mammals use passive acoustic detection of prey as an important feeding strategy. However the potential for an effect is greatest for mysticetes whose best hearing sensitivity is thought to be at lower frequencies than other marine mammals. Therefore, it is *unknown* whether exposure to seismic sound could hamper the passive acoustic detection of prey by marine mammals.

<u>Hampered Passive Acoustic Detection of Predators</u>

18) There have been no direct studies of the potential for seismic sound to hamper the passive acoustic detection of predators by marine mammals. The potential for an effect is greatest for mysticetes, whose best hearing sensitivity is thought to be at lower frequencies than other marine mammals. However it is not known if such an effect occurs during exposure to seismic sounds, and if so, to what extent. Therefore, it is *unknown* whether exposure to seismic sound could increase the vulnerability of marine mammals to predators.

<u>Hampered Avoidance of Anthropogenic Threats (such as ship strikes, net entanglement)</u>

19) There have been no direct studies of the potential for seismic sound to reduce the ability of marine mammals to avoid anthropogenic threats. There are published reports of other types of sounds interfering with the ability of individual whales to avoid anthropogenic threats such as ship strikes and net entanglements, but it is not known how widespread this response is. It is also not known if such an effect could result from exposure to seismic sounds. Therefore, it is a *concern* that exposure to seismic sound could reduce the ability of marine mammals to avoid anthropogenic threats, but the risk has not been demonstrated.

<u>Hampered Parental Care or Bonding</u>

20) There have been no direct studies of the potential for seismic sound to hamper parental care or bonding in marine mammals. Therefore, it is *unknown* if exposure to seismic sound can hamper parental care or bonding in marine mammals.

Chronic Effects (e.g., stress-related physiological changes, reduced fecundity)

21) There have been no studies of the potential for seismic sound to induce chronic effects, such as immunosuppression or reduced fecundity, in marine mammals. Therefore, it is *unknown* if exposure to seismic sound can result in such chronic effects on marine mammals.

Indirect Effects (e.g., reduced prey availability)

22) There have been no studies of the potential for seismic sound to reduce prey availability, through displacement or reduced catchability, for marine mammals. Therefore, it is *unknown* if exposure to seismic sound can result in such indirect effects on marine mammals.

Research Needs

In the review a large number of areas of future research were identified. Some emerged as particularly helpful in increasing the information available to those quantifying and those managing the risks of seismic surveys in marine ecosystems.

1) More work is required to determine the sound characteristics and environmental conditions under which seismic effects on behavior, physiology, and physical well-being of all types of marine species might occur.

2) The available information on the effectiveness of mitigation measures needs to be more fully evaluated, as a basis for both interim advice on appropriate operational requirements in the short term and additional research needs to increase our knowledge in the longer term.

3) In addition to targeted research, there is great value to linking a program of structured collection of information to the conduct of seismic surveys, to facilitate learning-by-doing. However, such information collection programs must be well coordinated, and accompanied by the resources to analyse, interpret, and apply the new information, as it is collected and submitted to scientific authorities.

4) A few representative studies on distance-effect relationships for all taxa, but particularly eggs and larvae, would greatly aid understanding of potential risks posed by seismic sound. The potential for effects stemming from sound exposure level (cumulative over a survey) as well as peak received sound pressure level should be considered, including under conditions of 3-D surveys.

5) Specific research is needed on the level of received sound experienced by sessile invertebrates, and the effects of seismic sounds on such organisms. The physics of the sound levels to which benthic organisms are exposed is complicated due to shear effects interacting with pressure effects, and the proximity to the bottom substrates. Hence results of generic sound propagation models are likely to be misleading with regard to exposure levels of sessile benthic species. However, the errors could be in any direction, and in sites of complex bathymetry there could be very patchy distributions of areas with higher intensities of exposure than predicted by sound propagation models and other areas with lower intensities.

6) There is a specific absence of information on the effects of seismic sounds on molting of invertebrates with hard exoskeletons.

7) There is a need to further clarify the best sound propagation models for the areas likely to host seismic exploration, and how habitat characters should influence model selection. Generic models also need to be evaluated relative to the sensitivity and precision of their predictions relative to requirements for evaluating potential impacts, although site-specific implementations of generic models will continue to be desirable.

8) Better data input is needed during modelling of the expected pattern of spread of seismic sounds during surveys. Near-and far-field sound measurements should be encouraged as part of seismic operations planned for an area that has not been surveyed previously, or if previous models have been shown to be inaccurate.

9) Further research on potential impacts of seismic sound on marine mammals is urgently needed. The issues in most need of attention through scientific research or further analysis of existing data include:

    a) An important scientific unknown limiting our ability to predict the effects of seismic surveys on marine mammal populations is knowledge of their spatio-temporal distribution, and physiological state and needs. Without knowledge about what species are present in which areas at what time of the year and for what purpose, there will always be risks of disturbance and injury to sensitive species. An effort should also be made to characterise the degree of long-term natural variation in abundance and residency.

b) There is a need for significantly more information regarding the reactions of marine mammals (and their prey) to underwater sound from seismic arrays. Baseline studies prior to seismic operations, plus comparative reports during periods with and without seismic would contribute important new data.

c) There is a need for better and more accurate information on naturally-occurring and man-made noise in the ocean.

d) The effectiveness of all potential mitigation measures needs to be explored and documented more fully. In particular there is a need to document the extent to which passive and/or active acoustic monitoring of marine mammals from the source vessel is an effective mitigation strategy.

e) There is a particular need for directed studies of social behavior of marine mammals during seismic exposures, given the importance of these activities to marine mammals' biology.

f) The effects of anthropogenic sounds on the vocalisation patterns of marine mammals are well documented, but the effects of specifically seismic sounds are poor known, and warrant further study.

Many of these factors are also poorly known for many taxa of marine turtles, fish, and invertebrates. Research to fill in such knowledge gaps, particularly with regard to spatio-temporal distribution of important prey taxa and their reactions to seismic sound, would be valuable, although the topics listed above were given higher priority. A number of other topics requiring additional research were proposed by various individuals, and are recorded in the meeting proceedings.

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The Leach's Storm-Petrel:
General information and handling instructions

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The Grand Banks is an area that is frequented by large numbers of seabirds, representing a variety of species. Large populations are found in this area in both summer and winter, and come from the Arctic, northern Europe, and the south Atlantic, as well as from colonies along the Newfoundland Coast. One of the species found in the area of the Terra Nova Field is the Leach's Storm-Petrel (*Oceanodroma leucorhoa*).

The Bird:

Leach's Storm-Petrels are small seabirds, not much bigger than a Robin. They have relatively long wings and are excellent fliers. Leach's Storm-Petrels are dark brown in colour and show a conspicuous white patch at the base of the tail. In the hand, you can easily notice a small tube at the top of their bill, and you will also notice that the birds have a peculiar, not unpleasant smell (although some Newfoundlanders call these birds "Stink Birds"). Storm-Petrels are easy prey for gulls and other predators, and so to protect themselves from predation, Leach's Storm-Petrels are only active at night when on land at the breeding colonies.

Nesting Habitat:

Leach's Storm-Petrels are distributed widely in the northern hemisphere, however, their major centres of distribution are Alaska and Newfoundland. The bird breeds on offshore islands, often in colonies numbering tens or hundreds of thousands of pairs, even millions at one colony in Newfoundland. The nest is a chamber, sometimes lined with a some grass, located at the end of a narrow tunnel dug in the topsoil.. Depending on the colony, burrows may be under conifer or raspberry thickets or open grassland.

Reproduction:

In Newfoundland, Leach’s Storm-Petrels lay their single egg in May and June. The egg is incubated by both parents alternately, sometimes for stretches exceeding 48 hours. The egg is incubated for 41-42 days, which is a long time for such a small egg. The peak hatching period is in the last half of July. The young petrel remains in the tunnel for about 63-70 days. Once breeding is over in late-August or early September, the birds disperse from the colonies and migrate to their wintering grounds in the Atlantic. September is the most important period for migration of Storm-Petrels to the offshore areas such as near the Terra Nova field.

Populations:

Canada alone supports more than 5 million pairs of Leach's Storm-Petrels. Most of them are found in Newfoundland. The Leach’s Storm-Petrel colony located on Baccalieu Island is the largest known colony of this species.

Nesting sites for Leach’s Storm-Petrels are found along the southeast coast of Newfoundland. These are - i) Witless Bay Islands (780,00 nesting pairs), ii) Iron Island (10,000 nesting pairs), iii) Corbin Island (100,000 nesting pairs), iv) Middle Lawn Island (26,000 nesting pairs), v) Baccalieu Island (3,336,000 nesting pairs), vi) Green Island (72,000 nesting pairs), and vii) St. Pierre Grand Columbier (100,000 nesting pairs).

Feeding Habits:

Leach’s Storm-Petrels feed at the sea surface, seizing prey in flight. Prey usually consists of myctophid fish and amphipods. The chick is fed planktonic crustaceans, drops of stomach oil from the adult bird, and small fish taken far out at sea. Storm-Petrels feed far out from the colony and it would be reasonable to assume that birds nesting in eastern Newfoundland can be found feeding around the Terra Nova site.

The Problem:

As identified in the C-NOPB Decision 97-02, seabirds such as Leach’s Storm-Petrels are attracted to lights on offshore platforms and vessels. Experience has shown that Storm-Petrels may be confused by lights from ships and oil rigs, particularly on foggy nights, and will crash into lighted areas such as decks and portholes. Fortunately, this type of accident does not often result in mortality, however, once on deck the bird will sometimes seek a dark corner in which to hide, and can become fouled with oil or other contaminants on deck.

Period of Concern:

Leach’s Storm-Petrels are in the Terra Nova area from about May until October and birds could be attracted to lights at any time throughout this period. The period of greatest risk of attraction to lights on vessels appears to be at the end of the breeding season when adults and newly fledged chicks are dispersing from the colonies and migrating to their offshore wintering grounds. September is the most important period for migration of storm-petrels to the offshore areas. Past experience suggests that any foggy night in September could be problematic and may result in hundreds or even thousands of birds colliding with the vessel.

The Mitigation:

On nights when storm-petrels are colliding with the vessel, the following steps should be taken to ensure that as many birds as possible are safely returned to their natural habitat.

- All decks of the vessel should be patrolled as often as is needed to ensure that birds are picked up and boxed (see below) as soon as possible after they have collided with the vessel. After collision, birds will often "freeze" below lights on deck or seek dark areas underneath machinery and the like.
- Birds should be collected by hand and gently placed in small cardboard boxes. Care should be taken not to overcrowd the birds and a maximum of 10-15 birds should be placed in each box, depending upon its size. The birds are very easy to pick up as they are poor walkers and will not fly up off the deck so long as the area is well-lit. They will make a squealing sound as they are picked up- this is of no concern and is a natural reaction to be handled (the birds probably think they have been captured to be eaten!).
- When the birds are placed in the box the cover should be put in place and the birds left to recover in a dark, cool, quiet place for about 5-10 minutes. The birds initially will be quite active in the box but will soon settle down.
- Following the recovery period, the box containing the birds should be brought to the bow of the boat or to some other area of the vessel that has minimal (if any) lighting. The cover should be opened and each bird individually removed by hand. The release is usually accomplished by letting the bird drop over the side of the vessel. There is no need to throw the bird up in the air at release time. If the birds are released at a well-lit part of the vessel they usually fly back towards the vessel and collide again.
- If any of the birds are wet when they are captured (i.e. they drop into water on the deck) then they should be placed in a cardboard box and let dry. Once the bird is dry it can be released as per the previous instruction. Also, temporarily injured birds should be left for longer to recover in the cardboard box before release.
- Any birds contaminated with oil should be kept in a separate box and not mixed with clean birds. Contact Canadian Wildlife Service at (709) 772-5585 for instructions on how to deal with contaminated birds.
- In the event that some birds are captured near dawn and are not fully recovered before daylight, they should be kept until the next night for release. Storm-Petrels should not be released in daylight as at this time they are very vulnerable to predation by gulls. Birds should be kept in the cardboard box in a cool, quiet place for the day, and do not need to be fed.
- Someone should be given the responsibility of maintaining a tally of birds that have been captured and released, and those that were found dead on deck. These notes should be kept with other information about the conditions on the night of the incident (moonlight, fog, weather),

date, time, etc). THIS IS A VERY IMPORTANT PART OF THE EXERCISE AS IT IS THE ONLY WAY WE CAN LEARN MORE ABOUT THESE EVENTS.

Handling Instructions:

- Leach's Storm-Petrels are small, gentle birds and should be handled with care at all times.
- It is recommended that the person handling the birds should wear thin rubber gloves or clean, cotton work gloves. The purpose of the gloves is to protect both the Storm-Petrel and the worker.
- As mentioned Storm-Petrel's have a strong odor that will stick to the handler's hands. Washing with soap and water will remove most of the smell.
- Handling Leach's Storm-Petrels does not pose a health hazard to the worker, however some birds may have parasites on their feathers, such as feather lice. These parasites do not present any risk to humans, however, as a precaution we recommend wearing cotton work gloves or thin rubber gloves while handling birds and washing of hands afterwards.

Wilson's Storm Petrels:

A relative of the Leach's Storm-Petrel is the Wilson's Storm-Petrel. They breed in the south Atlantic and Antarctica and migrate north in our spring to spend the summer in Newfoundland waters. This species is very numerous on the Grand Banks in the summer, and shares the same nocturnal habits as the Leach's Storm-Petrel. Thus it is possible that Wilson's Storm-Petrels may also be attracted to the lights of a vessel at night. The two species are very similar and should be handled in the same way as described above for our Leach's Storm-Petrel.

Permits:
A permit to handle storm-petrels issued by the Canadian Wildlife Service will be held on board the vessel to cover personnel involved in bird collision incidents.