Husky Energy **REPORT**

Labrador Shelf Seismic Program – Environmental Assessment

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Executive Summary

Husky Energy proposes to undertake 2-D and 3-D seismic and follow-up geo-hazard surveys on its exploration acreage (Exploration Licenses 1106 and 1108) on the Labrador Shelf. Husky foresees the potential for a 2-D seismic survey in the summer of 2010, while other surveys – 2-D, 3-D or geo-hazard and Vertical Seismic Profiles – may occur at various times between 2010 and 2017.

This document provides a Screening Level Environmental Assessment to allow the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) to fulfill its responsibilities under the *Canadian Environmental Assessment Act*.

During the course of the environmental assessment, Husky Energy consulted with stakeholders with an interest in the Project. Husky Energy and consultants undertook a consultation program with the interested stakeholders in Happy Valley-Goose Bay, Nain, Rigolet, Postville, Hopedale, Cartwright, Makkovik and Sheshatshiu, as well as consultation with regulatory agencies and other stakeholders in St. John's.

As per the Scoping Document issued by the C-NLOPB, the valued ecosystem components (VECs) include Species at Risk (both those listed under the *Species at Risk Act* Schedule 1 and under consideration by the Committee on the Status of Endangered Wildlife in Canada), Marine Fish and Fish Habitat, Marine Mammals and Sea Turtles, Marine Birds, Commercial Fisheries and Sensitive Areas. The biological environment is described in terms of these six VECs. The physical environment is also described, including the metocean conditions and sea ice and icebergs. The existing environment descriptions draw heavily on the Labrador Shelf Strategic Environmental Assessment (Sikumiut 2008), with information updated where more recent data exist.

Environmental management measures (i.e., mitigative measures) include a Marine Mammal Observer(s) (MMO(s)) on board the vessel(s) to provide proper identification of marine mammals and species at risk for mitigation purposes and to collect opportunistic data on marine mammal behaviours and distribution with and without air guns operating. Seabird observations will also be collected. In addition, mitigation measures will be applied as set out in the "*Geophysical, Geological, Environmental and Geotechnical Program Guidelines*" (C-NLOPB 2008), which incorporates verbatim the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment*. Plans will be developed to avoid or lessen any potential effects on the commercial fishery. These plans will include elements such as good communications (e.g., fishery broadcast notifications and Notices to Shipping), a dedicated Fisheries Liaison Officer (FLO) on the vessel(s), a Single Point of Contact, use of a picket vessel, avoidance of areas during times of heavy fixed gear use, and a fishing gear damage compensation program.

With the application of mitigative measures, this environmental assessment predicts that potential adverse environmental effects on the above VECs will be of low magnitude, short duration and range from localized to regional in extent. The extent of potential physically harmful sound levels occurs within approximately 1 m of the air gun source.

Potential cumulative environmental effects external to the Project include seismic program(s) by other operators, commercial and traditional fishing, marine transportation and tourism/recreation. The potential exists that the other seismic survey(s) could occur concurrently, resulting in a temporal overlap with the Project (there would be no immediate spatial overlap as there must be enough distance between streamers as to avoid interfering with data acquisition by individual vessels); therefore, there is some potential for cumulative environmental effects with the Project in this context. As access of non-Project vessels within close proximity the source vessel will be restricted during the seismic survey, the residual cumulative environmental effect with noise and traffic external to the Project will be negligible. Compared to existing vessel traffic in the area, the incremental amount of vessel traffic as a result of this Project will be negligible. Cumulative environmental effects resulting from any of the Project activities will not be additive or cumulative because the Project activities are transitory. With the implementation of mitigative measures and the limited spatial (and potentially temporal – if the programs are not run concurrently) overlap with other projects and activities, the residual cumulative environmental effect of the Project in conjunction with other projects and activities is predicted to be *not significant*.

The potential of accidental events is limited to release of the flotation fluid (unless solid core streamers are used), or a diesel spill in the unlikely events of a seismic vessel sinking or a collision with another vessel. Given how unlikely these events are, and the mitigative measures that will be applied to the Project (including an FLO, on-board spill response plan and equipment), the residual environmental effect of an accident or malfunction is predicted to be *not significant*.

As noted previously, MMO(s) will be on board the vessel(s) to provide identification of marine mammals and sea turtles (including species at risk) for mitigation purposes and to collect opportunistic data on marine mammal behaviours and distribution with and without air guns operating. Seabird observations will also be conducted. The observer will report any dead birds on board the vessel. As well, routine checks will be done for stranded birds that may have been attracted to vessel lighting. Any dead birds will be handled and documented as per a required Bird Salvage Permit and Husky's procedures on this topic that are on file with the C-NLOPB.

Given the application of planned mitigative measures, significant adverse environmental effects, including cumulative environmental effects, are not predicted to result from the Project.

VEC	Residual Adverse Environmental Effect Rating	Level of Confidence	Probability of Occurrence (Likelihood)
Species at Risk	Not Significant	Moderate	na
Marine Fish	Not Significant	High	na
Marine Mammals and Sea Turtles	Not Significant	High	na
Marine Birds	Not Significant	High	na
Commercial Fisheries	Not Significant	High	na
Sensitive Areas	Not Significant	High	na
na = likelihood is only indicated for those VECs that have a significant residual adverse environmental effect rating.			

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Glossary of Acronyms

Acronym	**Definition**
BIO	Bedford Institute of Oceanography
CEAA	*Canadian Environment Assessment Act*
CEA Agency	Canadian Environmental Assessment Agency
C-NLOPB	Canada-Newfoundland and Labrador Offshore Petroleum Board
C-NOPB	Canada-Newfoundland Offshore Petroleum Board
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
dB	Decibel
DFO	Fisheries and Oceans Canada
FLO	Fisheries Liaison Officer
HOIMS	Husky's Operational Integrity Management System
Hz	Hertz
kHz	KiloHertz
m^3	Cubic metre
MMO	Marine Mammal Observer
MSC	Meteorological Service of Canada (formerly AES (Atmospheric Environment Services))
NAFO	Northwest Atlantic Fisheries Organization
NMFS	US National Marine Fisheries Service
PAH	Polycyclic aromatic hydrocarbon
psi	Pounds per square inch
P(t)	Pressure Disturbance
rms	Root-mean-square pressure level
SARA	*Species at Risk Act*
SDL	Significant Discovery License
SEL	Sound Exposure Level
SL	Source Level
SPL	Sound Pressure Level
SPL_{Pk}	Peak Pressure Level
VEC	Valued Environmental Component

1.0 INTRODUCTION

Husky Energy proposes to undertake 2-D and 3-D seismic and follow-up geo-hazard surveys on its recently acquired exploration acreage (Exploration Licenses 1106 and 1108) on the Labrador Shelf (Figure 1-1); the geographic coordinates (NAD 83 Zone 22) of the area within which seismic survey operations will be conducted are provided in Figure 1-1.

Husky Energy foresees the potential for a 2-D seismic survey in the summer of 2010, while other surveys – 2-D, 3-D or geo-hazard and Vertical Seismic Profiles (VSPs) – may occur at various times between 2010 and 2017.

As mentioned, this environmental assessment addresses not only 2-D and 3-D seismic surveys, but all exploration seismic-related activities, including:

- geo-hazard surveys, such as well site surveys; and
- VSPs, which are activities related to drilling activities, but because they involve the use of similar technologies (i.e., air gun) as other marine seismic surveys, they will be addressed in this environmental assessment.

This document provides a Screening Level Environmental Assessment to allow the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) to fulfill its responsibilities under the *Canadian Environmental Assessment Act* (*CEAA*). The technical and scope advice received from the C-NLOPB and other Federal Agencies through the *Federal Coordination Regulations*, and from other stakeholders consulted by Husky Energy, has guided the preparation of this Environmental Assessment.

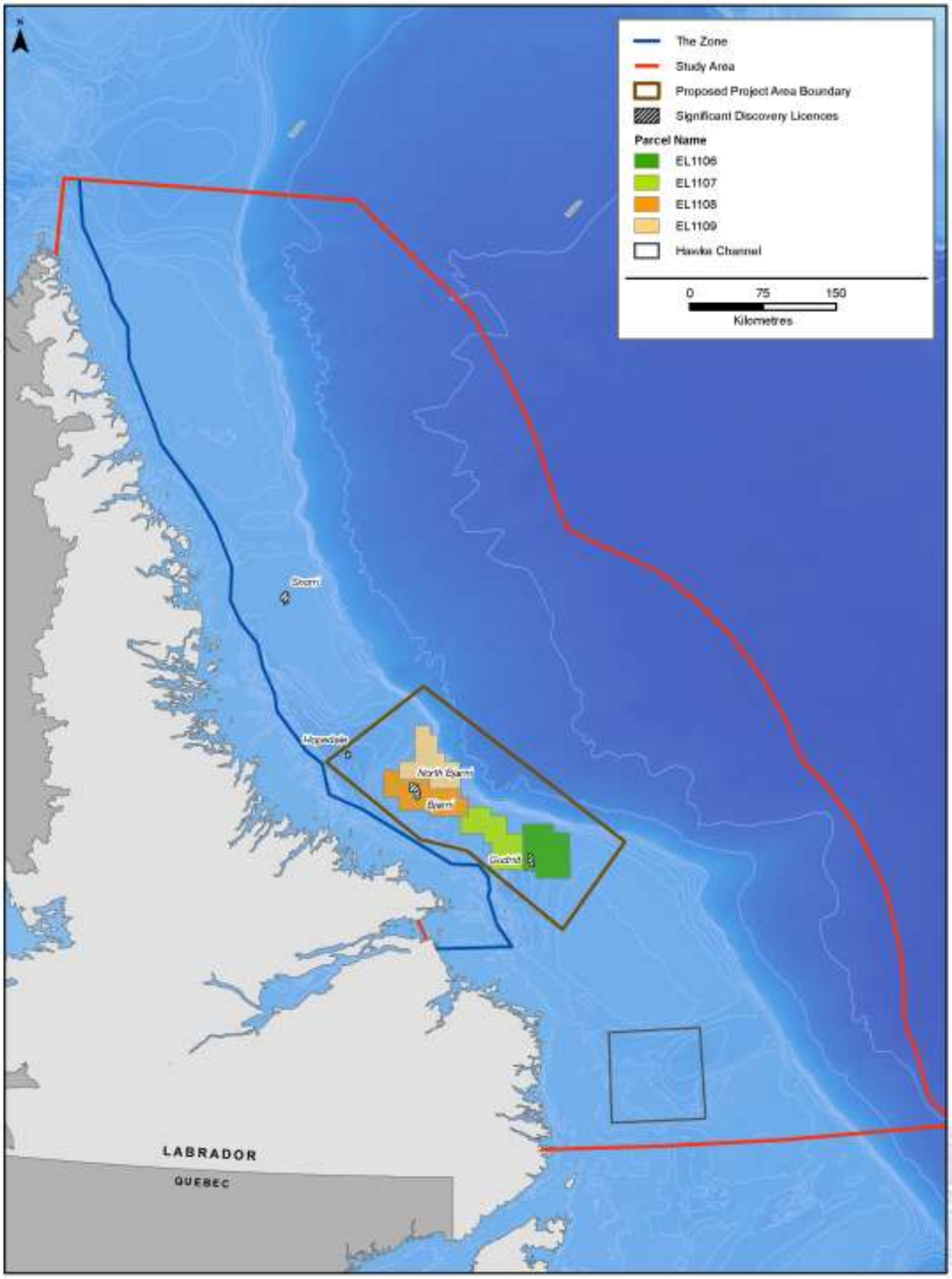

Figure 1-1 **Location of Exploration Leases on the Labrador Coast to be Subject to Seismic Surveys**

Note: Corner Coordinates in decimal degrees (NAD 83) of the Proposed Project Area Boundary are:

W -59.1923,N 55.8095	W -57.6151,N 56.5295	W -54.3606,N 55.0654
W -55.3947,N 54.2780	W -56.9188,N 55.0174	W -57.6516,N 55.1154

2.0 RELEVANT LEGISLATION AND REGULATORY APPROVALS

2.1 RELEVANT LEGISLATION

An Authorization to Conduct a Geophysical Program will be required from the C-NLOPB. The C-NLOPB is mandated by the *Canada-Newfoundland Atlantic Accord Implementation Act* (S.C. 1987, c.3) and the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (R.S.N.L. 1990, c. C-2) (Atlantic Accord Acts). Offshore geophysical surveys (including geo-hazard surveys) on federal lands are subject to screening under *CEAA*. The C-NLOPB acts as the Federal Environmental Assessment Coordinator. Because seismic survey activities have the potential to affect seabirds, marine mammals, and fish and commercial fisheries, the Fisheries and Oceans Canada (DFO) and Environment Canada are the federal agencies primarily interested. Legislation that is relevant to the environmental aspects of this Project includes:

- Atlantic Accord Acts;
- *CEAA*;
- *Oceans Act*;
- *Fisheries Act*;
- *Navigable Waters Protection Act*;
- *Canada Shipping Act*;
- *Migratory Bird Convention Act*; and
- *Species at Risk Act* (*SARA*).

One of the specific C-NLOPB Guidelines relevant to this Project is the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2008). The *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (DFO 2007a) is integrated verbatim into Appendix 2 of the above referenced C-NLOPB guidelines.

2.2 SCOPE OF THE ASSESSMENT

The scope of the project includes the combination of works and activities that must be considered during the environmental assessment. The Project components that may influence the exercise of federal powers were identified by the Scoping Document (C-NLOPB 2009; Appendix A), based on analysis of the Project Description (Husky Energy 2009) submitted by Husky Energy. The following components will be included in the scope of the Project.

2.2.1 SCOPE OF THE PROJECT

The Project to be assessed consists of the following components (C-NLOPB 2009):

- Seismic and geo-hazard data collected on exploration licenses 1106, 1107, 1108 and 1109 on the Labrador Shelf (the Project Area), as described in "*Labrador Shelf Seismic Program – Project Description*" (Husky Energy 2009). A 30-km buffer around the exploration leases is included in the Project Area to accommodate both streamer deployment and seismic vessel turning radius. Seismic survey operations will be carried out such that streamer deployment and end-of-survey line turning operations will not extend into the Labrador Inuit Settlement Area (known as the "Zone").

- Approximately 2,000 to 3,000 km of 2-D seismic data will be collected in 2010. The 2-D seismic survey vessel will tow a sound source, one air gun array 4,000 to 7,000 cubic inches in total volume and towed at depths about of approximately 6 to 15 m. The air guns will be operated with compressed air at pressures of 2,000 to 2,500 psi and producing peak-to-peak pressures of approximately 140 to 165 bar-m (14 x 10^{12} to 16.5 x 10^{12} microPascal (µPa)) There will be one towed streamer, 6,000 to 10,000 m in length, which will be towed behind the vessel at depths of approximately 8 to 30 m. The wellsite/geo-hazard survey will be collected using a closer survey line spacing (250 m) using smaller equipment and lower pressures.

- 2-D seismic data will be collected in 2010. Additional 2-D, 3-D, and/or geo-hazard surveys may be undertaken in subsequent years up to and including 2017. The timing of survey activities will be between July 1 and November 30 of any given year. The duration of the initial 2-D survey is estimated at 40 to 60 days and the duration of a typical geo-hazard (well site) survey is approximately four to six days. The estimated duration of a 3-D program, depending on the area to be covered, is approximately 30 to 75 days. However, these are estimates and timing can change due to operational constraints (e.g., weather, logistics, etc.).

- VSPs, generally take less than 24 hours.

2.2.2 FACTORS TO BE CONSIDERED

The environmental assessment will include (but is not restricted to) a consideration of factors in accordance with Section 16 of *CEAA* (C-NLOPB 2009):

- the purpose of the Project;

- the environmental effects (as defined in Section 2 of *CEAA*, which includes any listed wildlife species, its critical habitat or the residences of individuals of that species, as those terms are defined in subsection 2(1) of *SARA*) of the Project, including those due to malfunctions or accidents that may occur in connection with the Project and any change to the Project that may be caused by the environment;

- cumulative environmental effects of the Project that are likely to result from the project in combination with other projects or activities that have been or will be carried out;

- the significance of the environmental effects described in bullets two and three;

- measures, including contingency and compensation measures as appropriate, that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the Project;

- the significance of adverse environmental effects following the employment of mitigative measures, including the feasibility of additional or augmented mitigative measures;

- the need for, and the requirements of, any follow-up programs in respect of the Project consistent with the requirements of *CEAA* and *SARA* (refer to the CEA Agency's 2007 "*Operational Policy Statement" regarding Follow-up Programs*"); and

- report on consultations undertaken by Husky Energy with interested parties who may be affected by program activities and/or the general public respecting any of the matters described above.

2.3 CONSULTATION

During the course of the assessment, Husky Energy consulted with stakeholders with an interest in the Project. In order to assist in scoping the effects assessment and mitigation plan and to aid in addressing any issues of concern, Husky Energy and consultants undertook a consultation program with the interested parties in communities chosen within Labrador and relevant stakeholders, including but not limited to:

- Nunatsiavut Government;

- Labrador Métis Nation;

- Innu Nation;

- One Ocean;

- Fish Food and Allied Workers Union;

- Southeastern Aurora Development Corporation;

- town managers and/or mayors in the various communities visited during the consultation process;

- fish processors; and

- other relevant parties as identified.

The Natural History Society was approached but has not yet responded to an invitation for a meeting. Husky Energy remains open to continuing consultation with interested stakeholders.

2.3.1 CONSULTATION WITH COMMUNITIES AND KEY STAKEHOLDERS

Consultation was held in Happy Valley-Goose Bay, Nain, Rigolet, Postville, Hopedale, Cartwright. The Consultation Team could not meet with stakeholders in Makkovik due to weather; a Husky Energy representative met with stakeholders in Makkovik at a later date. Husky Energy senior management on the East Coast met with the Innu Leadership in St. John's and later, a Husky Energy representative attended a public meeting with Sheshatshiu Innu as part of an all-operators session arranged by an Innu Nation consultant.

A mix of public meetings and meetings with governments and organizations were held in the seven communities. Thirteen meetings were held during the initial two weeks, seven of which were public meetings. Depending on the numbers attending, the meetings were either one on one discussions or a slide presentation interspersed with discussion.

Key issues raised during the public meetings included:

- the need for ongoing discussions and information as the project planning proceeds;
- the need for maximizing local opportunities for employment and supply of services and supplies;
- very recent fishing history is important for determining where the fishing effort is likely to occur in the near future (the exploration licenses are areas for fishing shrimp, crab and turbot, which areas change from year to year);
- fishers need to receive factual and scientifically sound information to allay fears of negative effects on the fishing industry;
- communication is critical if fishers and oil and gas activities are to work in harmony;
- the potential effects of the associated noise on whales and other marine mammals;
- the use of Traditional Knowledge and the quality of information on ice, marine mammals and fishing activity;
- the effects of sound on whales and fish;
- the effects of oil spills (during the drilling/development phases);
- reflection of sound from ice;
- how marine mammal observations are made;

- what are the discharges from the vessels and how are they controlled;
- what are the benefits to the Innu? It was recommended that consultation include the Innu Business Development Office in Goose Bay – Messers Paul Rich and Fred Hall;
- want to see that companies demonstrate their “responsibility” (i.e., both environmental and social);
- stated that they appreciated the presentation and found it informative; stated that they appreciated the companies coming to them as opposed to being chased by the Innu; and
- Husky Energy indicated that these were ideas we could follow-up and noted that our level of engagement will be determined by our level of business activity.

A detailed report of the consultations is provided as Appendix B.

2.3.2 CONSULTATION WITH REGULATORS

The following agencies were contacted for information during the preparation of this environmental assessment:

- Canadian Wildlife Services (information on birds);
- DFO Policy and Economics Branch (commercial fisheries data);
- DFO Species at Risk (wolffish critical habitat update);
- DFO Marine Mammals Section (marine mammals information); and
- DFO Conservation and Protection, Goose Bay Detachment (contacted during the consultation sessions in Labrador).

2.4 THE OPERATOR

Headquartered in Calgary, Alberta, Husky Energy Inc. (the Operator) is a Canadian-based integrated energy company serving global customers, committed to maximizing returns to its shareholders in an ethical and socially responsible way, through the dedicated effort of its people. It is involved in:

- exploration and development of crude oil and natural gas,
- production, purchase, transportation, refining and marketing of crude oil, natural gas and natural gas liquids and sulphur, and
- transportation and marketing of refined products.

2.4.1 CANADA-NEWFOUNDLAND AND LABRADOR BENEFITS

Husky Energy is committed to bringing maximum benefits associated with East Coast operations to Canada and in particular Newfoundland and Labrador, where commercially achievable in accordance with our operating philosophy and legislative requirements. In the spirit of the Atlantic Accord, Husky Energy actively seeks to enhance the participation of Canadian, and Newfoundland and Labrador, individuals and organizations in offshore oil and gas activity on the East Coast. Husky Energy's commitment to delivering benefits to the Province and to Canada is outlined in the White Rose Development Application Volume One: Canada-Newfoundland Benefits Plan.

Husky Energy manages its East Coast operations from St. John's, Newfoundland and Labrador. Canadian, and in particular Newfoundland and Labrador, individuals and organizations are provided with full and fair opportunity to participate in Husky Energy's activities on the East Coast. Husky Energy also supports the principle that first consideration be given to personnel, support and other services that can be provided by Newfoundland and Labrador, and to goods manufactured in Newfoundland and Labrador, where such goods and services are competitive in terms of fair market price, quality and delivery. Contractors and sub-contractors working for Husky Energy on its East Coast operations must also subscribe to and apply these principles in their own operations.

2.4.2 HUSKY'S ENVIRONMENTAL MANAGEMENT SYSTEM

Husky's Operational Integrity Management System (HOIMS) covers all of Husky's business units, with particular emphasis on projects and operations, and manages Operational Integrity through the life-cycle of the assets. HOIMS includes 14 high-level elements, with each element containing well-defined aims and a clear set of expectations. These expectations guide Husky's employees in effectively managing the risks associated with its business related to safety, environment and assets.

Management is responsible for ensuring effective systems and procedures are implemented and adequate resources are made available to meet the HOIMS expectations. Business Units, Operating Districts, Facilities and Functional Areas implement HOIMS. The resources applied are consistent with the evaluated operational integrity risk.

Achieving conformance to HOIMS expectations requires commitment and sustained efforts. Strong leadership and commitment at all levels of Husky's organization and clearly established responsibilities and accountabilities are key to the success of HOIMS.

Resources are applied and dedicated to the implementation of HOIMS, and progress is be tracked and monitored at the business units, operating districts, facility, functional areas and Corporate levels. Periodic reviews and audits are undertaken to ensure that HOIMS is effectively integrated into daily operations and to continuously improve performance.

Husky's Environmental Management System has its basis in HOIMS. More specifically, Element 8 titled "Environmental Stewardship" sets a clear aim to: *"Operate responsibly* *to minimize the environmental impact of how we conduct business”* and *“Leave a positive legacy behind us when we leave”*. A clear set of expectations details how Husky Energy intends to meet this aim. They are the following:

8.1 A process is implemented to assess the risks and potential impacts to the environment associated with our operations. Such assessments are subject to periodic review and, where appropriate, a Life Cycle Value Assessment is carried out.

8.2 Management systems are established and specific measures are implemented to eliminate, minimize, prevent, detect, control and mitigate environmental threats. Our first priority is prevention.

8.3 Environmental impact is monitored and reported to demonstrate compliance with relevant local, national and international regulations and to ensure that any commitments are honored. Local sites metrics and targets are set to drive continual improvement in managing waste, emissions and discharges and energy efficiency.

8.4 A process is implemented to evaluate and manage the specific risks and liabilities associated with decommissioning and reclamation.

Environmental management of Husky’s East Coast operations is achieved using a compilation of tools to manage the environmental component of its business. Systems, plans and procedures are in place to manage Husky’s environmental commitments, regulatory obligations and stakeholder expectations, as well as areas of risk. Detailed descriptions of the programs and plans that form Husky’s environmental management system are provided in Appendix C. All plans and procedures are responsive to applicable legislation and undergo periodic reviews to ensure compliance with legislation.

As a key part of these expectations, all of Husky’s East Coast environmental assessments undergo annual reviews. These reviews are to assist Husky Energy in fulfilling its responsibilities under CEAA by ensuring that the scope of the assessment(s) and the mitigations committed to therein remain valid.

2.4.3 CONTACTS

2.4.3.1 EXECUTIVE CONTACT INFORMATION

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2.4.3.2 GEOPHYSICAL CONTACT

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2.4.3.3 ENVIRONMENTAL CONTACT

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3.0 PROPOSED PROJECT

3.1 NAME AND LOCATION

The Labrador Shelf Seismic Program application encompasses the following C-NLOPB Exploration Licenses 1106, 1107, 1108 and 1109 (see Figure 1-1). Exploration Licenses 1106 is owned by Husky Energy directly and Exploration Licence 1108 is held jointly by Husky Energy (75 percent) and Suncor Energy (25 percent); Exploration License 1107 is owned by Vulcan Minerals Inc. and Exploration License 1109 by Chevron Canada Ltd. It is Husky Energy's intention to acquire a 2-D seismic survey over the exploration leases listed above in 2010, or as soon thereafter as possible. The exact dimensions of any survey area will be determined as a function of vessel availability and cost.

The proposed Project Area for the environmental assessment is defined in Figure 1-1 and includes an approximately 30 km buffer around the exploration leases to accommodate both streamer deployment and seismic vessel turning radius. Seismic survey operations will be carried out such that streamer deployment and end-of-survey line turning operations will not extend into the Zone. 3-D seismic surveys may also be carried out in later years, within the term of the explorations licenses dependent on the results of 2-D work and/or the availability of survey vessels. Buffer zones and streamer deployment areas similar to a 2-D survey would be required and implemented.

Subsequent geo-hazard surveys may be conducted anywhere on Husky Energy's exploration licenses (1106 and/or 1108) within the Project Area boundaries (Figure 1-1), depending on the final geophysical interpretation using the 2-D/3-D seismic acquired in the Project Area.

3.2 PROJECT OVERVIEW

The proposed Project is a ship-borne geophysical program consisting of approximately 2,000 to 3,000 km of 2-D survey in 2010 or 2011 or as soon thereafter as possible and yet-to-be-determined areas of 2-D and 3-D and/or geo-hazard surveys in later in the 2010 to 2017 period. Some adjacent lands are also included as part of the overall Project Area in order to ensure inclusion of ship turning, holding and streamer deployment areas.

The seismic survey vessel(s) will be approved for operation in Canadian waters and will be typical of the worldwide fleet. A specific vessel(s) has not yet been selected through the bidding process.

The 2-D seismic survey ship will tow a sound source and a single streamer up to several kilometres long composed of receiving hydrophones. The 3-D seismic survey ship will tow a small sound source (array) and streamer composed of receiving headphones. Survey lines may run north-south or east-west. The geo-hazard surveys will be conducted over a much shorter time frame using a smaller vessel and a combination of smaller scale seismic equipment, sonars, sparkers and boomers. VSPs are conducted within a 24-hour period. They are well based, so must occur with a drilling program. Nothing is towed through the water column.

Mitigation procedures for all surveys will be consistent with the C-NLOPB's guidelines (C-NLOPB 2008). They include dedicated Marine Mammal Observers (MMOs) and "soft-starts" or "ramp-ups" of the 2-D array and when possible maintenance of single air gun operation during end of line turns to help minimize disturbance to marine life, particularly marine mammals and species at risk. In addition, a Fisheries Liaison Officer (FLO) will be on board to ensure that communication procedures to avoid or reduce conflicts with the commercial fishery are implemented, and to identify fishing gear to avoid/reduce entanglement.

3.2.1 ALTERNATIVES TO PROJECT AND ALTERNATIVES WITHIN PROJECT

Husky Energy has reviewed the existing, interpreted 2-D seismic information available in the area. This information indicates structures that may contain significant volumes of producible hydrocarbons. Unfortunately, this existing seismic information is insufficient to determine exact size and internal complexity of these structures. Therefore, acquisition of new 2-D seismic is required to determine if future 3-D seismic and exploration drilling is warranted.

Husky Energy has exploration commitments on Exploration Licenses 1106 and 1108. A 2-D and 3-D seismic survey is now a standard precursor to offshore exploratory drilling. Acquisition of this information lessens the chances of expending resources "drilling dry holes" and increases safety margins. As such, there are no alternatives to the Project other than to incur financial penalties and explore for oil and gas elsewhere.

Viable alternatives within the Project are essentially the choices between different contractors' ships and survey equipment, which are presently being evaluated through the bid evaluation process. Husky Energy will plan its seismic survey to:

- use the minimum amount of energy necessary to achieve geological objectives;
- minimize the proportion of the energy that propagates horizontally; and
- minimize the amount of energy at frequencies above those necessary for the purpose of the survey objectives.

3.2.2 PROJECT PHASES

The Project will proceed in three phases once activities begin. The actual timing of these activities within the temporal scope will be dependent on economic feasibility, vessel availability and the results of interpretation of survey work from preceding phases. Phase 1 (Year 1) will be a 2-D survey in the area defined in Figure 1-1, Phase 2 foresees a 3-D survey of any areas that may be identified through analyses of existing and acquired 2-D data, and geo-hazard surveys potentially in preparation for a potential drilling program, Phase 3 will see collection of additional 3-D and/or geo-hazard data in anticipation of an potential ongoing drilling program. As mentioned, VSPs are also included within this assessment and would occur in phase 3, once a well was drilled.

3.2.3 PROJECT SCHEDULING

The surveys may occur between July 1st and November 30th of any given year. The duration of the proposed 2010 2-D survey is estimated at 40 to 60 days and the duration of a geo-hazard survey in support of a potential drilling program is approximately four to six days. The estimated duration of a 3-D program, depending on the area to be covered, is approximately 30 to 75 days.

3.2.4 SITE PLANS

The site map showing the Project Area is provided in Figure 1-1.

3.2.5 SEISMIC VESSELS

Vessel specifics will be provided once the contractors are selected. Most, if not all likely survey vessels have diesel-electric propulsion systems (main and thrusters) and operate on marine diesel.

3.2.6 2-D SURVEYS

As described above, the 2-D survey sound source will consist of one air gun array, 4,000 to 7,000 cubic inches (in^3) in total volume, and towed at depths about of approximately 6 to 15 m. The air guns will be operated with compressed air at pressures of 2,000 to 2,500 psi, and producing peak-to-peak pressures of approximately 140 to 165 bar-m (14×10^{12} to 16.5×10^{12} µPa). There will be one towed streamer (strings of hydrophone sound receivers), 6,000 to 10,000 m in length which will be towed behind the vessel at depths of approximately 8 to 30 m. Streamer flotation will be either solid or liquid (Isopar), depending upon availability from specific contractors. See Section 3.3.4.1 for more information on sound generated by a 2-D seismic survey.

Detailed specifications will be provided when the contractor is selected.

3.2.7 3-D SURVEYS

The 3-D sound source will consist of a larger air gun array and 8 to 10 streamers of hydrophones 75 to 100 m apart and 6,000 to 8,000 m long, towed in parallel behind the survey vessel at several metres depth. The streamers array width can be up to 500 m either side of the survey vessel. The sound source array source has multiple air gun units, usually operating at 2,000 psi. Individual source unit volumes can range from 70 to 250 in^3.

See Section 3.3.4.1 for more information on sound generated by a 3-D seismic survey.

3.2.8 WELL SITE GEO-HAZARD SURVEYS

Once a potential drilling site is located, it is standard offshore industry procedure, and a requirement of the C-NLOPB, that a well site/geo-hazard survey be conducted. The purpose of the survey is to identify, and thus avoid, any potential drilling hazards such as steep and/or unstable substrates or pockets of “shallow gas”. It involves acquisition of high resolution seismic, side scan sonar, sub-bottom profile, and bathymetric data over the proposed drilling area(s). Typically the seismic data for well site surveys are collected over closer lines (250 m or less in the case of a jack-up rig), using smaller equipment and lower pressures, over a shorter time period (e.g., several days) compared to 2-D and 3-D surveys.

Surficial data are collected using a broad band (e.g., 500 Hertz (Hz) to 6 kiloHertz (kHz)) sparker or boomer as a sound source which provides data as deep as 100 m into the substrate. A single or multi-beam echo sounder is used for bathymetry and a dual frequency side scan sonar system is used to obtain seabed imagery. Seabed video and/or grab samples are used to provide ground-truthing information on the character of the seabed and sediments.

Detailed specifications will be provided when the contractor is selected. See Section 3.3.4.2 for more information on sound generated by various geo-hazard seismic surveys.

3.2.9 VERTICAL SEISMIC PROFILES

VSPs are a collection of well bore measurements (seismograms) developed by means of geophones inside the wellbore and sound sources at the surface near the well. The seismic data can be gathered while the borehole is being drilled or afterwards. These measurements are used to correlate with surface seismic data, for obtaining images of higher resolution than surface seismic images and for looking ahead of the drill bit.

VSPs, also known as borehole seismic surveys, restrict receiver locations to the confines of a borehole. While this constraint limits the image volume, it also confers several advantages to seismic surveys in the borehole. For example, waves that travel from a surface source, reflect off a subsurface reflector and then arrive at a borehole receiver are less attenuated by shallow low-velocity layers.

With a “zero-offset” VSP, a seismic source array is deployed over the side of the platform. A typical VSP source array would be comprised of one or two air guns. The source is activated three to five times to create a sonic wave that is picked up by the geophones in the borehole. Typically, only one zero-offset VSP is conducted on each well when total depth has been reached. Another form is a “walkaway” VSP, where the air gun array is suspended from a supply vessel that moves away from the platform for a couple of kilometres. See Section 3.3.4.3 for more information on sound generated by various geo-hazard seismic survey.

3.2.10 LOGISTICS/SUPPORT

3.2.10.1 VESSELS

As noted above, primary support will be provided by a chartered seismic survey vessel. A mitigation plan will be developed as part of the Project in order to mitigate any potentially adverse effects on marine animals, the commercial fisheries and other vessel traffic. A standby or picket vessel will be used as a mitigation measure to help manage the interaction with fishing operations active during the survey. This vessel would be used as an additional method of obtaining information on commercial fishing activity in the area and would be responsible for communicating with fishers in the area. This activity is in place to avoid gear loss as well as avoidance of fishing gear entanglement with the streamers.

3.2.10.2 HELICOPTERS

The larger seismic vessels are usually equipped with a helicopter platform and helicopters are often used for crew changes, can be used in case of medical and other emergencies and re-supply. In some cases, survey contractors may prefer to come to shore for crew changes and re-supply (if required).

3.2.10.3 SHORE BASE, SUPPORT AND STAGING

Husky Energy and its contractors maintain offices and shore facilities in St. John's. However, some seismic contractors may prefer to crew change or re-supply in other ports. However, during a short operational program, re-supply may not be needed. No new shore base facilities will be established as part of this Project.

3.2.11 WASTE MANAGEMENT

Waste management aboard the seismic vessel will be implemented in a manner consistent with Husky Energy's *East Coast Waste Management Plan* and the contracted vessels policies and procedures. A gap analysis will be conducted on the seismic vessel's Waste Management Plan, to ensure that it aligns with Husky Energy policies and procedures.

3.3 UNDERWATER SOUND

3.3.1 WHY ARE WE CONCERNED WITH IT?

Ocean water conducts light very poorly but sound very well. Therefore, many marine animals rely - to varying degrees - on their acoustic sense for communication, social interaction, navigation, foraging and predator avoidance. Marine mammals appear to have the most advanced auditory system. They emit sound over a broad range of frequencies from a few Hz to 200 kHz - depending on species. Sounds emitted by marine mammals have been described as whistles, songs, moans, grunts, barks, growls, knocks, pulses, clicks, etc. Such sounds take on a variety of functions, and some calls of some species have been linked to different types of behavior, including travelling, resting, socializing, mother-calf contact, mating, nursing, foraging (coordinated group foraging as well as individual foraging), individual identification (signature whistles) and warning (alarm calls).

Underwater noise has the potential to interfere with sounds made by marine animals and with ambient sounds that animals listen to for successful navigation, foraging and threat avoidance. Dolphins and toothed whales (odontocetes) emit mid- to high-frequency sonar signals and listen to the reflections for navigation and foraging. Many animals likely listen to environmental sounds such as surf for navigation. Many species can hear the sounds of prey as well as the sounds of predators or other potential threats. Underwater noise can mask these sounds to the point where they are no longer recognizable or detectable.

Underwater noise has also been shown to affect the behavior of marine animals. While temporary noise will mostly cause only temporary effects, ongoing noise exposure can drive animals away from potentially critical habitat (e.g., mating grounds, nursing grounds, feeding grounds).

In extreme cases, loud underwater noise can cause physiological damage to marine animals, such as the rupture of eggs, larvae or gas-filled organs, and ear damage (hair cell damage in the inner ear), if the organism is at close range (within 1 to 2 m) to the sound source.

Even without the addition of anthropogenic noise, the ocean is not always a quiet place. Whether an anthropogenic source is audible to a marine animal, whether it interferes with animal sounds and whether it can cause a behavioral disturbance partly depends on how much louder the anthropogenic sound is compared to natural ambient levels. The following sections discuss ambient noise in the ocean, and underwater sounds associated with oil and gas exploration activity in particular. The effects of anthropogenic noise on marine mammals (as they relate to the proposed Project) are discussed in Section 7.1.2.2.

3.3.2 ACOUSTIC TERMINOLOGY AND UNITS

Sound is a mechanical (physical) wave travelling through a medium (such as air or water) by oscillation (a repetitive movement, typically in time, of some measure about a point of equilibrium) of the medium's particles. Frequency is the rate of that oscillation or the number of cycles per second(s), measured in units of Hertz (Hz); 1 Hz = 1cycle/s . The speed at which sound travels is the ratio of distance travelled per time (i.e., distance divided by the time to travel that distance). It is measured in units of metres per second (m/s). Sound speed depends on water temperature, salinity and hydrostatic pressure. As water characteristics change with location and depth, sound speed changes as well, creating location-specific sound propagation paths and patterns. When sound propagates through the ocean, particle oscillation causes periodic deviations in pressure from the ambient hydrostatic pressure. This acoustic pressure is measured in units of micro Pascal (µPa) under water. Acoustic pressure underwater can have a very large dynamic range (i.e., vary by many orders of magnitude (e.g., the level of snapping shrimp is approximately a few milli Pascal (10^{-3} Pa)), whereas the level of an air gun might be hundreds of kilo Pascal (10^{5} Pa)). To accommodate for such large ranges, acoustic pressure is expressed in logarithmic terms, the so-called decibel (dB).

An example of a pure-tone acoustic wave (a wave having a peak amplitude of 1, a peak-to-peak amplitude of 2, an root mean square (rms) pressure level amplitude of 0.7, a period of 0.25 s, and a frequency of 4 Hz) is illustrated in Figure 3-1.

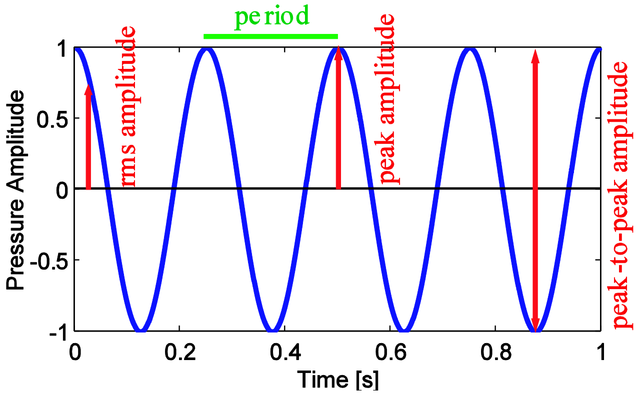


Figure 3-1 **Example of a Pure-tone Acoustic Wave**

If we consider an acoustic wave causing a pressure disturbance P(t), the peak pressure is the maximum absolute value (that is either a positive or a negative value) of the amplitude of P(t). It is also called the zero-to-peak pressure. Expressed in decibel, the peak pressure level is:

$$SPL_{Pk} = 20\log_{10}\left(\max(|P(t)|)\right)$$

The Sound Pressure Level equals 20 times the logarithmic value of the maximum value of the pressure disturbance. In underwater acoustics, it is standard to express P(t) in μPa; SPL_{Pk} is then referenced to 1 μPa (dB re 1 μPa).

The peak-to-peak pressure level is computed as:

$$SPL_{Pk-Pk} = 20\log_{10}\left(\max(P(t)) - \min(P(t))\right)$$

The *rms pressure level* gives an average of pressure over time and is useful for continuous sound:

$$SPL_{rms} = 20\log_{10}\left(\sqrt{\frac{1}{T}\int_T P(t)^2\,dt}\right)$$

The *source level* (SL) refers to the acoustic pressure measured at 1m distance from a point source. It is commonly symbolized as SL (dB re 1μPa @ 1m). For sources that are physically larger than a few centimetres (ship propellers, air guns, etc.), the pressure is measured at some range, and a sound propagation model applied to compute what the pressure would have been at 1 m range if the source could have been collapsed into a point-source.

The *sound exposure level* (SEL) measures the total energy of a signal and is expressed in dB re 1 µPa^{2}s. It is not a useful measure of continuous sound, as the energy will grow to infinity. However, it is useful for pulsed or transient signals (e.g., as from seismic surveys).

$$SEL = 10\log_{10} \int_T P(t)^2 \, dt$$

The power spectrum density describes how the power (proportional to energy) of a signal is distributed with frequency. A power spectrum is computed by Fourier transforming P(t). Power spectrum density levels are expressed in dB re 1 µPa^2/Hz, and are usually plotted as a power spectrum showing how much energy is contained in each frequency band.

An octave is a factor of two in frequency. For example, middle C on the music scale is at 262 Hz; the next higher C on the scale, an octave higher, is at 524 Hz. From octave to octave, frequency of the sound or noise doubles. A series of adjacent octave bands might have its first frequency band from 10 to 20 Hz, the second band from 20 to 40 Hz, the third from 40 to 80 Hz, etc. Rather than giving a single sound level for the full breadth of frequencies, octave bands give sound levels for each band of frequencies, allowing a more detailed characterization of energy versus frequency. 1/3 octave bands provide more detail still by splitting each octave band into three sub-bands. The first band might contain frequencies between 10 and 13 Hz, the second between 13 and 16 Hz, the third between 16 and 20 Hz, the fourth between 20 and 25 Hz, etc.

In underwater acoustics, noise levels are commonly computed as 1/3 octave band levels by integrating the power density spectrum into a series of adjacent 1/3 octave bands. 1/3 octave bands split the frequency range of the signal into pass-bands that are each 1/3 of an octave wide.

An example for snapping shrimp noise (recorded by JASCO in Queensland, Australia) is provided in Figure 3-2. Note that 1/12, 1/3 and whole-octave band levels are shown. There are twelve 1/12-octave bands in each octave, and three 1/3-octave bands. Band levels are at least as high as the underlying spectrum density levels. The wider the band, the higher the level, because more power gets integrated.

Percentile levels are useful if the measured sound changes with time. The 50th percentile is equal to the median sound level. The nth percentile gives the level below which the signal falls n% of the time (engineering definition).

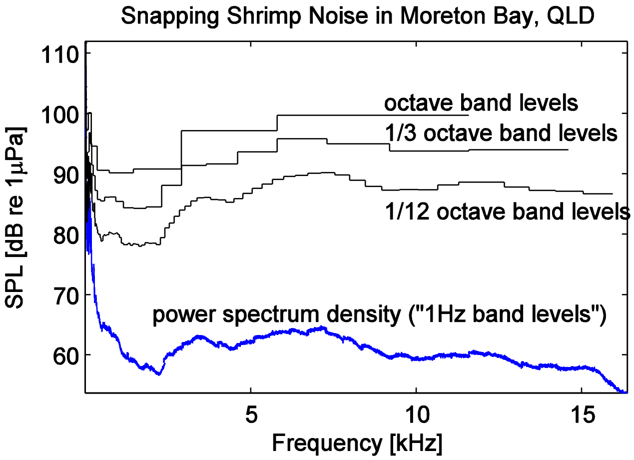


Figure 3-2 **Illustration of Band Levels versus Power Spectrum Density Levels for Snapping Shrimp Noise**

3.3.3 AMBIENT SOUND

3.3.3.1 AMBIENT NOISE LEVELS

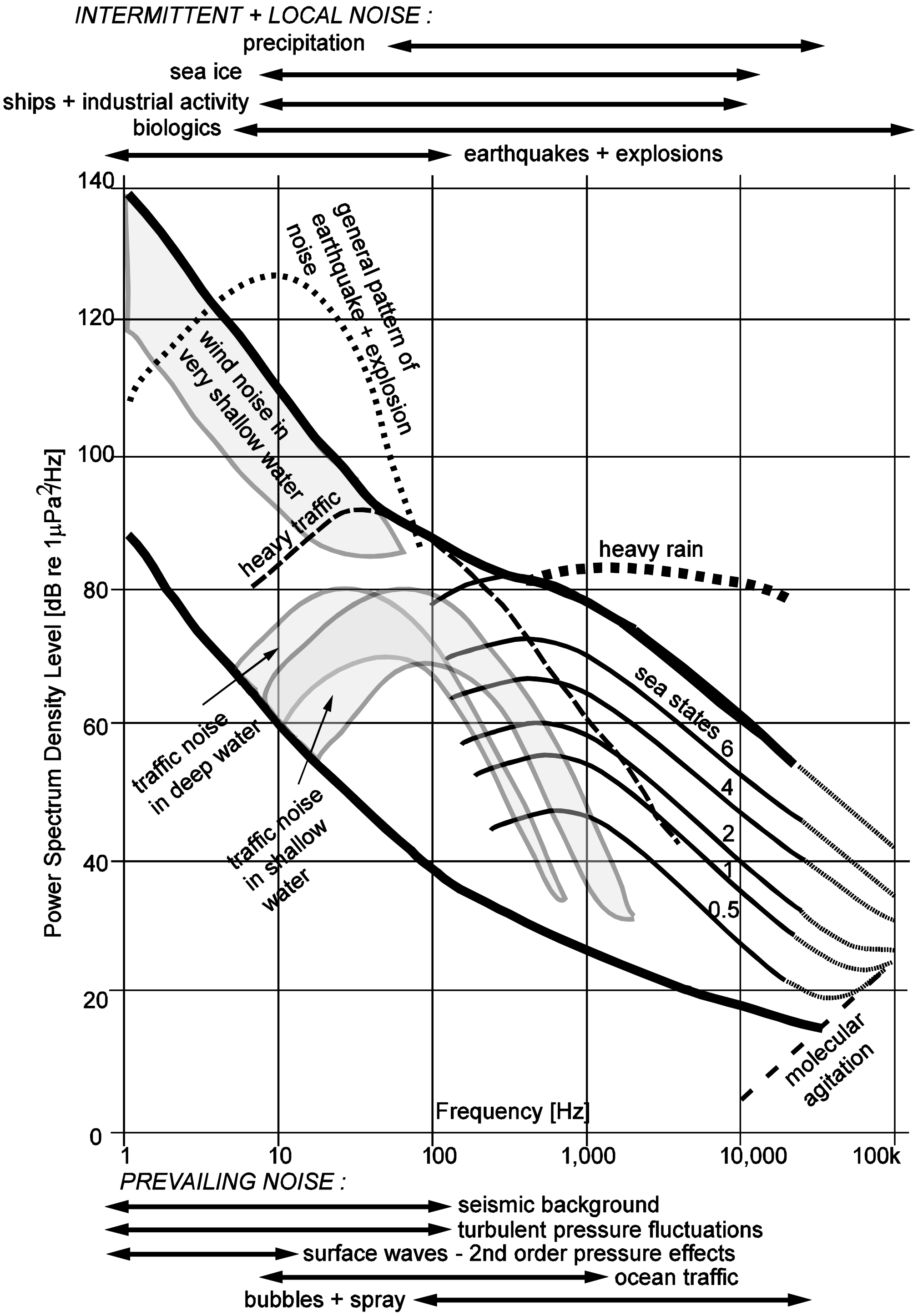
An overview of ocean noise is given in Figure 3-3 (Wenz 1962).

3.3.3.2 SHIPPING TRAFFIC AND ANTHROPOGENIC NOISE

Vessels are major contributors to background sound in the ocean. Sound levels generated by boats and ships are highly variable but generally relate to type, age, size, power, load and speed. The primary sources of sound are propeller cavitation and singing and propulsion, pumping, compressor and generating systems. A ship breaking ice creates additional sound from the ice but most of the increase in sound level is due to the increased load on the vessel and increased cavitation. Traffic noise is the combined effects on ambient noise levels of all shipping at long ranges and dominates the ambient noise in the 20 to 300 Hz frequency range. Noise from distant fishing vessels also contribute to ambient noise, peaking at 300 Hz (Richardson *et al.* 1995).

3.3.3.3 WIND- AND WAVE-GENERATED SOUND

Meteorological conditions such as wind and precipitation can make measurable contributions to ambient noise. Noise produced by wind is in the range of approximately 100 Hz to 50 kHz, noise produced by large surface waves occurs in the 1 to 20 Hz range and noise produced by precipitation occurs at frequencies above 500 Hz (Wenz 1962).



Source: Wenz 1962.

Figure 3-3 Bandwidths of Typical Sources of Ambient Noise

3.3.3.4 MARINE MAMMAL NOISE

The Labrador Shelf is home to a diverse ecological community. Many of the species who inhabit or migrate through the Labrador Shelf contribute to ambient noise levels via acoustic communication and echolocation techniques. Cetaceans are common in the area, especially in the summer months, when whales, porpoises and dolphins migrate north through the area. Cetaceans use sound for communication, navigation and hunting. The acoustic characteristics of Labrador Shelf cetaceans are summarized in Table 3-1.

Table 3-1 Regional Cetacean Acoustic Characteristics

Species	Season/Time Spent in Region	Frequency range of acoustic emission (kHz)[3]	Intensity of Acoustic Signals
Beluga whale	Occasional migration to NL coast from Arctic[1]	0.1 to 20	
Bottlenose whale	Occasional migration to NL coast from Labrador coast[1]	0.5 to 26	
Blue whale	Summer and Fall month[4]	0.01 to 31	Source level: ~150 - 195 dB re 1 µPa at 1 m
Long-finned Pilot Whale	Follows squid migrations[2], summer and winter month	1 to 18	
Minke whale	Summer months, attracted by capelin[2]	0.06 to 20	Source level: ~150 - 175 dB re 1 µPa at 1 m
Humpback whale	Primarily Summer months;[2] sighted throughout year in Study Area	0.02 to 8	Source level: ~175 - 192 dB re 1 µPa at 1 m
Sperm whale	Primarily Summer months;[2] sighted throughout year in Study Area	0.1 to 30	Source level: < 236 dB re 1 µPa at 1 m
Fin whale	Primarily Summer months;[2] sighted throughout year in Study Area	0.01 to 28	Source level: ~155 - 186 dB re 1 µPa at 1 m
Harbour Porpoise	Primarily Summer months;[2] sighted throughout year in Study Area	0.1 to 150	Source level: ~125 - 180 dB re 1 µPa at 1 m
Dolphins (white-sided and white-beaked)	Primarily Summer months;[2] sighted throughout year in Study Area	1 to 20	

Source: 1. Guerrero 2006.
2. DFO 1993.
3. Richardson *et al.* 1995.
4. DFO Data.

Note: Greatest abundances tend to occur in the summer, all species may occur within the Labrador Shelf at anytime during the year.

3.3.3.5 COMPARISON OF NOISE LEVELS

A comparison of natural and potential exploration-related noise levels is provided in Table 3-2.

Table 3-2 Comparison of Natural and Seismic Exploration-related Sound Levels

Source	Source Level (dB re 1µPa)	Sound Frequency (kHz)	Notes
Ambient Noise			
Calm Seas	60	-	
Moderate Waves/surf	102	0.1 to 0.7	
Fin whales	160 to 186	0.02	Fin whales produce series of one to five second noise pulses across 3 to 4 Hz around the 20 Hz level.
Seismic Exploration			
Small Single Air gun	216	0.01 to 5	0 to peak
Medium Single Air gun	225	0.01 to 5	0 to peak
Large Single Air gun	232	0.01 to 5	0 to peak
GSC 7900 Array	259	0.01 to 5	0 to peak
ARCO 4000 Array	255	0.01 to 5	0 to peak
GECO 3100 Array	252	0.01 to 5	0 to peak
Supply boats	170 to 180	0.1	
Other Industrial Noise			
Fishing trawlers	158	At 0.1	
Commercial freighter	172	-	
Supertanker *Chevron London*	190	dominant tone of 0.0068	
Helicopter (Sikorsky @ 305 m above water)	105	-	
Source: Richardson *et al.* 1997, in Hurley and Ellis 2004; Lawson *et al.* 2000, in Hurley and Ellis 2004; Thompson *et al.* 2000, in Hurley and Ellis 2004.			

3.3.4 OFFSHORE OIL AND GAS SOUNDS

Sources of underwater sounds associated with exploration activities include:

- 2-D and 3-D seismic surveys;
- vertical seismic profiling and geo-hazards surveys; and
- support vessels and aircraft.

3.3.4.1 TWO-DIMENSIONAL AND THREE-DIMENSIONAL SEISMIC SURVEYS

Two-dimensional and three-dimensional seismic surveys (Figure 3-4) are most commonly carried out using air guns and streamers towed behind a seismic vessel. The length of time a seismic survey continues depends on the area in question, but usually ranges from a week to a month. A typical seismic survey can last from a few weeks to several months; the time frames expected in this Project are described in Section 2.2.1. Similarly, the distances covered vary widely; however, in the 2-D survey planned for 2010 as part of the program assessed in this environmental assessment, some 2,000 to 3,000 line km of survey are expected. The ship towing the array is typically 60 to 90 m long and moves through the water at speeds usually in the range of 8 to 10 km/h (4.5 to 5.5 knots).

A 2-D survey consists of a sound source that is a single air gun array and a single towed streamer, which is a string of hydrophone sound receivers, 6,000 to 10,000 m in length, which will be towed behind the vessel at depths of approximately 8 to 30 m.

Even though most of the sound energy is focused downward, some energy travels horizontally through the ocean and partly through the seafloor radiating back into the water at some distance that varies depending on the nature of the seafloor. Received sound pressure levels in the ocean will vary with range, depth and bearing. Sound propagation characteristics (paths, patterns and attenuation) depend on the local environment at the time (water temperature, salinity, bathymetry, seafloor geology, etc.).

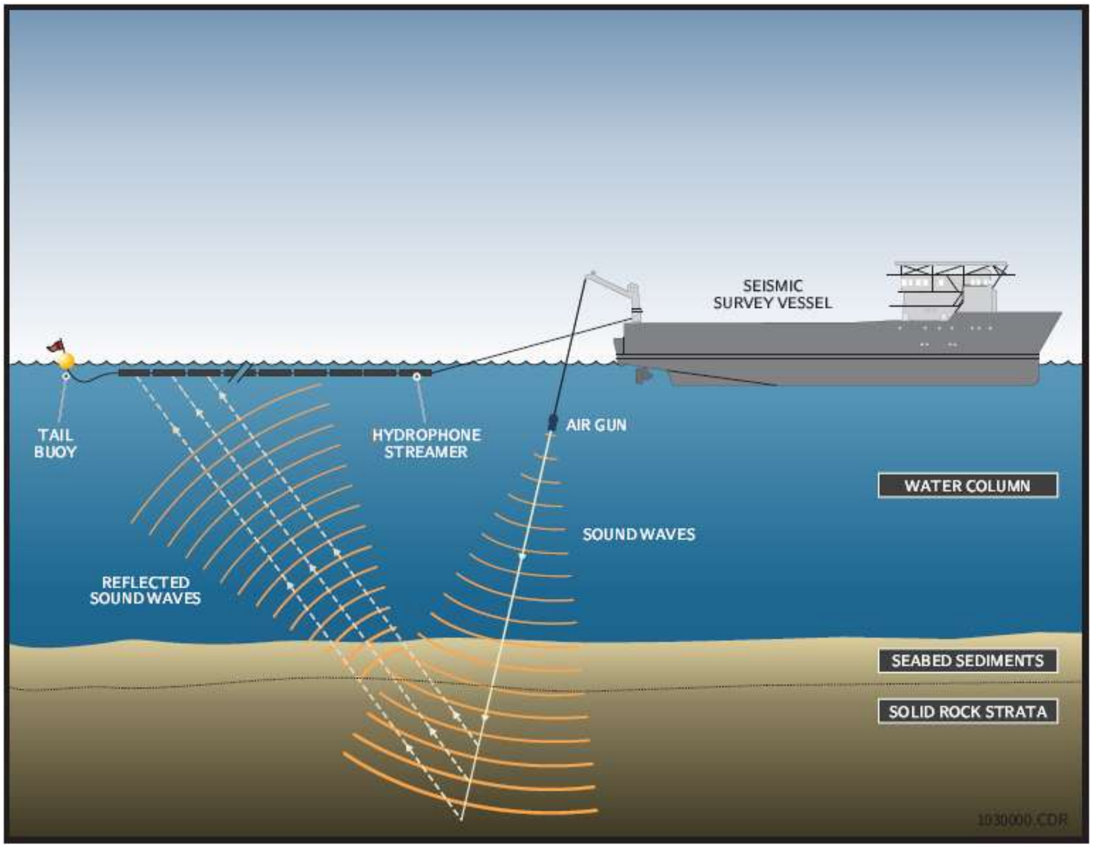


Figure 3-4 Typical Seismic Survey

Air gun Operating Principles

An air gun is a sound source driven by air pressure. It consists of a metal chamber which is filled with highly compressed air (typically 2,000 psi). When the air gun is "fired", the chamber quickly opens, releasing the compressed air into the water, forming a gas bubble. The acoustic pressure measured near a sample air gun is illustrated in Figure 3-5. At time 0, the chamber is opened, air is injected into the water and the acoustic pressure rises rapidly. This is a rapid and dynamic process. The bubble grows so rapidly that its radius actually "overshoots" or gets larger than would be expected based on the air pressure at this point; the pressure inside the bubble becomes less than the water pressure; and the water pressure forces the air back into a smaller volume again. This process also "overshoots" in the other direction as the air bubble collapses, resulting in a higher pressure in the collapsed bubble relative to the water pressure allowing a new bubble to form, which expands and over-expands as with the first bubble; and the process is repeated. This goes on over a very short period of time until enough energy is lost as heat, some gas dissipates and the bubble rises to the water surface. This whole process repeats each time the air gun is fired.

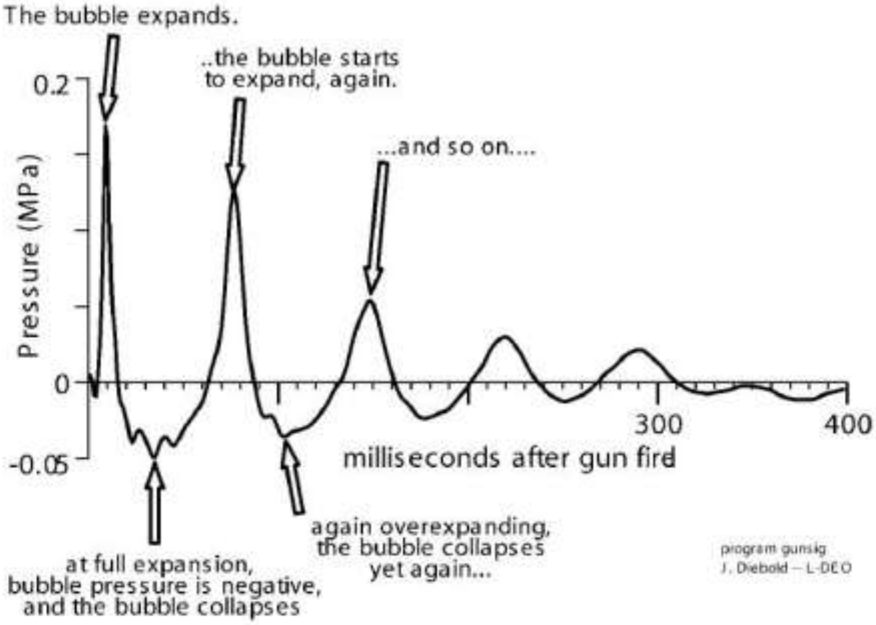


Figure 3-5 Air gun Pressure Signal

The acoustic pressure in the initial bubble expansion (called primary peak) and the subsequent dampened oscillations (called bubble pulses) are clearly shown in Figure 3-5. The amplitude of the initial peak depends primarily on the firing pressure and chamber volume of the air gun, whereas the period and amplitude of the bubble pulse depend on the volume and firing depth of the air gun.

Some air guns, called generator-injector air guns, consist of two chambers. The generator is fired first, producing the primary peak, which is the signal desired by the geophysicist. The injector is fired at half the bubble period to reduce the unwanted bubble pulse, which is noise to the geophysicist. The spectrum of a generator-injector gun is smoother than that of a single-chamber gun (Figure 3-6).

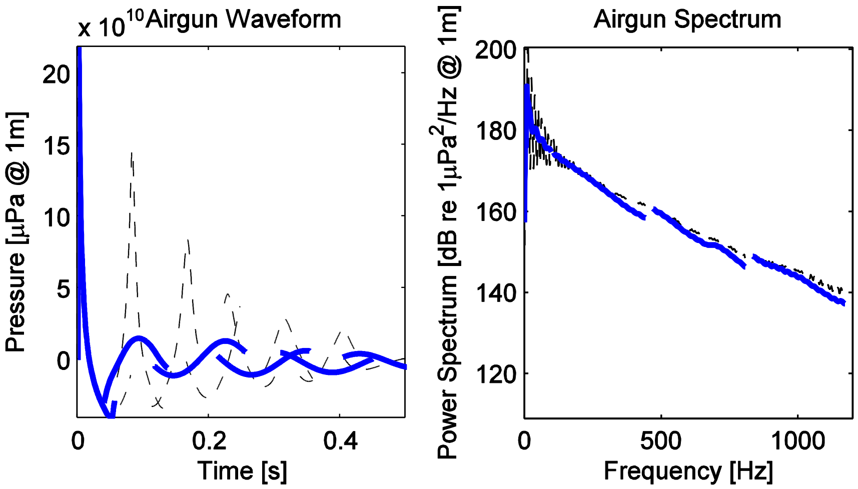


Figure 3-6 **Waveform and Spectrum of a Single-chamber Air gun (dashed line) and of a Generator-injector Gun (solid line)**

Zero-to-peak source levels for single air guns are typically between 220 and 230 dB re 1 µPa @ 1m, with larger air guns generating higher peak pressures than smaller ones. However, the peak pressure of an air gun does not increase linearly with volume, but less (proportional to the rms of the chamber volume).

Furthermore, the amplitude of the bubble pulse also increases with the volume of the air gun and for the geophysicist, the bubble pulse is an undesirable feature of the air gun signal, since it smears out sub-bottom reflections.

Therefore, in order to increase the pulse amplitude (which allows us to see deeper into the Earth), geophysicists generally combine multiple air guns together into arrays. Air gun arrays provide several advantages over single air guns for deep geophysical surveying:

- the peak pressure of an air gun array in the vertical direction increases nearly linearly with the number of air guns;
- air gun arrays are designed to project maximum peak levels toward the seabed (i.e., directly downward); and
- by using air guns of several different volumes, air gun arrays may be “tuned” to increase the amplitude of the primary peak and to simultaneously decrease the amplitude of the bubble pulse.

Air gun Array Source Levels

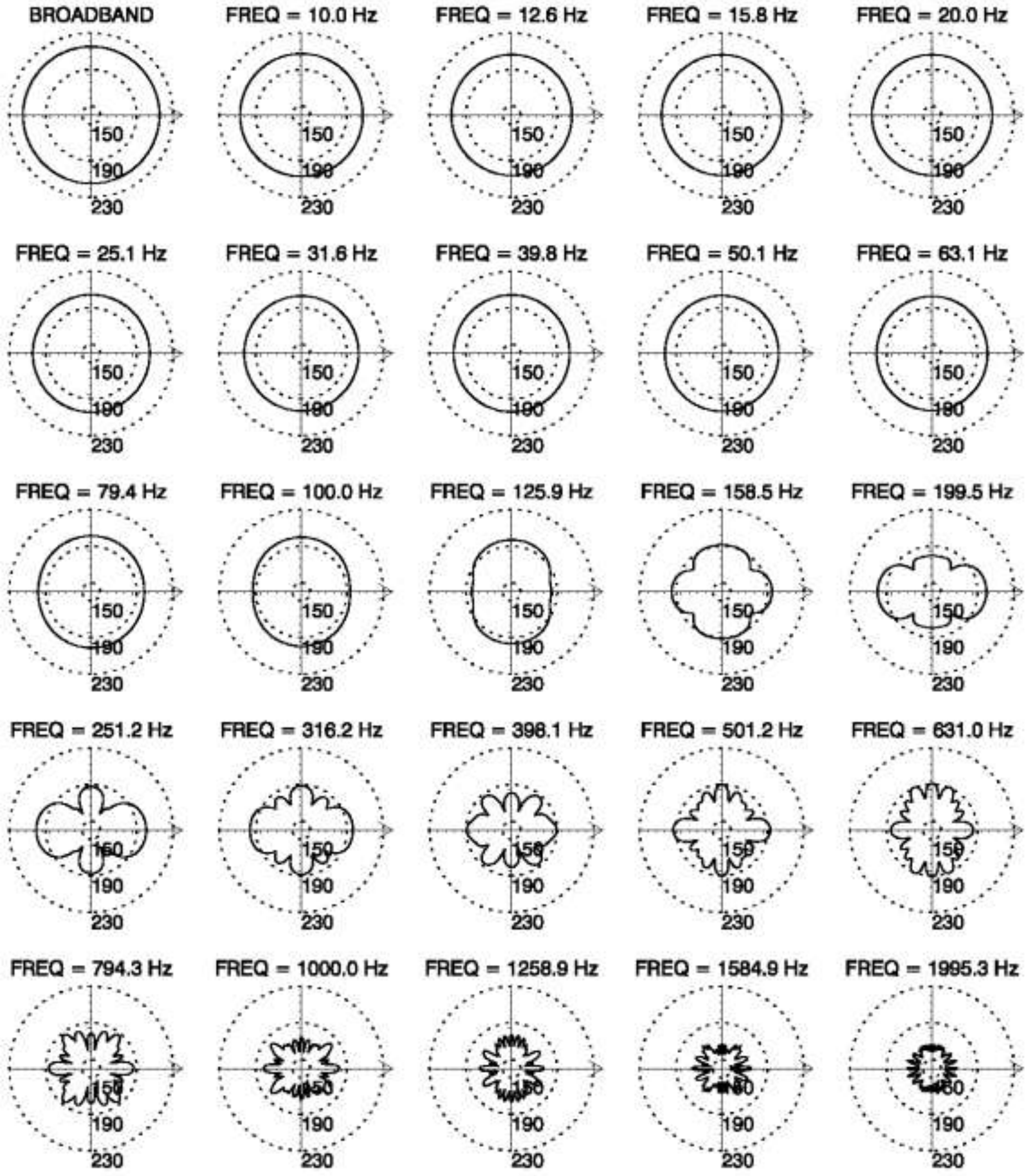
The acoustic source level of a seismic air gun array varies considerably in both the horizontal and vertical directions, due to the complex configuration of guns composing the array. This variability must be accounted for in order to correctly predict the sound field generated by an air gun array. If the source signatures of the individual air guns are known, then it is possible to accurately compute the source level of an array in any direction by summing up the contributions of the array elements with the appropriate time delays, according to their relative positions.

The difference in sound levels between one direction and another of an air gun array is called its directivity. To model sound propagation horizontally through the ocean, the directivity pattern of the air gun array in the horizontal plane is used. A “typical” directivity pattern of a seismic array is shown in Figure 3-7. The directivity pattern is frequency-dependent. Polar plots are shown for the centre frequencies of adjacent 1/3 octave bands. The array is towed in the positive x-direction (i.e., to the right). The opposite direction, to the aft of the array, is called the endfire direction. Broadside is 90 degrees from the tow direction (i.e., in the up and down directions in the polar plots of Figure 3-7).

At low frequencies, the array appears omni-directional, emitting equal energy in all horizontal directions. At mid-frequencies (100 Hz in Figure 3-7), the array becomes dipolar (oval-shaped emission pattern). At approximately 160 Hz, the illustrated array becomes quadrupolar (exhibiting four lobes in its emission pattern). At higher frequencies, the radiation pattern is multi-polar A towed air gun array may have sound levels more than 10 dB greater at broadside than endfire. The directivity of an array is a function of its geometry and varies depending on the particular air guns being used.

An array of 30 guns, for example, may have a zero-to-peak source level of 255 dB re 1µPa @ 1m in the vertical direction. This apparently high value for the source level can lead to erroneous conclusions about the effect on marine mammals and fish for the following reasons:

1. Peak source levels for seismic survey sources are usually quoted relative to the vertical direction. The vertical direction is the desired direction for sub-bottom profiling and the direction of maximum energy, as arrays are designed to focus energy downwards. Source levels off to the sides of the array in the horizontal are generally lower.
2. Sound levels estimated or measured at some range (greater than a few tens of metres from most arrays) correspond to the array’s far-field, also called Fraunhofer Zone. At this range, the array is far enough away for sound propagation paths to apparently originate at a point-like source. Close to the array, this is not true; propagation paths will be substantially different for each air gun in the array. Individual air guns can be resolved as the sound received from each air gun will arrive along paths that differ in length, travel time and phase. This zone close to the array is called the Fresnel Zone, or the near-field. As the individual propagation paths overlap constructively (i.e., waves in the same phase amplify each other) and destructively (i.e., waves in opposite phase cancel each other out) at different places in the near-field, the total received sound level is less than what would be expected by simply adjusting far-field measurements for range.



BROADBAND

FREQ = 10.0 Hz

FREQ = 12.6 Hz

FREQ = 15.8 Hz

FREQ = 20.0 Hz

FREQ = 25.1 Hz

FREQ = 31.6 Hz

FREQ = 39.8 Hz

FREQ = 50.1 Hz

FREQ = 63.1 Hz

FREQ = 79.4 Hz

FREQ = 100.0 Hz

FREQ = 125.9 Hz

FREQ = 158.5 Hz

FREQ = 199.5 Hz

FREQ = 251.2 Hz

FREQ = 316.2 Hz

FREQ = 398.1 Hz

FREQ = 501.2 Hz

FREQ = 631.0 Hz

FREQ = 794.3 Hz

FREQ = 1000.0 Hz

FREQ = 1258.9 Hz

FREQ = 1584.9 Hz

FREQ = 1995.3 Hz

Note: Dotted circular axes indicate source level in dB re 1µPa.

Figure 3-7 Horizontal Directivity Pattern of an Air gun Array

Air gun energy levels generally decrease (due to spreading, absorption and scattering), and signal duration increases (due to energy arriving via different propagation paths at slightly different times; and to a lesser extent due to dispersion (i.e., the difference in travel speed of different frequencies)), with increasing range. In shallow water, higher frequencies (approximately 200 Hz) usually arrive at the “receiver’s” location before lower frequencies (approximately 70 Hz) at ranges of several kilometres. This results in a downward sweeping “chirp”-like sound.

Greene and Richardson (1988) made recordings using open bottom gas guns in water 9 to 11 m depth, hydrophone depth 8 m, ranges 0.9 to 14.8 km. Received levels ranged from 177 dB re 1µPa at range 0.9 km to 123 dB at 14.8 km. Lee *et al.* (2005) reported on measurements recorded during a seismic survey in The Gully Marine Protected Area (with the air gun array approximately 55 km from The Gully); the rms was 133 dB re 1µPa-m at 77 m and 127 dB re 1µPa-m at 180 m. Measurements indicated that sound levels received below 100 m depth were greater than those at 180 m as a result of a seasonal surface sound channel; these are comparable to those recorded during other studies (McQuinn and Carrier 2005, in Lee *et al.* 2005; Simary *et al.* 2005, in Lee *et al.* 2005) at a similar depth distances.

3.3.4.2 GEO-HAZARD SURVEYS

Several tools exist for geoscientists to get an idea of what the bottom of the ocean looks like and determine if hazards to oil and gas activities are present. Active sonar is the most common tool for undertaking geo-hazard surveys. Types of sonar include simple depth sounders, multibeam sonar and side-scan sonar.

Depth sounders and multibeam sonar work by transmitting a ping of noise (signal) through the water column and measuring the time the sound takes to return to the receiver; the distance to the bottom or object of interest can be calculated this way. Multibeam sonar sends a fan-shaped swath of pings to the bottom, so that enough depth information can be gathered to get a very detailed image of the bathymetry, including any marine geo-hazards present.

Side-scan sonar is similar to multibeam sonar except instead of measuring the time for a signal to return to the transmitter, it measures the strength of the return signal. This creates an image of the ocean bottom where objects that protrude from the bottom create a dark image (strong return) and shadows from these objects are light areas (little or no return). No information on the water depth can be gained using this method. A sidescan is usually towed behind a vessel. VSP surveys are also types of geo-hazard surveys.

Side-scan Sonar System for Seabed Imaging

Side-scan sonar builds up a 2-D picture of the seabed, together with any targets on the seabed, using a combination of an asymmetrical transducer and the motion of the sonar platform through the water. Typical side-scan sonar uses a simultaneous dual frequency (105 kHz and 390 kHz) system. It has peak to peak source levels of 228 dB re 1µPa @ 1m for 105 kHz and 222 dB re 1µPa @ 1m for 390 kHz. The side scan firing rate is 3.3 times per second (300 msec firing rate) at 200 m range. Side-scan horizontal beam widths are 1.2 degrees at 105 kHz and 0.5 degrees at 390 kHz. Both sweep over an arc (perpendicular to transect) of 50 degrees.

Sub-bottom Profiler

Sub-bottom profiling operations use a Deep Tow System deployed from the stern of the survey vessel, through an “A” Frame. The system is towed approximately 150 m behind the survey vessel (dependent on cable deployed, water depth and vessel speed), and approximately 20 to 40 m above the seabed.

The Deep Tow System uses a broadband acoustic source with frequency bandwidth from 500 Hz to 6 kHz. Power output is typically 500 Joules (J), but may be increased to 1 kiloJoule (kJ) if necessary. Rise time of the pulse is less than 0.1 millisecond. The boomer derived pulse is primarily restricted to a 60-degree cone. Maximum peak to peak amplitude is 221 dB re 1 µPa @ 1m. The system uses an internal and external hydrophone to record the return signal. Vertical resolution is approximately 10 cm, with penetration of 40 m in sands and 100 m in soft sediment. The option exists to use a sparker source, instead of the boomer, if seabed conditions and data quality warrant it. This system is more omni-directional, and provides similar output power at a lower frequency.

Echosounder

Geophysical surveying operations may employ either a dual frequency single beam sounder or a multibeam echo-sounder. A typical single beam echo-sounder, which is dual frequency capable, operates at 24 kHz and 200 kHz. Single beam echo-sounder source levels are 219 dB re 1µPa @ 1m for 24 kHz, and 215 dB re 1µPa @ 1m for 200 kHz (peak to peak). The single beam echo-sounder firing rate is typically two times per second. Conical beam widths are 9 degrees (200 kHz) and 24 degrees (24 kHz). A multibeam echo sounder operates at 240 kHz, with a source level of 213 dB re 1µPa @ 1m (peak to peak). Its firing rate is approximately four to six times per second, with a beam width of 1.5 degrees per beam. To cover a 150 degree arc, 101 beams are used perpendicular to the transect direction.

3.3.4.3 VERTICAL SEISMIC PROFILES

Standard surface seismic surveys use a seismic source on or near the Earth surface that emits energy that reflects at subsurface interfaces and is recorded by a set of receivers also located on or near the surface. VSPs, also known as borehole seismic surveys, differ in that receiver locations are restricted to the confines of a borehole. While this constraint limits the image volume, it also confers several advantages to seismic surveys in the borehole. For example, waves that travel from a surface source, reflect off a subsurface reflector and then arrive at a borehole receiver are less attenuated by shallow low-velocity layers, having traversed them only once, instead of the two times traveled by surface seismic waves.

The borehole usually is a quieter environment than the surface, so receivers can collect data with higher signal-to-noise ratio. Receivers clamped in the borehole record multiple components of seismic energy in the form of converted shear and direct compressional waveforms, whereas towed marine seismic and standard land seismic acquisition methods record a single component of data that is processed to enhance only compressional arrivals.

Borehole receivers can record direct downgoing airwaves, and/or signals that have been reflected from subsurface geology adjacent to the receivers. Changes in the direct signal recorded at multiple calibrated borehole receivers help determine the attenuation properties of overburden layers. Knowledge of attenuation properties helps restore portions of signal lost during transmission of both borehole and surface seismic waves. Receivers can be positioned accurately at specified depths in the borehole, allowing geophysicists to derive a profile of layer velocities at the well location. This helps convert time-indexed surface seismic data to depth, so seismic images can be tied to well-log data and drill-bit positions can be tracked on seismic sections.

There are numerous methods for acquiring VSPs. VSPs include the zero-offset VSP, offset VSP and walkaway VSPs. Zero-offset VSPs have sources close to the wellbore directly above receivers. Offset VSPs have sources some distance from the receivers in the wellbore. An offset VSP uses a source located at an offset from the drilling rig during acquisition to allow imaging to some distance away from the wellbore. In a walkaway VSP, the source is moved to progressively farther offset at the surface and receivers are held in a fixed location, effectively providing a mini 2-D seismic line that can be of higher resolution than surface seismic data and provides more continuous coverage than an offset VSP. The source is attached to a vessel and fired, then the vessel moves away from the platform and fires gain at specific locations in accordance with the planned grid, etc. Three-dimensional walkaways, using a surface grid of source positions, provide 3-D images in areas where the surface seismic data do not provide an adequate image due to near-surface effects or surface obstructions.

With a zero-offset VSP, a seismic source array is deployed over the side of the drilling platform. A typical VSP source array would be comprised of four 150-cubic inch air guns and four 40-cubic inch air guns with a calibrated peak vertical source level of 242.5 dB re 1µPa @ 1m. The source is activated three to five times to create a sonic wave that is picked up by the geophones in the borehole.

A typical zero-offset compressional source signal has a 12 s linear sweep covering the frequency band 10 to 200 Hz. Frequency content for other VSPs include 10 to 100 Hz for an offset compressional source and 10 to 50 Hz for a zero offset shear source (Mi *et al.* 1999).

3.3.4.4 VESSEL TRAFFIC AND AIRCRAFT OPERATIONS

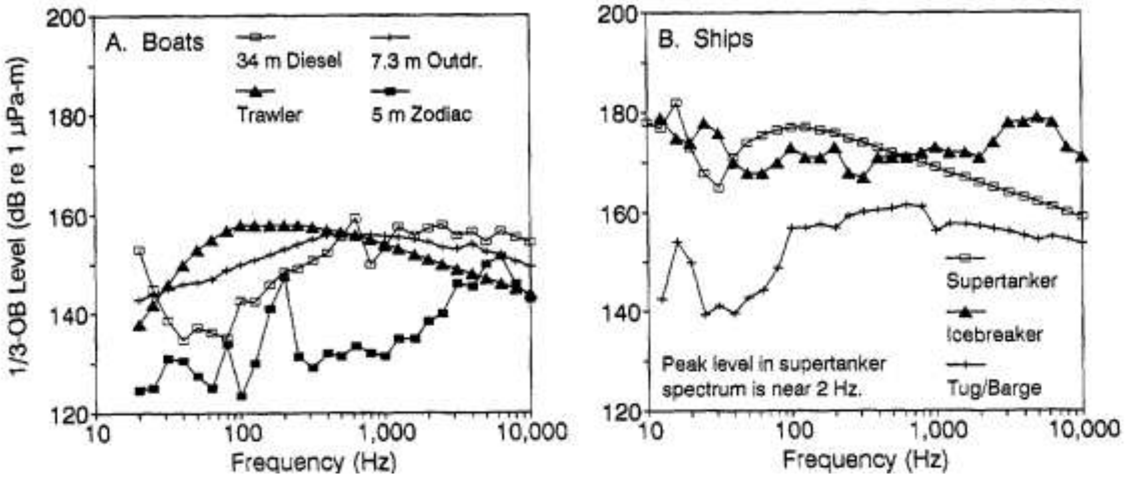
Various supply vessels will be involved in the support of exploration; they will serve a variety of roles, ranging from personnel transport to re-provisioning to inspection, cargo and maintenance work. In addition to marine vessel traffic, helicopters will fill a vital role especially in the transport of personnel to and from ships and platforms. All of these sources of noise will contribute to the overall acoustic environment of the area.

Underwater noise due to vessels and aircraft associated with the installation and operation of oil and gas platforms can be attributed primarily to dredgers, tugs and barges, icebreakers, supply ships, small vessels and helicopters.

Vessels discussed in this section can be characterized essentially as continuous noise sources, though, as discussed below, helicopter overflight is considered a transient noise source due to the limited angle of propagation of the airborne sound into the water column. The vessels involved in offshore oil and gas operations span a wide range of sizes, power ratings and applications and, consequently, generate widely different levels of underwater sound. Vessel and helicopter noise are a combination of tonal and broadband sounds, which in the case of vessels, is dependent on their size, design and speed (Richardson *et al.* 1995).

Boat and ship noise is attributable mainly to propeller cavitation, propeller singing, propulsion engines (noise transmitted through the vessel's hull) or other machinery. Noise from any of these sources can be exacerbated given any damage or improper operation. Cavitation is usually the dominant noise source according to Ross (1976, in Richardson *et al.* 1995). The frequency spectrum of cavitation noise has been observed to be a broadband noise consisting of sharp pulses that correspond with the propeller rotation frequency times the number of blades (Erbe and Farmer 2000). Noise from older, medium to high-speed diesel engines built with simple connecting rods is strong enough to potentially overshadow cavitation (Ross 1976). Modern diesels built with articulated connecting rods (mostly found in tankers, freighters and container ships) are slow speed (<250 rpm) and relatively quiet, with cavitation being the dominant noise source (Richardson *et al.* 1995).

Generally, the larger the vessel, the greater the level and lower the frequency of sound emitted. A comparison of 1/3 octave bands associated with both small and medium to large vessels is provided in Figure 3-8. In an operation involving diverse vessel sizes, noise will be mainly due to medium and large vessels. When operating at relatively close range, small vessels with outboard engines, such as zodiacs, may also contribute considerable underwater noise levels (Erbe 2002).



Note: The icebreaker noise is from the Robert Lemeur (studied by Greene 1987) pushing on ice at full power (7.2 MW) and zero speed. This is estimated to be louder than that generated by an ocean-going tug pulling a load at low speed.

Source: Richardson *et al.* 1995.

Figure 3-8 **Estimated One-third Octave Sound Levels of Underwater Noise at 1 m for A) Boats; and B) Ships**

Airborne sound waves only penetrate effectively into the ocean environment within a 13-degree cone off the vertical; much of the noise outside this cone does not penetrate the water surface. Because of the conical acceptance volume, aircraft are audible in the water column for longer periods when flying at higher altitudes. Furthermore, the duration of audibility is greater for shallow receiver depths (Urick 1972; Greene 1985).

Propellers or rotors generate the primary source of aircraft noise. Blade rotation produces tones with fundamental frequencies dependant on the number of blades and rate of rotation. An increase in the number of blades also produces a corresponding increase in the fundamental frequency for a given rotation rate (Richardson *et al.* 1995). Generally, noise spectra are below 500 Hz, with dominant tones produced as harmonics of the blade rates of the main and tail rotors (Richardson *et al.* 1995). Tones associated with the engines and other rotating parts may also be present, resulting in a potentially large number of less prominent tones at many frequencies.

4.0 PHYSICAL ENVIRONMENT

This section provides a physical environment setting description and discussion of potential effects of the environment on the Project. The setting includes geology and bathymetry for the area as well as a summary of normal and extreme meteorological, oceanographic, and ice conditions. This includes a broad overview of the physical environment of the Labrador Shelf Offshore Area Strategic Environmental Assessment (SEA) (Sikumiut 2008) with focus on the Project Area. The information presented is based almost exclusively on the SEA which was assembled from published literature, unpublished reports, and other relevant information sources. Where appropriate, new data queries and analysis products have been prepared to update the information for the Project Area.

4.1 CLIMATE CHANGE

Current research indicates that climate change is an evolving reality. That the climate is changing has been recognized by the federal, provincial and territorial governments in Canada and internationally, with a resultant increase in temperature (primarily attributable to human activity such as the use of fossil fuels and land clearing in the last 50 years (CEA Agency 2003)) and its related changes to ecosystems. This human activity has resulted in increased atmospheric concentrations of greenhouse gases (GHGs).

Climate changes can not only have a potential effect on physical and biological environments, but can also result in the environment affecting the Project through changes in storm activity, fog, wind, wave action and storm surge.

4.2 GEOLOGY

As stated in the Labrador Shelf SEA (Sikumiut 2008) the seabed and near-seabed material of the Study Area is a combination of bedrock, till and marine sediments. The geological and geotechnical interpretation described above have been established primarily from geophysical survey data, particularly high resolution seismic performed in the 1970s and early 1980s. For more information about geology see Section 3.1 of the Labrador Shelf SEA (Sikumiut 2008).

4.2.1 SURFICIAL GEOLOGY

The surficial geology of the Labrador Shelf was compiled and discussed in NORDCO (1982) and Josenhans *et al.* (1986) and is summarized in Section 3.1 of the SEA (Sikumiut 2008). The seabed and near-seabed material on the Labrador Shelf can divided into five geological units:

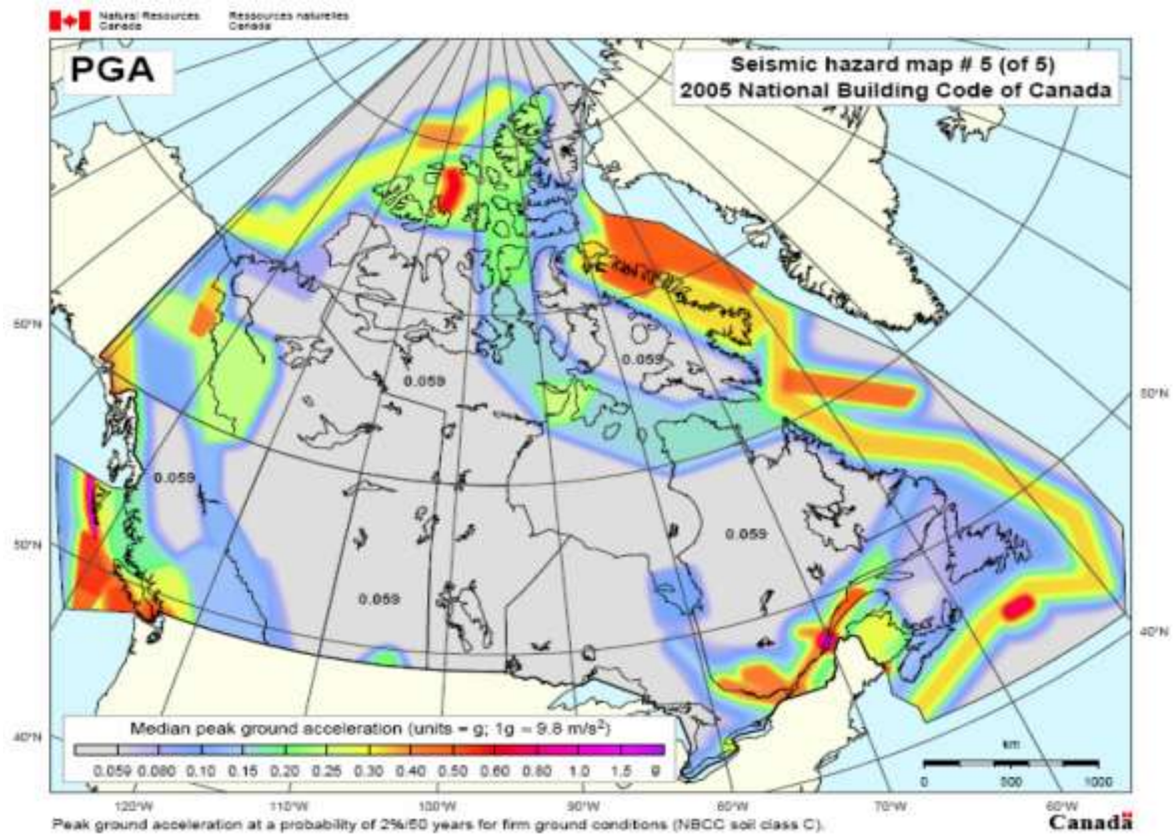
- Unit 1 - Precambrian bedrock: Metamorphic and igneous Precambrian bedrock dominate the inner shelf seafloor. Structural trends are predominantly east-west in the Cape Harrison area;

- Unit 2 - Tertiary strata: Tertiary bedrock is divided into two subunits - the Mokami Formation (claystone and shale) and the Saglek Formation (unconsolidated feldspathic and cherty conglomeratic sandstone);
- Unit 3 – Till: a direct glacial deposit comprised of a variety grain sizes and lacking stratification that can be less that 20 m thick to over 100 m thick (in the Bjarni area) along the Labrador Shelf, but is generally less than 50 m;
- Unit Four - Pro-glacial and sub-glacial sediments: these sediments can be found up to 35 m thick within the deepest portions of the Marginal Trough (where they are primarily found) and the saddles; and
- Unit 5 - Post-glacial marine sediments. Comprised of three sub-units (the Makkaq Clay (Unit 5a); Sioraq Sand (Unit 5b); and Sioraq Silt and Gravel (Unit 5c)) that form the surficial deposits over almost the entire outer Labrador Shelf and Marginal Trough.

Cobbles and boulders are widely distributed in the upper sediments of the Labrador Shelf. Boulders up to 0.7 m diameter have recovered at well site areas (IFP 1977), and boulder beds ranging in thickness between 2 and 22 m thick have also been reported (McWhae and Michel 1975).

4.2.2 SEISMICITY

The seismic hazard map developed as part of the National Building Code of Canada (Adams and Atkinson 2003) is presented in Figure 4-1 and illustrates that the Labrador Shelf region has a moderate earthquake hazard, with peak ground accelerations between 0.06 and 0.4 g (the west coast of Canada near the Queen Charlotte Islands on the west coast of Canada has a value of 1.5 g), although large (Magnitude 6 to 7.3) earthquakes have been recorded in Baffin Bay, thought to be a result from the removal of surface loads from deglaciation.



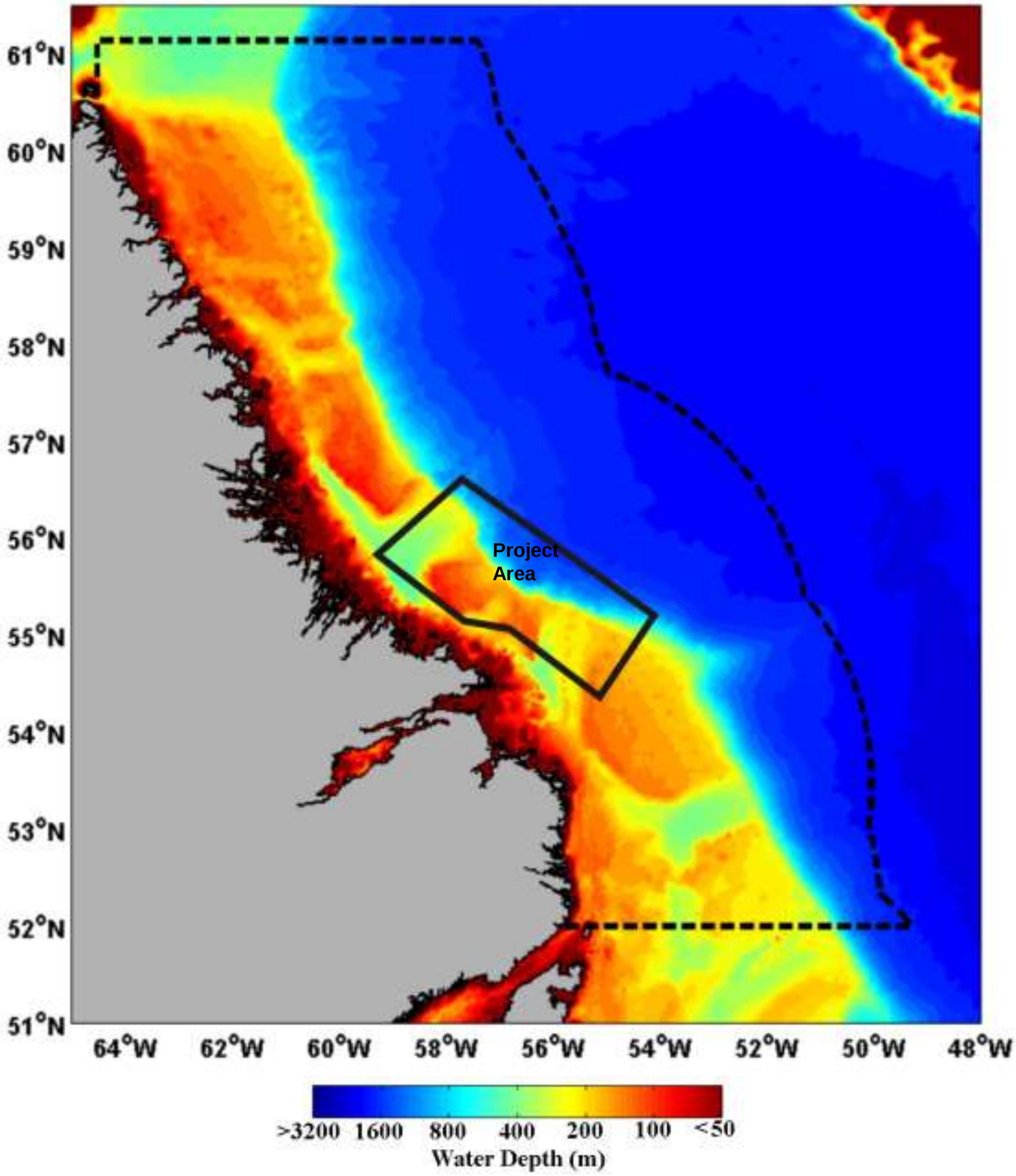
Source: Adams and Halchuk 2003, in Labrador Shelf SEA Section 3.1.7 (Sikumiut 2008).

Figure 4-1 **Seismic Hazard Map – 2005 National Building Code of Canada**

4.3 BATHYMETRY

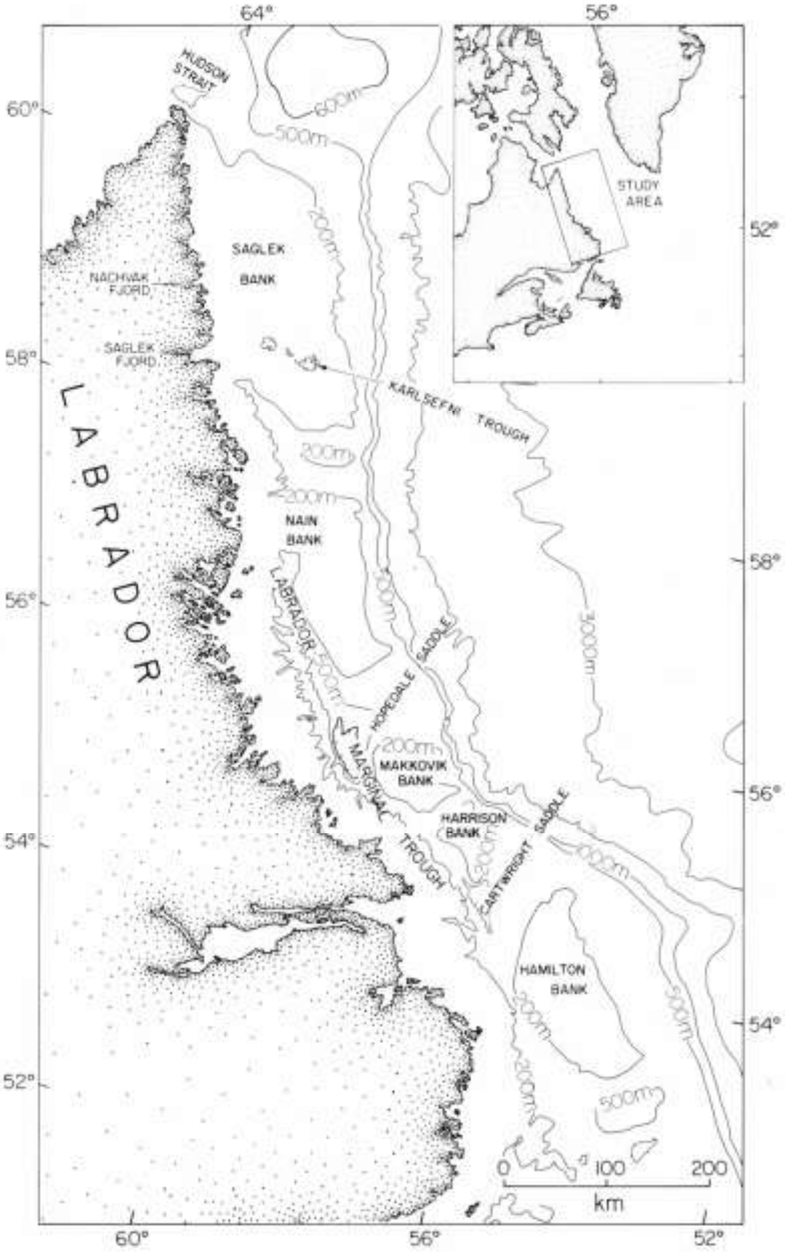
The Labrador Shelf is approximately 150 km wide, with water depths of less than 70 m within 2 km of shore. Deep saddles run in a northeast-southwest direction and there are separate shallow offshore banks with water depths less than 200 m. The banks extend to the edge of the shelf that rapidly drops off to depths greater than 3,000 m (Figures 4-2 and 4-3).

The Labrador Shelf can be divided into four distinct regions: the coastal embayment; a shallow rough inner shelf; a marginal trough; and a smooth, shallow outer shelf consisting of banks and intervening saddles. The inner shelf extends from the coast to approximately the 200 m isobath, with a width of approximately 25 km. The bathymetry features are complex with slopes, vertical faces, shoals, channels and rapidly changing bathymetry. The marginal trough divides the inner and outer shelf with depths of up to 800 m but mostly remains at 300 m. The outer shelf contains a series of banks which are separated by east-west trending depressions called saddles, with depths up to 800 m. The presence of moraines and other glacial features results in local bathymetric relief (mounds or depressions) of up to 10 m, with diameters of several hundred metres. Further discussion of bathymetry is presented in Labrador Shelf SEA Section 3.2 (Sikumiut 2008).



Source: Labrador Shelf SEA Section 3.2 (Sikumiut 2008)

Figure 4-2 Labrador Sea Bathymetry for the Study Area



Source: Labrador Shelf SEA Section 3.2 (Sikumiut 2008)

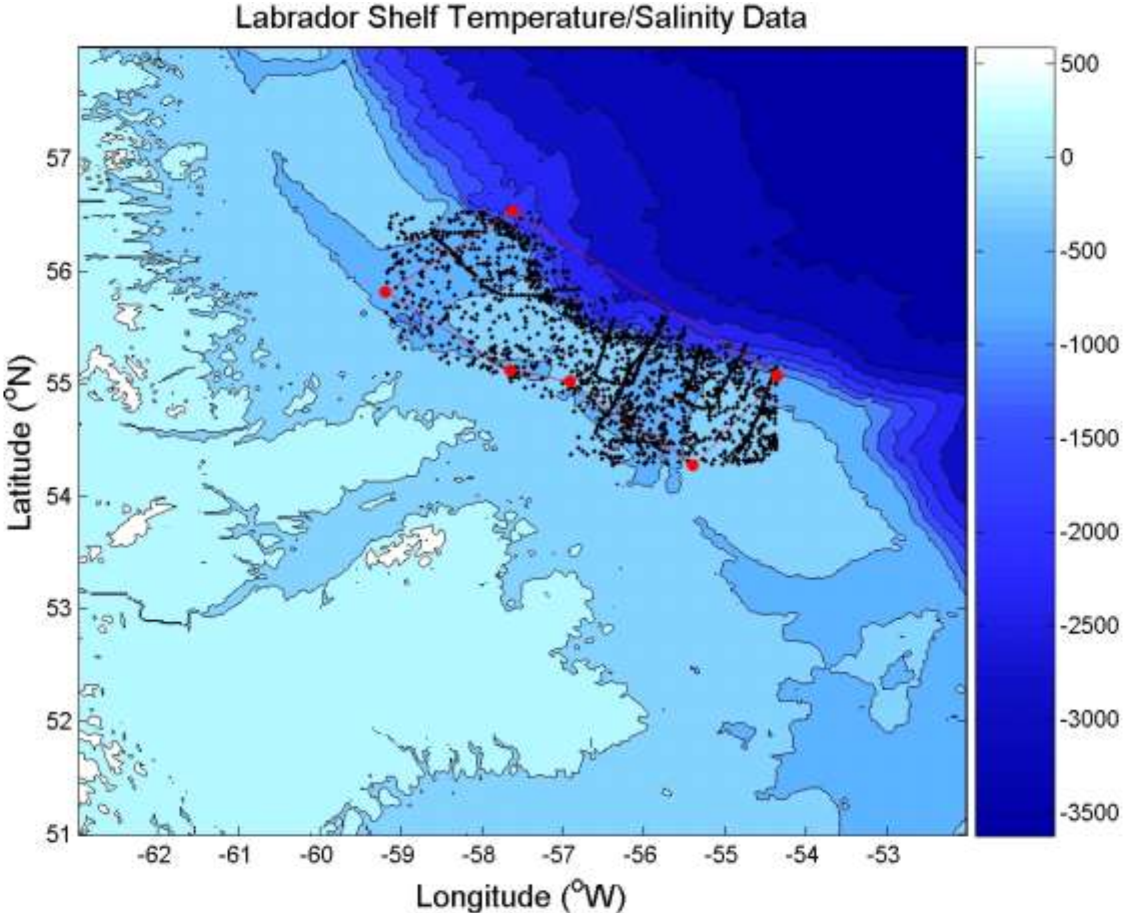
Figure 4-3 Location Map of Labrador Shelf Indicating Main Features

The banks within the Project Area include the Makkovik and Harrison Banks with the Hopedale saddle to the north and the Cartwright Saddle to the south. To the east of the Project Area is the edge of the shelf and to the west is the Labrador Marginal Trough (Figure 4-3).

4.4 OCEANOGRAPHIC CONDITIONS

4.4.1 SEA TEMPERATURE AND SALINITY

Temperature and salinity data were extracted from the Department of Fisheries and Oceans (DFO) Bedford Institute of Oceanography (BIO) hydrographic database (BIO Hydrographic Database 2009). This database is a collection of temperature and salinity measurements for the area roughly defined by 35° to 80°N and 42° to 100°W. The data come from a variety of sources including hydrographic bottles, CTD casts, spatially and temporally averaged Batfish tows, expendable digital or mechanical bathythermographs and near real-time data in the form of IGOSS (Integrated Global Ocean Services System) Bathy or Tesac messages (codes for oceanographic data). The database currently consists of approximately 782,000 profiles and 35 million individual observations from 1910 to the present. For this study, 29,192 (temperature, salinity, density) observations were extracted for the proposed Project Area boundary as shown in Figure 4-4.



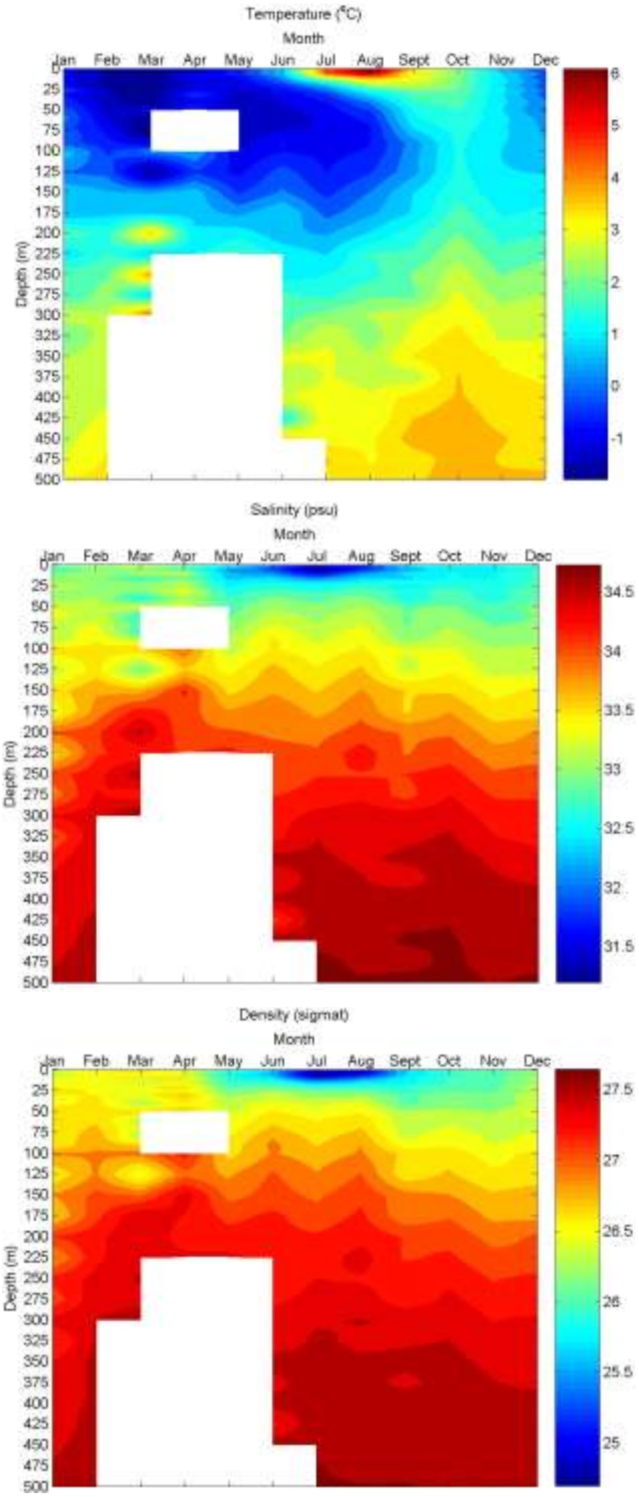
Note: The red dots and lines outline the Project Area.
Source: BIO Hydrographic Database, 2009. (Bathymetry source: Smith and Sandwell 1997).

Figure 4-4 Temperature and Salinity Measurement Locations for the Labrador Shelf, Newfoundland and Labrador

Following some additional data QC, approximately 25,531 observations remained: these were averaged by depth with bin depth of 2 m for 0 to 25 m with steps of 5 m, bin depth of 2 m for 30 to 100 m with steps of 10 m, bin depth of 5 m for 125 to 500 m with steps of 25 m and bin depth 10 m from 600 to 1500 m every 50 m. The resultant temperature, salinity, and density values were contoured to yield a monthly sectional view to 500 m depth as shown in Figure 4-5. There are some missing data for March, April and May, especially at lower depths. Complete monthly statistics are provided in Appendix D. Seasonal temperature and salinity profiles for select depths are shown in Figure 4-6 and Table 4-1.

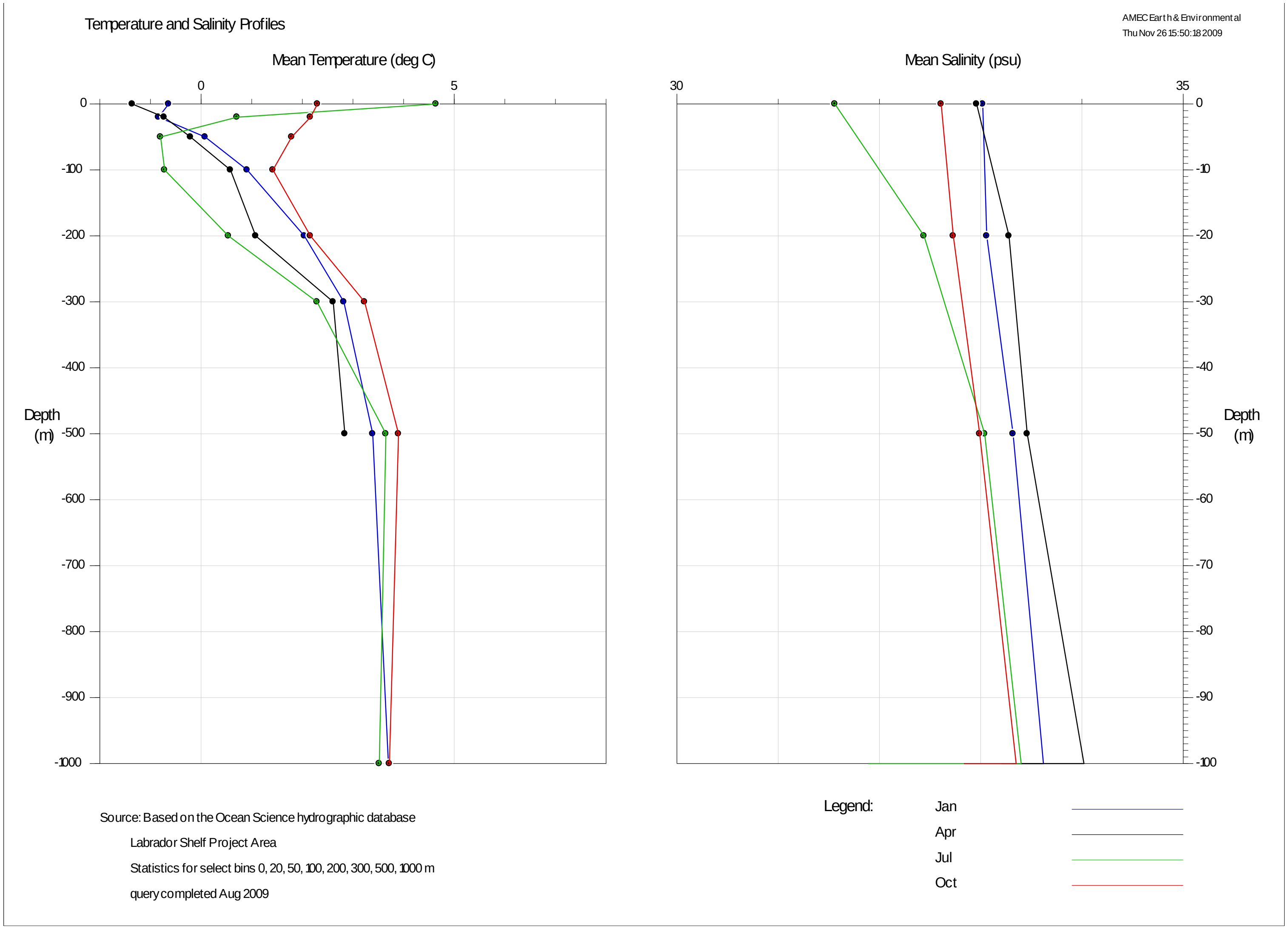
Approximately 29,200 measurements were available; these were averaged by depth with bin depth of 2 m for 0 to 25 m with steps of 5 m, bin depth of 2 m for 30 to 100 m with steps of 10 m, bin depth of 5 m for 125 to 500 m with steps of 25 m and bin depth 10 m from 600 to 1,500 m every 50 m. The results are presented in Figure 4-5 down to 500 m and monthly statistics are provided in Appendix D with a summary in Table 4-1. There are missing data for March, April and May especially at lower depths.

Stratification shows as a two layer system all year and a third surface layer in summer. In summer the surface layer is down to about 50 m with average temperatures reaching 6.5 °C and average salinities down to 31.7 psu. The stratification changes in October to a two layer and remains two layers until June. The upper layer is colder and saltier than the lower layer present in the upper 175 m. This is called the cold intermediate layer (CIL) (<0°C) which occurs at different extends on the entire continental shelf. In the upper layer in fall the average temperature ranges from 2.2°C in October to -1.4 °C in February and the average salinities range from 32.6 psu in October to 34.6 psu in March. Below 500 m, water properties are stable and with average temperature ranging from 3.4 to 3.9 °C and salinity of 34.6 to 34.9 psu.



Source: BIO Hydrographic Database 2009.

Figure 4-5 Contours of Temperature, Salinity and Density



Source: BIO Hydrographic Database 2009.

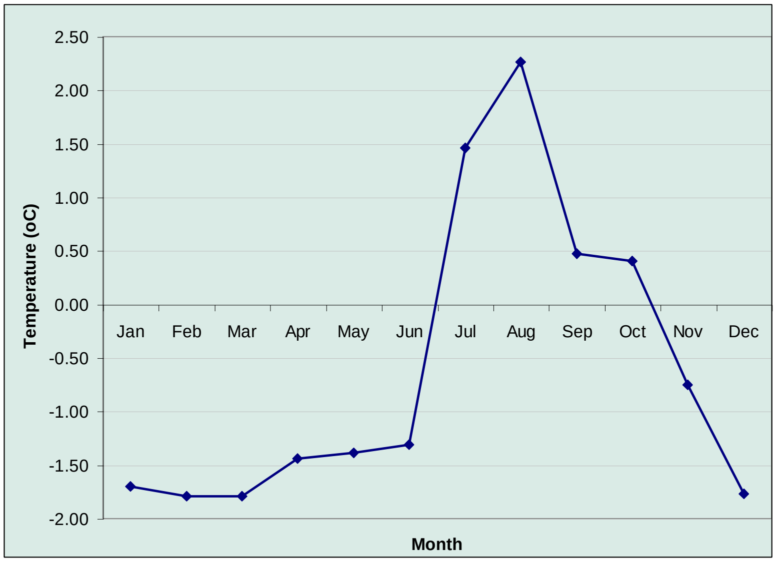
Figure 4-6 Mean Temperature and Salinity Profiles for Project Area

Table 4-1 Temperature and Salinity Statistics

Depth (m)	Temperature (^oC)					Salinity (psu)				
	Min	Max	Avg	Std Dev	Total Count	Min	Max	Avg	Std Dev	Total Count
January										
0	-1.70	1.74	-0.64	0.82	59	32.15	33.86	33.02	0.39	59
20	-1.72	1.09	-0.84	0.64	39	32.42	33.88	33.06	0.39	39
50	-1.68	2.78	0.08	1.19	52	32.39	34.49	33.32	0.57	52
100	-1.48	3.67	0.91	1.32	52	32.48	34.68	33.62	0.60	52
200	-0.97	4.13	2.04	1.47	58	32.62	34.80	34.05	0.62	58
300	-0.10	4.10	2.82	1.11	29	33.22	34.84	34.40	0.46	29
500	2.09	4.02	3.39	0.61	8	34.24	34.86	34.69	0.21	8
1,000	3.65	3.78	3.70	0.07	3	34.87	34.89	34.88	0.01	3
April										
0	-1.44	-1.27	-1.36	0.12	2	32.88	33.03	32.96	0.11	2
20	-1.47	0.71	-0.73	1.25	3	32.83	33.99	33.28	0.62	3
50	-1.40	2.04	-0.21	1.95	3	32.85	34.40	33.46	0.83	3
100	-1.06	2.22	0.58	2.32	2	33.56	34.47	34.02	0.64	2
200	-1.01	3.15	1.08	2.08	3	33.24	34.77	34.06	0.77	3
300	2.00	3.21	2.61	0.86	2	34.39	34.81	34.60	0.30	2
500	2.84	2.84	2.84	0.00	1	34.69	34.69	34.69	0.00	1
1,000	-	-	-	-	-	-	-	-	-	-
July										
0	1.46	9.51	4.64	1.50	121	28.64	33.86	31.56	0.95	121
20	-1.70	6.76	0.71	1.56	144	30.79	34.42	32.44	0.56	144
50	-1.80	4.14	-0.80	1.03	178	32.04	34.76	33.04	0.41	178
100	-1.71	3.84	-0.72	1.12	163	32.35	34.76	33.40	0.42	163
140	-1.52	4.46	0.54	1.59	106	33.10	34.83	33.97	0.42	106
300	-0.85	4.53	2.29	1.47	46	33.81	34.86	34.43	0.32	46
500	1.62	4.19	3.65	0.60	17	34.23	34.88	34.80	0.16	17
1,000	3.42	3.58	3.52	0.09	3	34.84	34.88	34.86	0.02	3
October										
0	0.40	5.28	2.30	0.90	259	29.08	34.12	32.61	0.55	259
20	0.40	5.20	2.16	0.87	325	31.04	34.38	32.73	0.53	325
50	-0.72	5.40	1.79	1.09	335	31.17	34.45	32.99	0.51	335
100	-1.40	5.24	1.42	1.11	321	32.36	34.68	33.35	0.50	321
200	-0.93	4.66	2.16	1.21	280	32.93	34.80	34.00	0.50	280
300	0.85	4.77	3.23	0.91	183	33.55	34.89	34.49	0.30	183

Depth (m)	Temperature (^oC)					Salinity (psu)				
	Min	Max	Avg	Std Dev	Total Count	Min	Max	Avg	Std Dev	Total Count
500	2.77	4.67	3.90	0.41	87	34.42	34.91	34.77	0.10	87
1,000	3.32	4.11	3.72	0.23	19	34.81	34.90	34.85	0.02	19
Source: BIO Hydrographic Database 2009.										

The monthly minimum surface water temperature is shown in Figure 4-7. From November to June temperatures can reach below 0°C, with a minimum ranging from -1.7°C to -1.79°C from December to March.



Source: BIO Hydrographic Database 2009.

Figure 4-7 Minimum Sea Temperature

4.4.2 WAVES

Characterization of the wave climate in the offshore Newfoundland and Labrador area can be made using the long-standing AES40 North Atlantic Wind and Wave Climatology or the MSC50 Wind and Wave Climatology update. The AES40 was developed at Oceanweather with support from Climate Research Branch of Environment Canada. The hindcast involved the kinematic reanalysis of all significant tropical and extra-tropical storms in the North Atlantic for the continuous period 1958 to 1998. Oceanweather's 3rd generation wave model (OWI3G) was adopted onto a .625 by .833 degree grid, wind and wave fields were archived at all active model points. The AES40 methodology and validation has been extensively documented and presented in peer-reviewed journals and conferences. In 2005, the AES40 hindcast in Canadian waters was improved by a shallow water version of the OWI3G on a 0.1 degree grid covering much of the Canadian Maritimes. The North Atlantic basin model was similarly upgraded and run at a 0.5 degree resolution. The MSC50 also extended the time-series to the 52 years 1954-2005 (MSC50 2006).

The MSC50 Grid Point M3013763 (55.5°N, -57°W) located on the Labrador Shelf in 341.3 m water depth (location shown in Figure 4-8) is relevant for the Project Area.

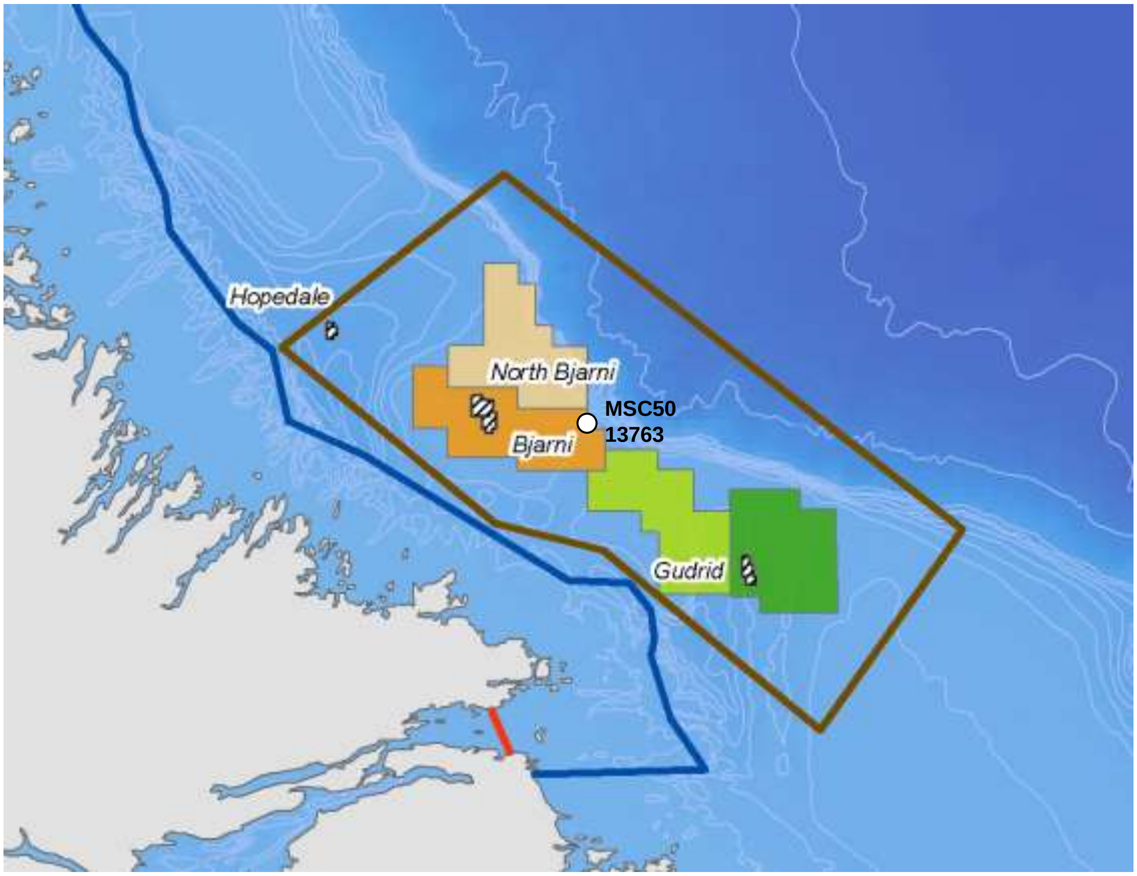


Figure 4-8 **MSC50 Climatology Grid Point, M3013763 (55.5°N, -57°W) Labrador Shelf, Newfoundland and Labrador, in Relation to Project Area**

Wave roses for MSC50 Grid Point M3013763 are presented in Figure 4-9 to Figure 4-11. Monthly and annual significant wave height and peak wave period statistics are shown in Table 4-2. A bivariate table of significant wave height versus peak period, based on all months, is provided in Table 4-3.

Wave parameters include significant wave height (Hs) and peak wave period (Tp). Significant wave height, Hs, is the average height of the one third largest waves. The peak wave period, Tp, is the period of the waves with the greatest energy. Hs reaches a maximum of 11.5 m in January. The greatest occurrence of Hs (60 percent) was between 0 and 2 m. While in the summer, waves are most frequently from the east and east-south-east, by fall north is the most frequent direction from which waves propagate into the area. Peak wave period ranges from 1.6 to 18.7 s with the greatest occurrence (33.4 percent) being between 6 and 8 s.

The monthly maximum Hs for the Project Area Grid Point 13763 is shown in Figure 4-12. From October to January, Hs is greater than 10 m with a maximum ranging from 11 to 11.5 m.

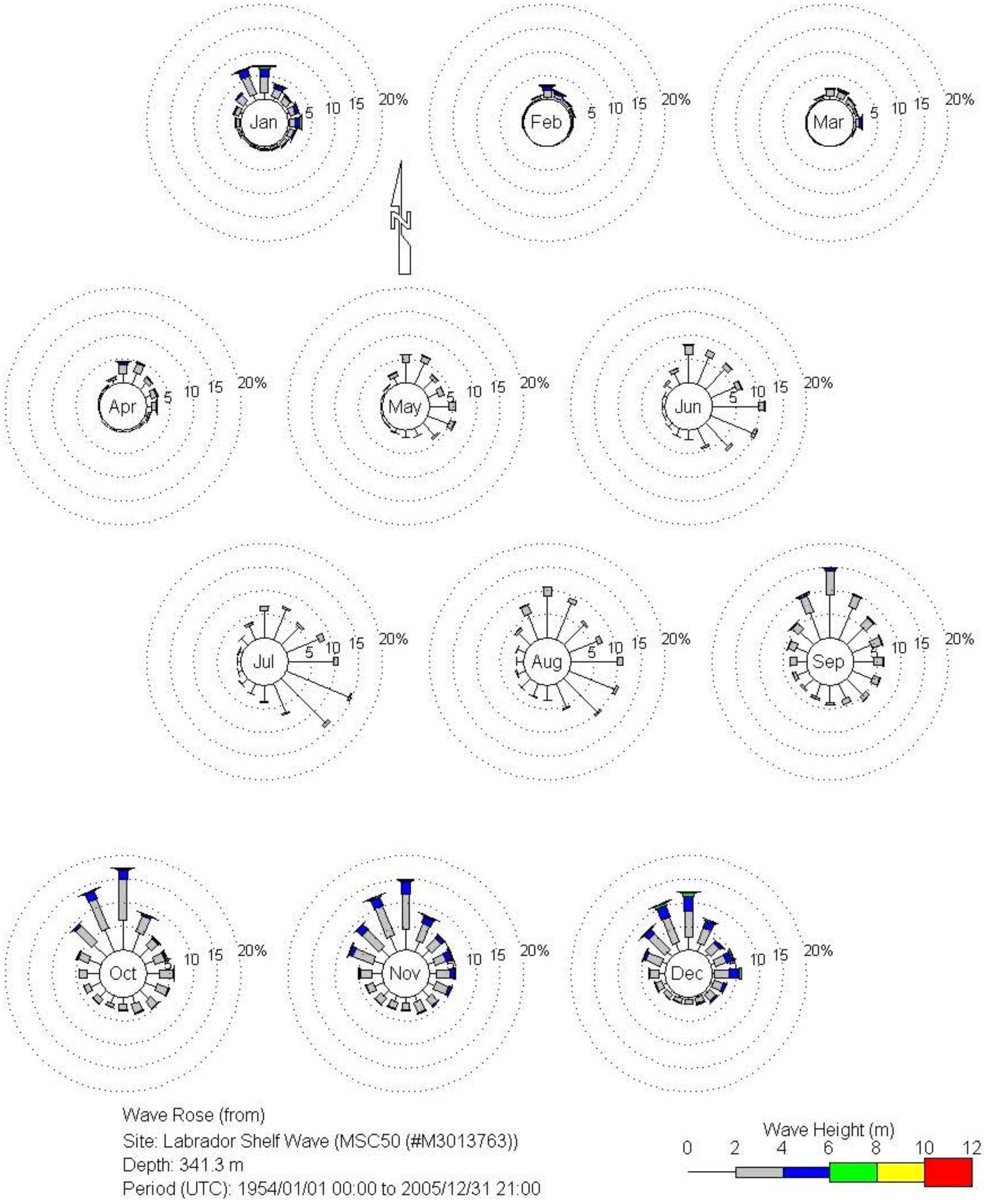


Figure 4-9 **Monthly Frequency of Significant Wave Height Occurrence by Direction for the MSC50 Grid Point (M3013763) on the Labrador Shelf**

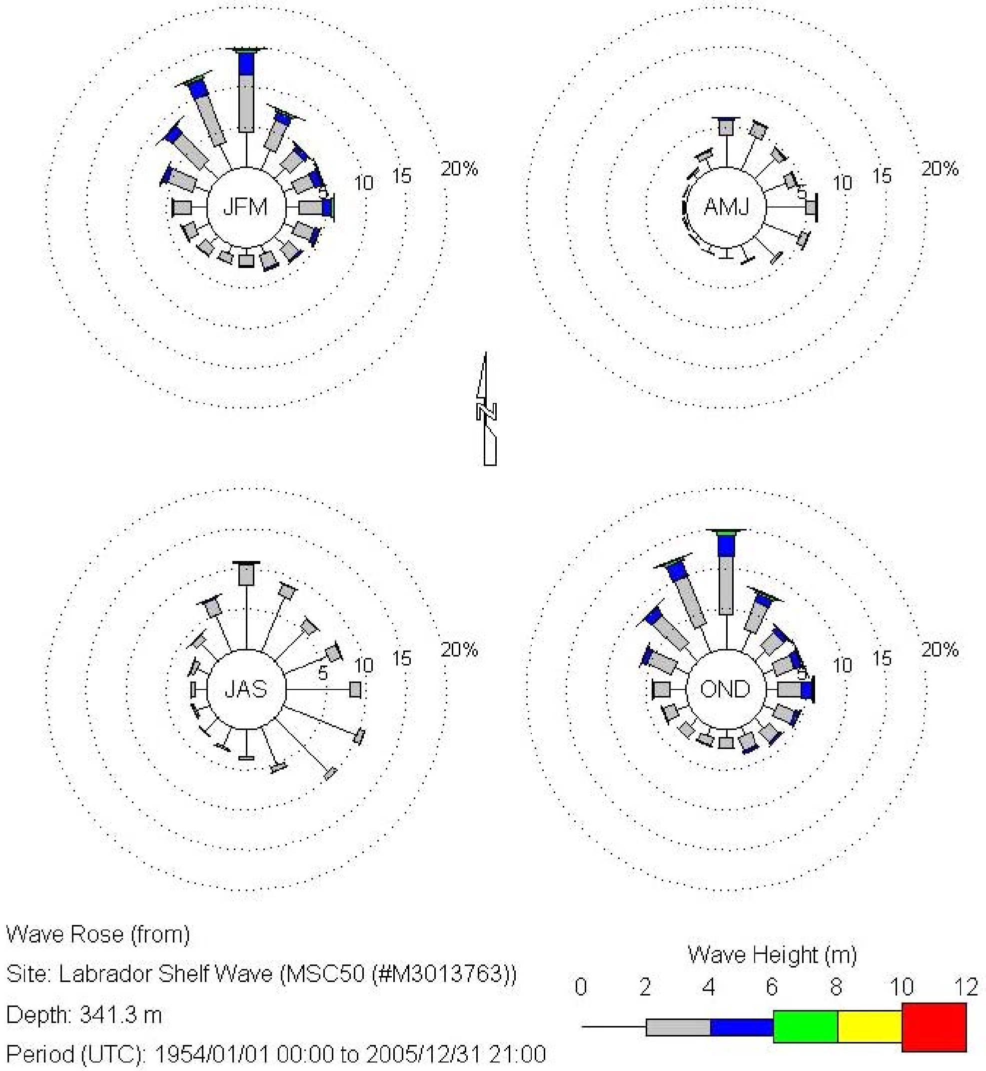


Figure 4-10 **Seasonal Frequency of Significant Wave Height Occurrence by Direction for the MSC50 Grid Point (M3013763) on the Labrador Shelf**

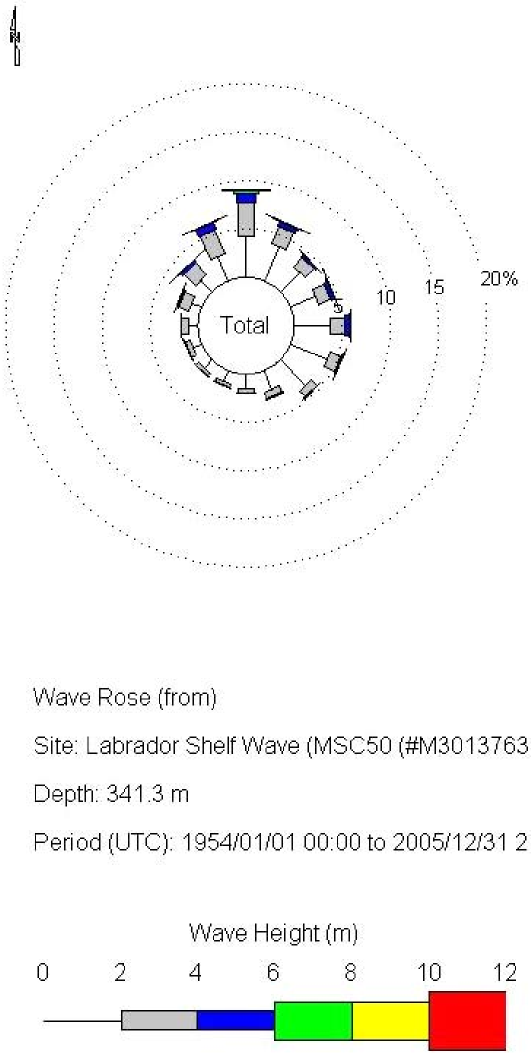


Figure 4-11 Annual Frequency of Significant Wave Height Occurrence by Direction for the MSC50 Grid Point (M3013763) on the Labrador Shelf

Table 4-2 Monthly Significant Wave Height and Peak Period Statistics from MSC50 Grid Point (M3013763) on the Labrador Shelf

Month	Significant Wave Height (m)				Peak Period (s)		
	Minimum	Mean	Maximum	Most Frequent Direction	Minimum	Mean	Maximum
Jan	0.6	3.2	11.5	NNW	3.3	9.8	17.2
Feb	0.4	3.3	9.7	N	3.7	10.4	16.6
Mar	0.3	2.7	9.2	N	3.6	9.8	16.2
Apr	0.1	2.2	8.8	NNE	2.5	8.7	14.9
May	0	1.5	6.6	NNE	2.2	7.9	16
Jun	0.1	1.3	7.6	E	1.6	7.5	16
Jul	0	1.1	4.4	ESE	1.7	6.9	17.3

Month	Significant Wave Height (m)				Peak Period (s)		
	Minimum	Mean	Maximum	Most Frequent Direction	Minimum	Mean	Maximum
Aug	0.1	1.2	5.4	ESE	3.3	7	17.6
Sep	0.1	1.8	9.4	N	3.3	7.8	17.3
Oct	0.5	2.3	11.1	N	3.4	8.5	17.2
Nov	0.5	2.8	11.2	N	3.6	8.9	17.1
Dec	0.5	3.2	11	N	3.4	9.5	18.7
Year	0	2	11.5	N	1.6	8.2	18.7

Table 4-3 Significant Wave Height versus Peak Period, from MSC50 Grid Point (M3013763) on the Labrador Shelf

Peak Period (s)	Significant Wave Height (m)							
	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0
2-4	1,073	0	0	0	0	0	1,073	1.1
4-6	18,146	713	0	0	0	0	18,859	19.3
6-8	21,101	11,473	35	0	0	0	32,609	33.4
8-10	12,101	8,555	1,833	15	0	0	22,504	23.1
10-12	4,495	7,867	2,831	461	31	0	15,685	16.1
12-14	1,499	1,510	1,282	532	242	40	5,105	5.2
14-18	463	648	446	166	28	8	1,759	1.8
Total	58,878	30,766	6427	1174	301	48	97,594	100
% Exceed	39.7	8.1	1.6	0.4	0	0	0	0

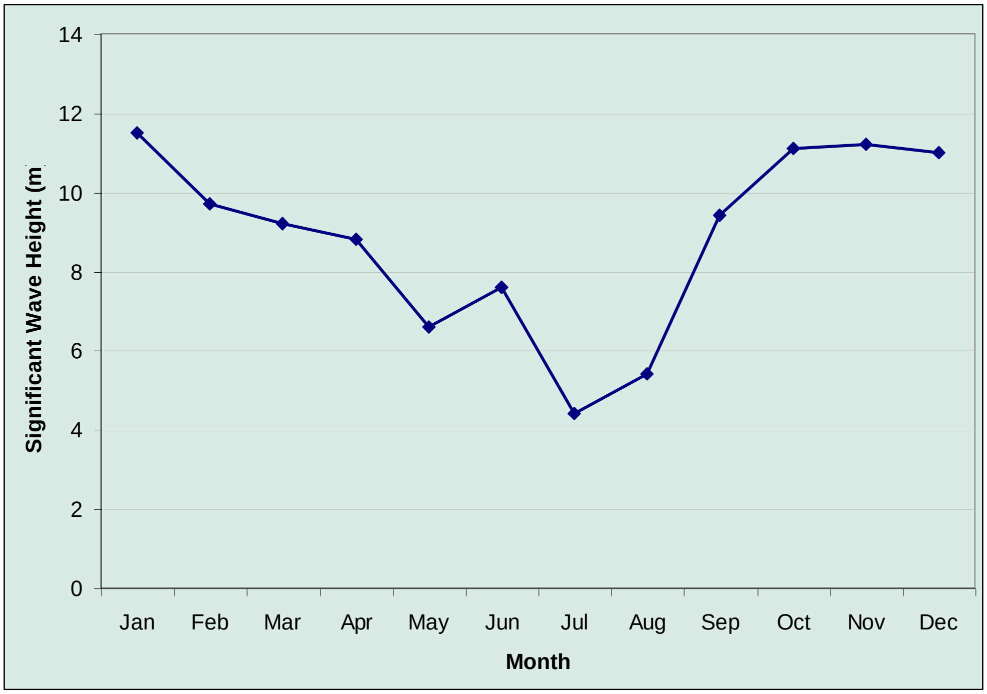


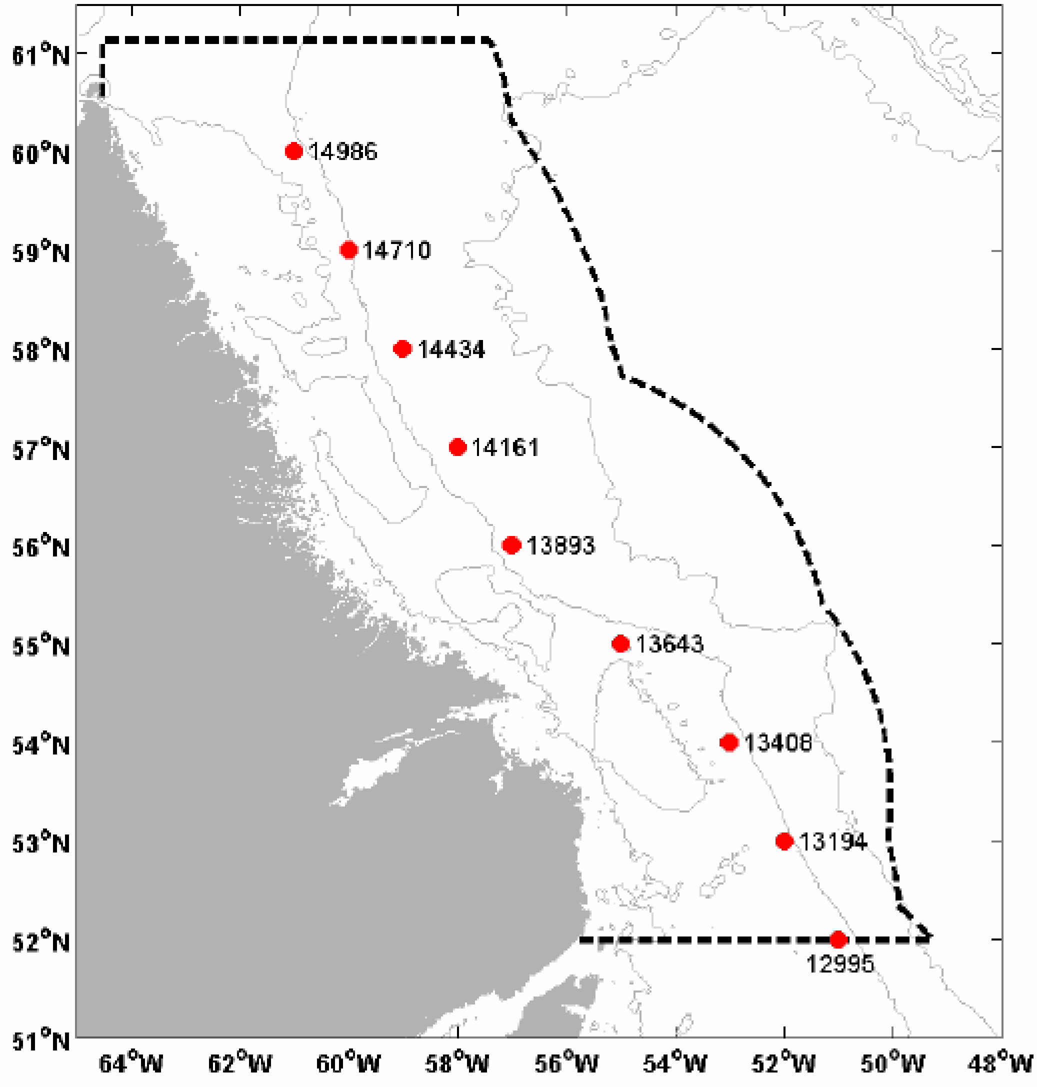
Figure 4-12 **Maximum Significant Wave Height for the MSC50 Grid Point (M3013763)**

By way of comparison with the Labrador Shelf SEA Study Area, Section 3.4.2 of the SEA (Sikumiut 2008) calculated extreme 10-year, 50-year and 100-year significant wave heights for selected MSC50 Grid Points along the Labrador Shelf. These statistics are presented in Table 4-4. Grid Point 13643 to the southeast is the one closest to node 13763 selected here for the Project Area (Figure 4-13).

Additional wave statistics are presented in Labrador Shelf SEA Section 3.4.2 (Sikumiut 2008).

Table 4-4 **Extreme 10-Year, 50-Year and 100-Year Significant Wave Heights**

Grid Point	Latitude	Longitude	10-Year Maximum (m)	50-Year Maximum (m)	100-Year Maximum (m)
14986	60.0°N	61.0°W	9.63	10.81	11.26
14710	59.0°N	60.0°W	10.55	12.13	12.72
14434	58.0°N	59.0°W	11.07	12.35	12.82
14161	57.0°N	58.0°W	11.15	12.49	12.99
13893	56.0°N	57.0°W	11.14	12.51	13.01
13643	55.0°N	55.0°W	11.19	12.56	13.07
13408	54.0°N	53.0°W	11.66	12.78	13.19
13194	53.0°N	52.0°W	11.72	12.77	13.16
12995	52.0°N	51.0°W	11.41	12.11	12.36
Source: Labrador Shelf SEA Section 3.4.2 (Sikumiut 2008).					

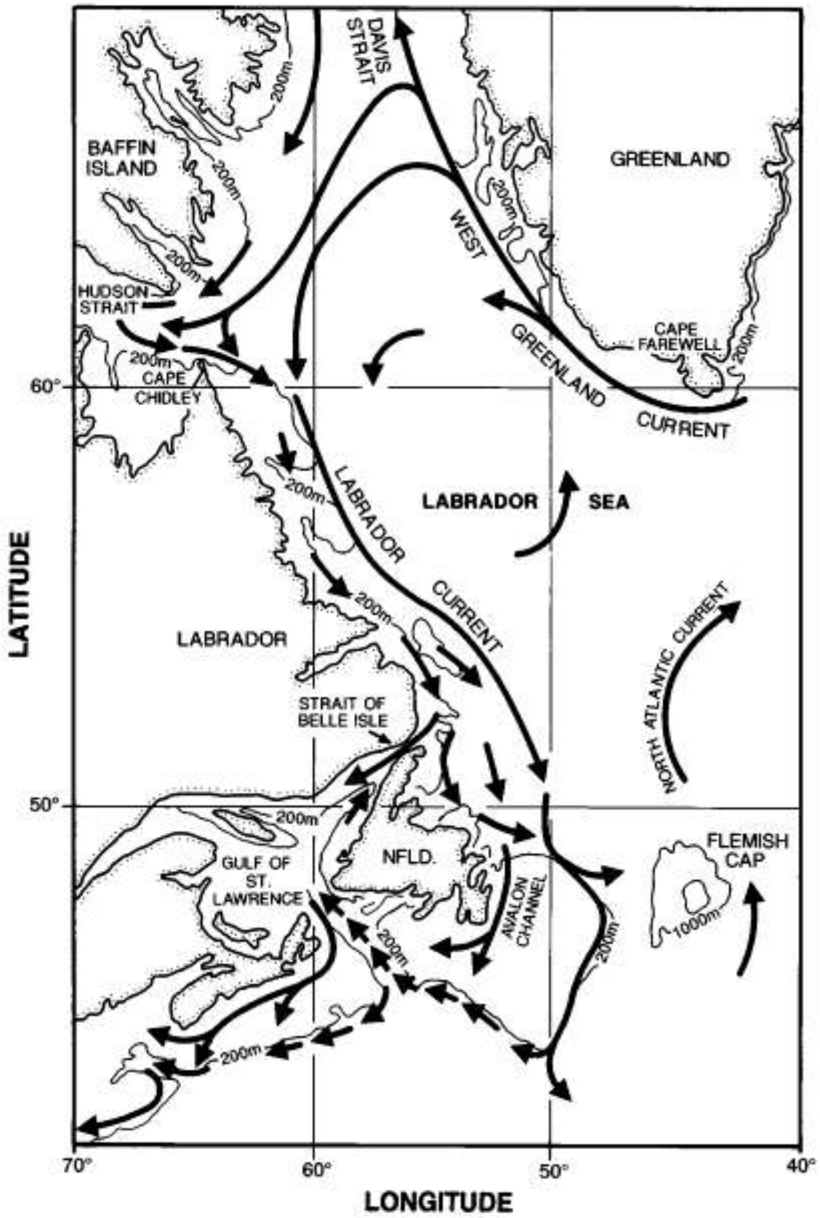


Source: Labrador Shelf SEA Section 3.4.2 (Sikumiut 2008).

Figure 4-13 Labrador Shelf MSC Grid Point Locations

4.4.3 CURRENTS

As described in Section 3.4.4 of the SEA (Sikumiut 2008), the Labrador Current is the major current that flows over the Labrador Shelf. It is a combination of West Greenland Current, the Baffin Island Current and flow from Hudson Bay. The Labrador Current is divided into two streams: an inshore stream consisting of water from Hudson Strait and the Baffin Current; and an offshore stream consisting of water from the West Greenland current. The inshore stream flows along the coast and in the Marginal Trough, located inside the banks and the offshore flows along the outer edge of the banks and over the continental slope (Figure 4-14). The banks limit mixing of the streams so that they maintain their water properties along the length of the coast, there is some mixing that occurs in the saddles.

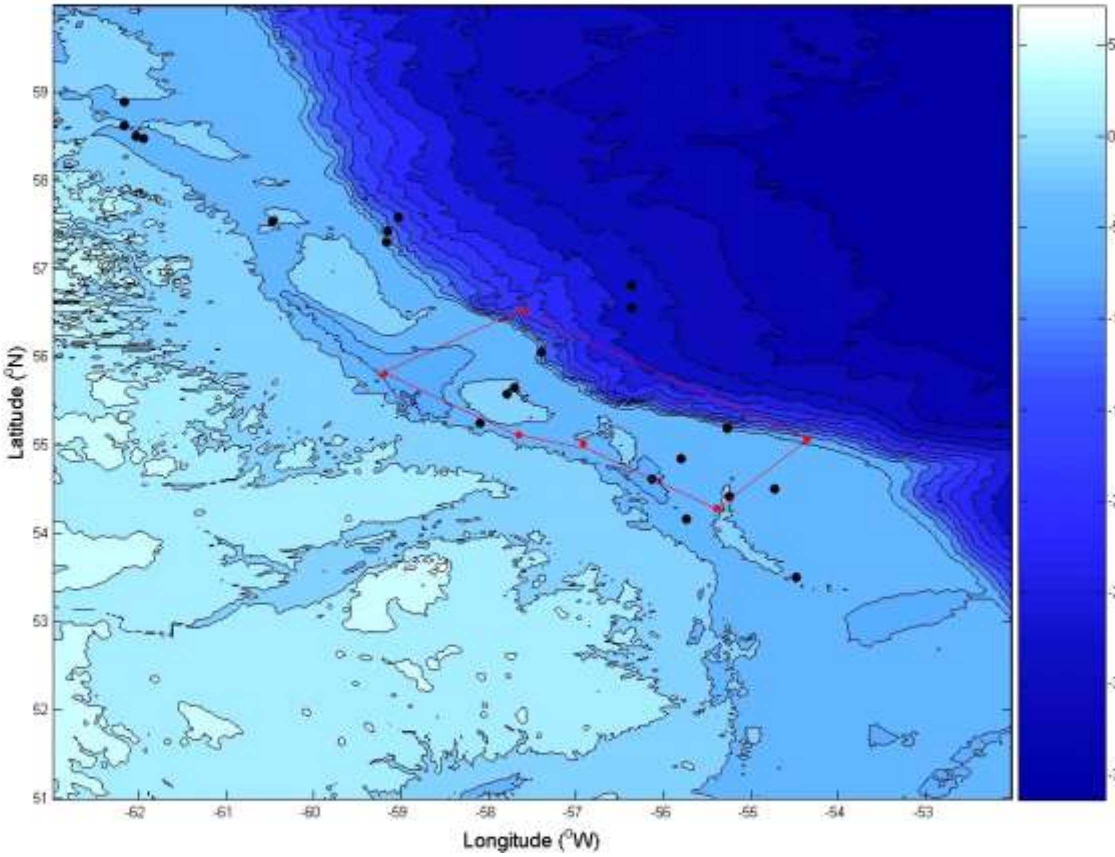


Source: adapted from Chapman and Beardsley (1989).

Figure 4-14 General Circulation in the Northwest Atlantic Showing Major Current Systems

Section 3.4.4 of the SEA (Sikumiut 2008) reviews current studies on the Labrador Shelf, which include the following: Petro-Canada summer of 1980, BIO Canadian East Coast Ocean Model (CECOM), and various studies prior to 1980. The location of these studies is shown in Figure 4-15 and results are presented in Tables 4-5 and 4-6, where the red lines outline measurement locations within the Project Area. The CECOM model has been implemented in a forecast system run daily at BIO. The studies prior to 1980 have measurements on the slope during winter and on the banks during summer. The point indicated by the red outline in Table 4-5 is within the Project Area. This point on the banks in August shows a maximum speed of 0.4 m/s and a mean speed of 0.14 m/s at

34 and 78 m and 0.12 m/s at 130 m. Other measurements on the banks are similar at 0.19 m/s at 37 m, 0.14 m/s at 81 m and between 0.12 and 0.2 m/s for depths over 120 m. Near surface bank current velocities (13 m) outside the project area range from 0.2 to 0.4 m/s. The maximum speeds range from 0.79 m/s at 13 m to 0.24 at 155 m. While on the slope the maximum speed reaches 0.94 m/s at 100 m and mean speed ranges from 0.25 to 0.39 m/s between 100 to 200 m with lower speeds in the range of 0.2 m/s at 250 m, 0.11 m/s at 500 and 0.06 m/s at 1,200 m. This is consistent with past studies that report the inshore branch of the Labrador current when it reaches Hamilton Bank has average speeds of approximately 0.15 m/s carrying approximately 15 percent of the total transport while the offshore Labrador current that remains bathymetrically trapped at the edge of the continental shelf with average speeds of approximately 0.40 m/s carrying approximately 85 percent of the total transport mainly between the 400 and 1200 m isobaths (Lazier and Wright 1993).



The red dots and lines outline the Project Area. Bathymetry source: Smith and Sandwell (1997).

Figure 4-15 Current Measurement Locations for Various Current Studies on the Labrador Shelf

Table 4-5 Moored Current Meter Measurements on the Labrador Shelf and Slope prior to 1980

Location	Banks (B) Slopes (S)	Water Depth (m)	Meter Depth (m)	Dates	Duration (Days)	Max Speed (cm/sec)	Mean Speed (cm/sec)	Mean Magnitude (cm/sec)	Velocity Direction (°T)	Steadiness (%)	Source
53°30'N	B	217	37	Jul-Aug 1970	14	n/a	19	n/a			(1)
54°29'W			81 124			n/a n/a	14 19	n/a n/a			
55°39'N	B	160	34	Aug-79	9	34	14	n/a			
57°42'W			78 130			40 40	14 12	2.7 2.6	218 179	19 22	(5)
56°49'N	S	3000	260	Mar-Apr 1976	27	45	20	8.7	13	44	(3)
56°33'N	S	2600	160	Mar-Apr 1976	27	75	35	15.2	188	43	(3)
56°22'W			2500			30	25	12.1	201	48	
57°25'N	S	600	100	Oct 1977 - Jan 1978	95	94	39	35.3	157	91	(4)
59°09'W			250 500			60 44	17 13	13.8 10.5	154 147	79 83	
57°35'N	S	1320	100	Oct 1977 – Jan 1978	95	89	25	22.3	109	89	(4)
59°02'W			500			37	13	11.6	157	89	
57°35'N	S	1306	1200	Jan-Jul 1978	166	31	6	3.6	152	55	(4)
57°18'N	S	600	100	Jan-Jul 1978	166	86	36	33.5	157	94	(4)
59°10'W		500	500			58	11	9	173	79	
58°30'N	B	200	13	Aug-72	14	79	40	13.7	193	34	(2)
62°02'W			166			27	20	8	252	40	
58°37'N	B	180	13	Aug-72	14	38	20	4.1	205	21	(2)
62°10'W			136			37	15	6.3	200	42	
58°28'N	B	200	13	Aug-72	14	75	30	9.2	200	31	(2)
61°57'W			155			24	15	4.6	183	31	
58°52'N	B	192	188	Aug-Oct 1978	40	30	12	6.6	251	55	(6)

Sources
(1) Scobie (1972).
(2) Holden (1973).
(3) Allen and Huntley (1977).
(4) Lazier (1979a).
(5) NORDCO (1979).
(6) MacLaren Marex (1980b).

Red Outline Indicates Measurements in the Project Area.
Source: Labrador Shelf SEA Section 3.4.4 (Sikumiut 2008).

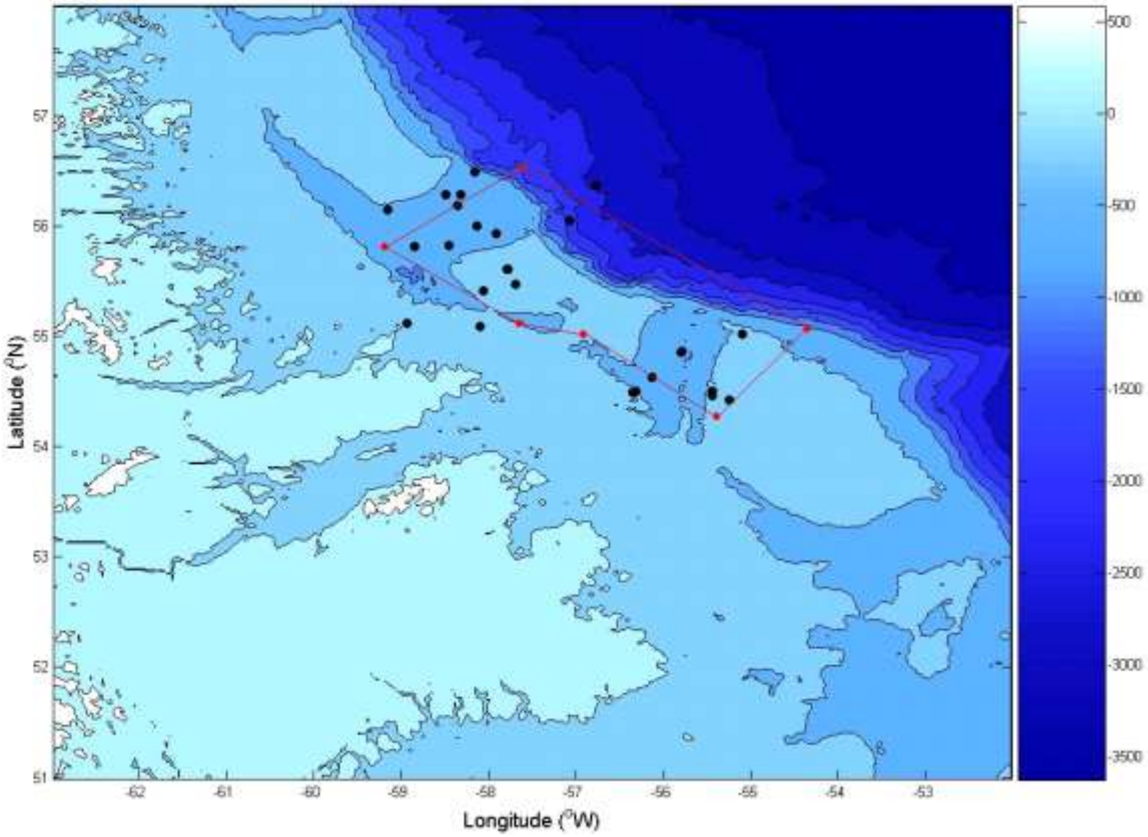
Table 4-6 Moored Current Meter Measurements from Petro-Canada's 1980 Summer Program, July to October 1980, Average 70 Days Duration

Location	Banks (B) Slopes (S) Trough (T)	Water Depth (m)	Meter Depth (m)	Max Speed (cm/sec)	Mean Speed (cm/sec)	Mean Velocity (cm/sec)	Velocity Direction (°T)
54°10°N 55°44°W	T	212	52	44	14.2	11.6	164
			203	23	8.0	4.2	164
54°25°N 55°15°W	B	152	53	37	10.8	1.6	226
			143	30	8.0	3.3	166
54°30°N 54°44°W	B	220	153	38	9.6	5.4	147
			171	38	9.2	4.7	141
54°37°N 56°08°W	T	523	58	53	16.3	12.6	150
			156	42	12.1	9.1	140
54°51°N 55°48°W	B (saddle)	278	30	98	24.1	6.8	110
			58	74	20.6	6.0	111
			158	33	12.3	2.4	68
			269	29	9.5	3.0	327
55°11°N 55°16W	S	326	62	83	35.1	-	-
			159	58	19.1	17.6	111
			277	41	11.8	9.4	121
55°15°N 58°06°W	T	274	64	45.9	11.4	6.9	127
			162	40.1	8.6	2.8	112
			265	20.5	3.1	1.4	233
55°35°N 57°47°W	B	154	25	77.4	17.4	5.6	141
			55	47.4	14.6	4.5	139
			145	33.4	11.0	5.5	121
56°03°N 57°25°W	S	706	102	52.8	17.8	16.1	172
			202	45.2	13.8	12.2	175
			656	28.8	5.3	3.0	186
57°32°N 60°28°W	B	165	56	34.4	10.7	4.9	154
			156	24.3	7.5	1.8	145
58°53°N 62°10°W	B	179	62	46.7	14.0	5.4	261
			170	34.0	12.0	5.4	253

Red Outline Indicates Measurements in the Project Area.
Source: Labrador Shelf SEA Section 3.4.4 (Sikumiut 2008).

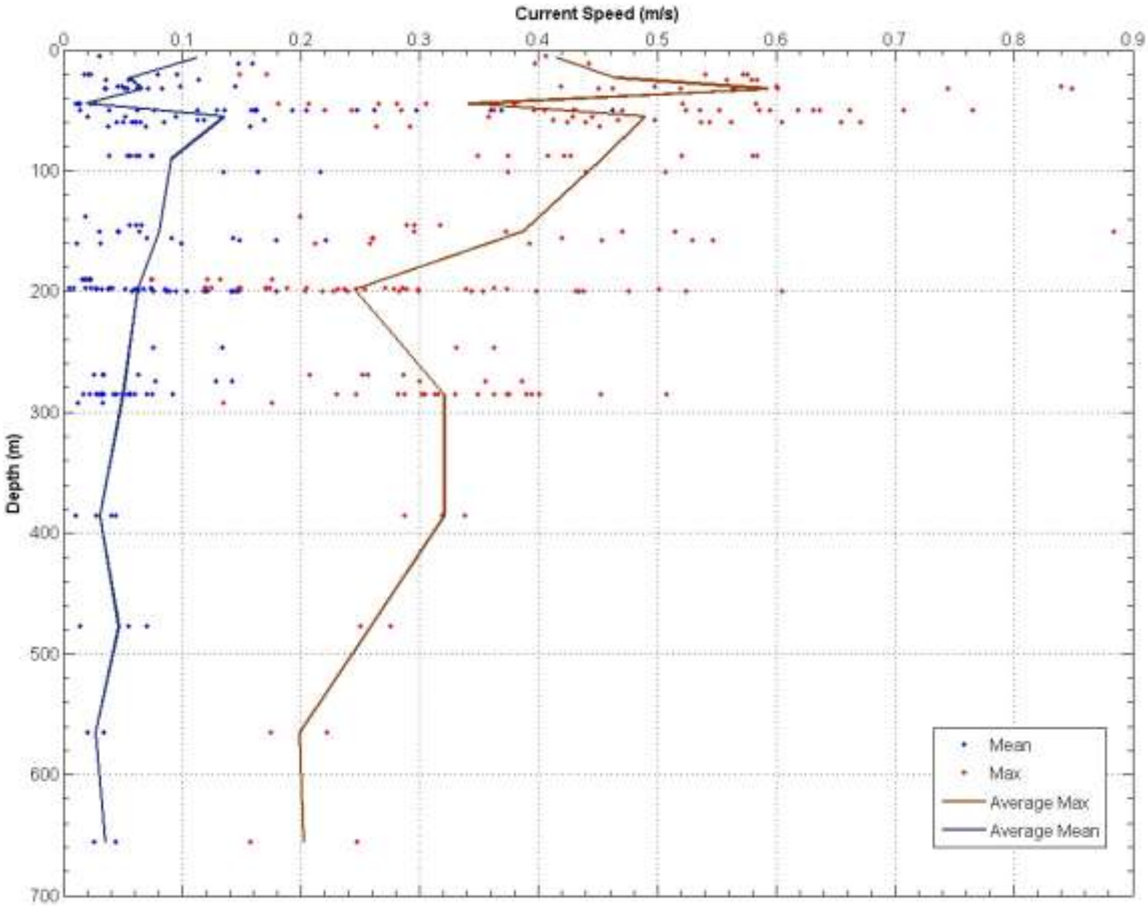
The Petro-Canada study was carried out by NORDCO Limited and collected current data during the summer season in 1980 in four main regions: on the banks, on the slope, in the Marginal Trough, and in the Cartwright Saddle (NORDCO 1979). The mean speeds were greatest along the slope and in the Marginal Trough, which ranged from 0.16 m/s at 58 m to 0.03 m/s at 265 m in the Trough and 0.35 m/s at 58 m to 0.05 m/s at 656 m for the slope. The maximum speed was greatest along the slope and in the Cartwright Saddle with a maximum of 0.98 m/s in the Saddle at a depth of 30 m and 0.83 m/s at 62 m along the slope.

Also, current data for the project area were extracted from the BIO Ocean Data Inventory (ODI) database (BIO 2009). The data archive includes approximately 5,800 current meter and acoustic doppler current profiler time-series, for the area roughly defined as the North Atlantic and Arctic, from 30° to 82° N, from 1960 to present. A total of 46 data records were extracted from the ODI database, two were on the slope the remainders were on the banks. Each record contains the start and end date, location and depth of the current meter, maximum speed, mean speed, and mean direction. The locations of the current measurements are shown in Figure 4-16. The records were divided into depth bins and the maximum and mean speed calculated within each bin as presented in Figure 4-17 and Table 4-7. On the Banks the current speed was generally lower than reported by the studies discussed above and ranged from 0.11 m/s near the surface to 0.06 m/s at 200 m with a spike at 50 m to 0.13 m/s and a maximum of 0.88 m/s at 150 m. Below 200 m the flow ranged from 0.03 to 0.05 m/s with a maximum of 0.51 m/s. The current direction was generally southeasterly.



Source: BIO ODI (2009).
The red dots and lines outline the Project Area. Bathymetry source: Smith and Sandwell (1997).

Figure 4-16 Current Measurement Locations



Source: BIO ODI (2009).

Figure 4-17 Mean and Maximum Current Speed

Table 4-7 Mean and Maximum Current Speed

Depth (m)	Maximum (cm/s)	Mean (cm/s)	Count
0-12	0.44	0.11	3
20-25	0.58	0.06	8
30-35	0.85	0.07	12
40-45	0.58	0.02	8
50-65	0.77	0.13	37
80-101	0.58	0.09	11
140-161	0.88	0.08	18
190-201	0.61	0.06	49
270-301	0.51	0.05	29
385	0.34	0.03	4
477	0.28	0.05	3
565	0.20	0.03	2

Depth (m)	Maximum (cm/s)	Mean (cm/s)	Count
656	0.25	0.04	2
2340	0.21	0.08	2
Source: BIO ODI (2009).			

4.4.4 TIDES

Tides on the Labrador Shelf are semi-diurnal with two highs and two lows every 24 to 25 hours. The dominant constituents on the Shelf are the M2 and S2 semi-diurnal constituents and the K1 and O1 diurnal constituents and the amplitudes of the semi-diurnal constituents are larger than those of the diurnal cycle. For the M2 constituents, the largest amplitude occurred on the Saglek Bank at 0.13 m/s at 62 m. At all locations excluding the Makkovik Bank and Nain Bank, the amplitude of the largest diurnal constituent (K1) ranged from 0.003 to 0.03 m/s. On Makkovik Bank, the K1 constituent ranged from 0.04 to 0.06 m/s, depending on depth.

Further discussion of tides including a list of the M2 and S2 semi-diurnal tidal constituents for 27 stations on the Labrador Shelf are presented in Section 3.4.5 of the Labrador Shelf SEA (Sikumiut 2008).

4.5 ATMOSPHERIC CONDITIONS

4.5.1 WIND

Monthly, seasonal, and annual wind roses for the Project Area, based on MSC50 (Section 4.4.2) Grid Point M3013763, are presented in Figures 4-18 to 4-20. Monthly wind speed statistics are shown in Table 4-8. The monthly maximum wind ranges from 16 m/s in July to 27.3 m/s in February. The monthly maximum wind speeds are shown graphically in Figure 4-21. From October to March the maximum wind speed is greater than 24.7 m/s.

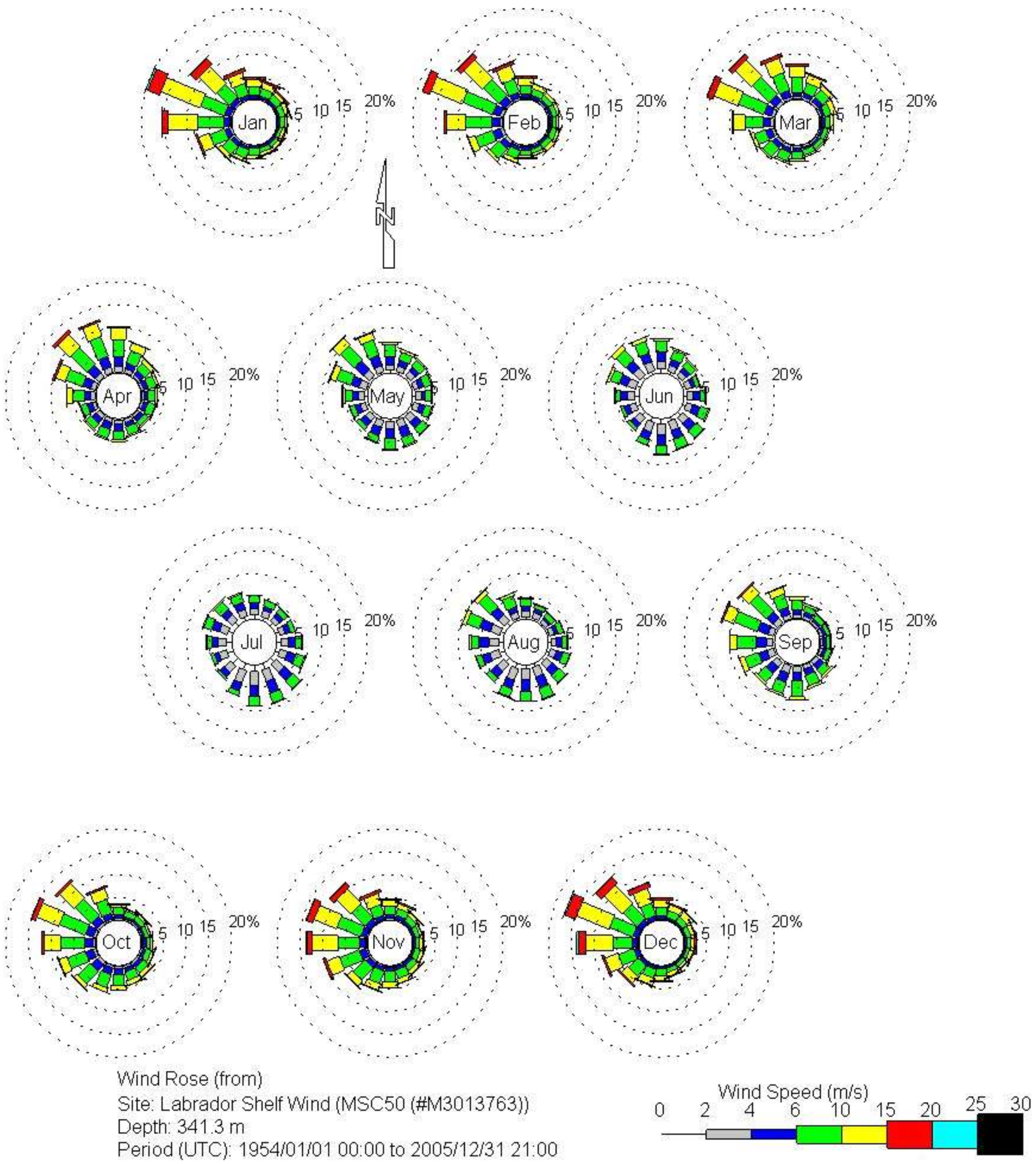


Figure 4-18 Monthly Frequency of Wind Speed Occurrence by Direction for the MSC50 Grid Point (M3013763) on the Labrador Shelf

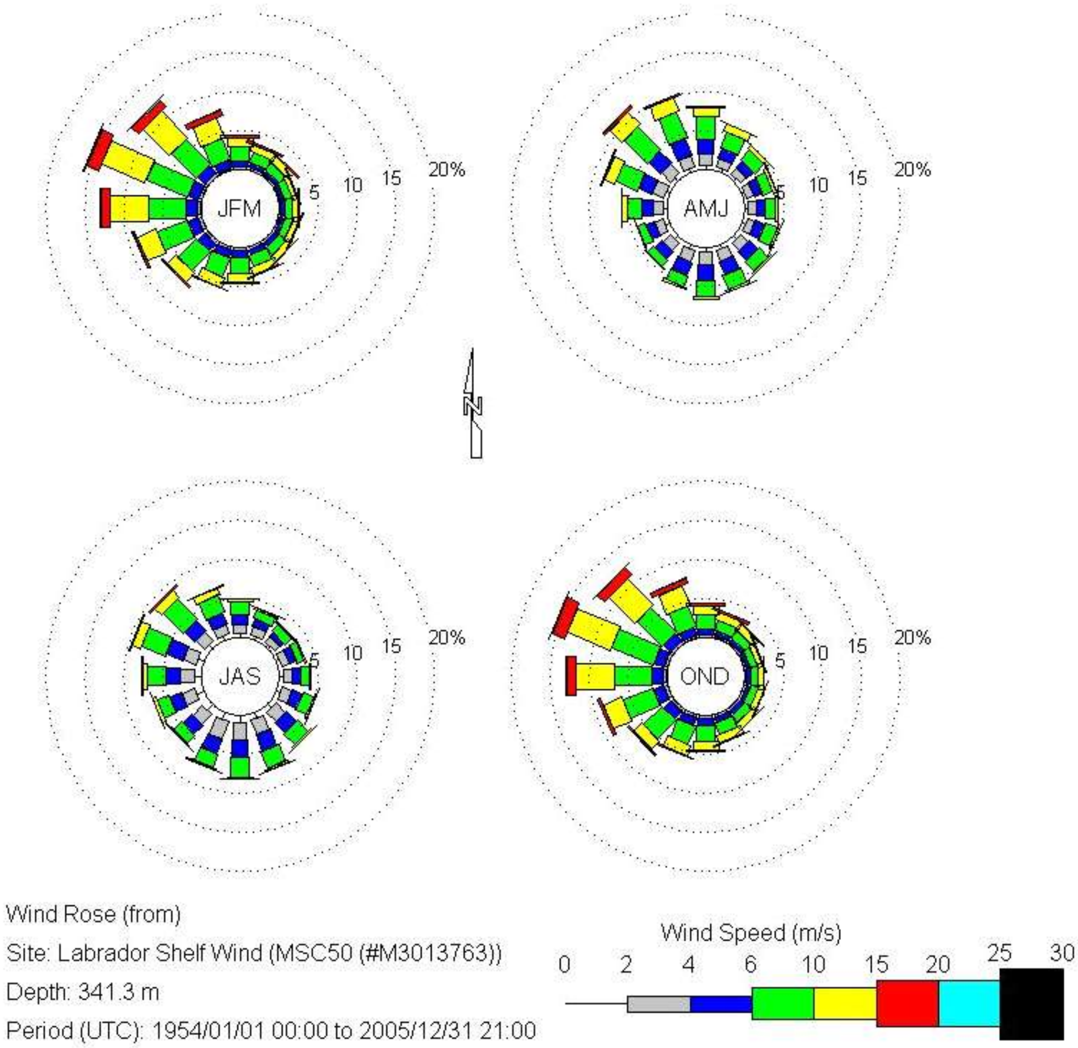
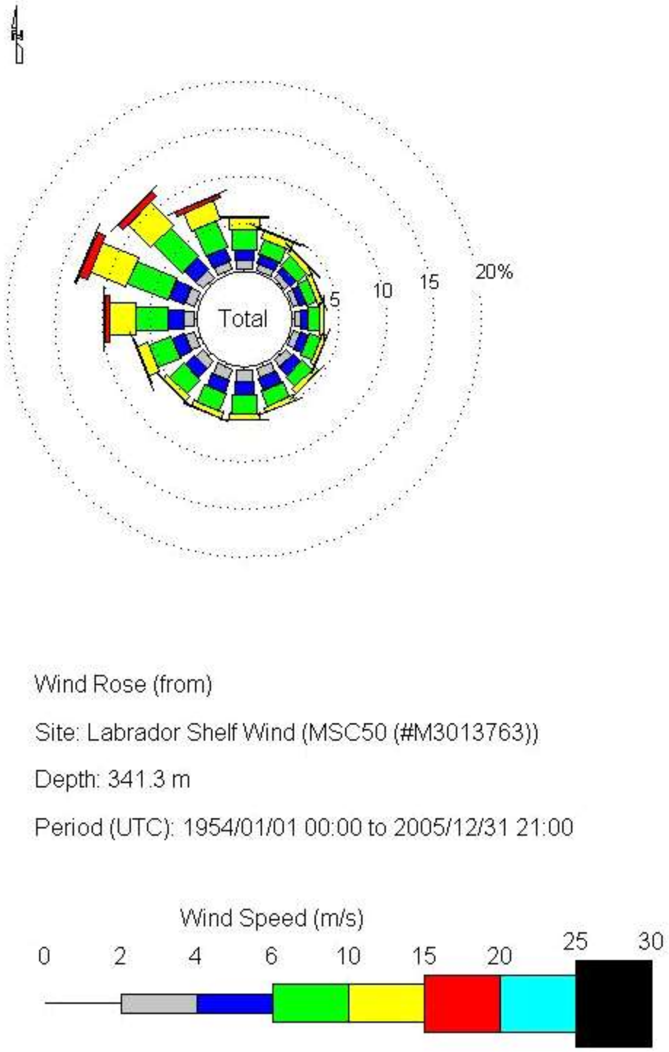


Figure 4-19 Seasonal Frequency of Wind Speed Occurrence by Direction for the MSC50 Grid Point (M3013763) on the Labrador Shelf



Wind Rose (from)

Site: Labrador Shelf Wind (MSC50 (#M3013763))

Depth: 341.3 m

Period (UTC): 1954/01/01 00:00 to 2005/12/31 21:00

Figure 4-20 Annual Frequency of Wind Speed Occurrence by Direction for the MSC50 Grid Point (M3013763) on the Labrador Shelf

Table 4-8 Monthly Wind Speed Statistics from MSC50 Grid Point (M3013763) on the Labrador Shelf

Month	Wind Speed (m/s)			
	Minimum	Mean	Maximum	Most Frequent Direction
Jan	1.2	9.9	27.2	WNW
Feb	0.6	8.9	27.3	WNW
Mar	0.5	8.5	24.7	WNW
Apr	0.5	7.3	21.6	NW
May	0.3	5.8	21.5	NW
Jun	0.4	5.1	18.1	NW
Jul	0.3	4.5	15.9	SSE

Month	Wind Speed (m/s)			
	Minimum	Mean	Maximum	Most Frequent Direction
Aug	0.3	5.1	16.9	WNW
Sep	0.4	6.8	23.4	WNW
Oct	0.6	8.3	24.7	WNW
Nov	0.5	9.3	24.7	WNW
Dec	1.5	10.2	26.8	WNW
Year	0.3	7.5	27.3	WNW

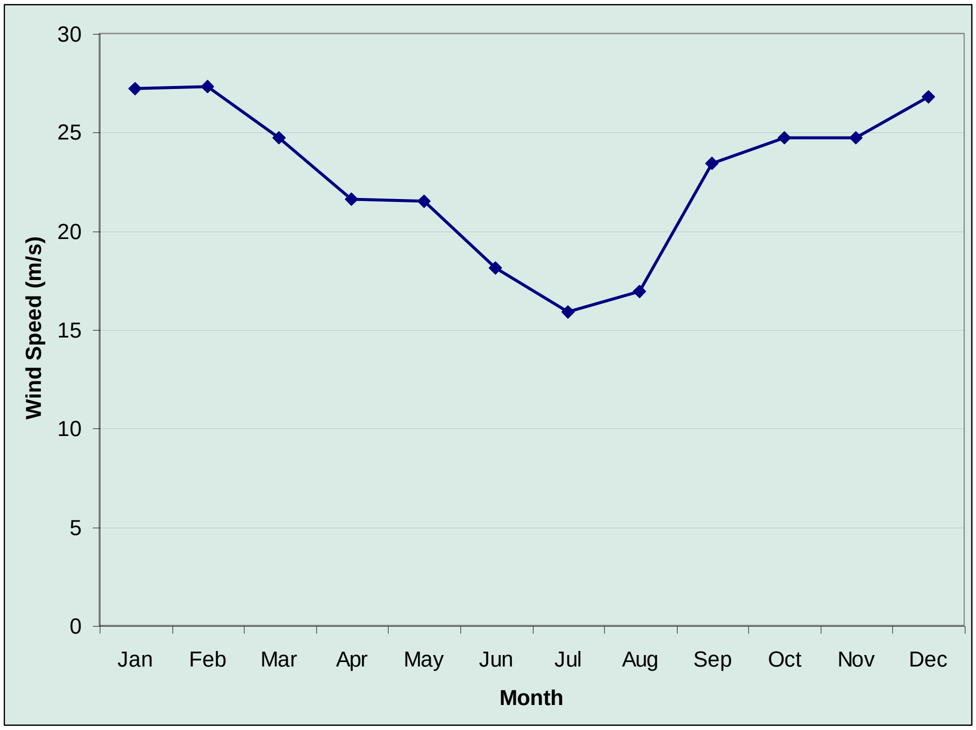


Figure 4-21 Maximum Wind Speed for the MSC50 Grid Point (M3013763)

A bivariate table of wind speed versus wind direction, based on all months, is provided in Table 4-9. Thirty-six percent of winds were between 6 and 10 m/s (36 km/h or 19.4 knots). Four percent of values are 15 m/s or greater, while less than 0.4 percent of the time are winds above 20 m/s (39 knots). West-northwest is the most frequent direction from which winds propagate into the area (13 percent of the time). In the summer wind direction is less dominated by the west through northwest directions and wind speed is less with maximums ranging from 15.9 to 18.1 m/s from June to August.

Table 4-9 Wind Speed versus Direction, from MSC50 Grid Point (M3013763) on the Labrador Shelf

Direction from	Wind Speed (m/s)									
	0-2	**2-4**	**4-6**	**6-10**	**10-15**	**15-20**	**20-25**	**25-30**	**Total**	**% Total**
N	461	1204	1812	3291	1725	354	26	0	8873	5.8
NNE	365	1127	1355	2479	1297	227	17	5	6872	4.5
NE	366	965	1193	2082	951	137	8	0	5702	3.8
ENE	353	970	1138	1781	764	91	3	0	5100	3.4
E	392	1096	1195	1670	705	82	2	0	5142	3.4
ESE	411	1099	1396	1957	692	118	2	0	5675	3.7
SE	486	1367	1731	2193	822	101	1	0	6701	4.4
SSE	499	1581	1976	2606	836	89	2	0	7589	5
S	595	1734	2253	3062	852	69	1	0	8566	5.6
SSW	618	1826	2102	2995	925	95	1	0	8562	5.6
SW	634	1569	2026	3158	973	120	9	0	8489	5.6
WSW	637	1509	2158	3864	1812	247	17	1	10245	6.7
W	566	1594	2430	5321	4076	764	99	4	14854	9.8
WNW	568	1640	2661	6982	6152	1463	169	8	19643	12.9
NW	513	1548	2627	6407	5166	1065	134	5	17465	11.5
NNW	410	1379	2253	4587	3159	615	60	3	12466	8.2
Total	7874	22208	30306	54435	30907	5637	551	26	151944	100
% Exceed	94.8	80.2	60.3	24.4	4.1	0.4	0	0	0	0

By way of comparison with the Labrador Shelf SEA Study Area, Section 3.4.3 of the Labrador Shelf SEA (Sikumiut 2008) calculated extreme 10-year, 50-year and 100-year wind speeds for selected MSC50 Grid Points along the Labrador Shelf (Figure 4-13). These statistics are presented in Table 4-10. Grid Point 13643 to the southeast is the one closest to node 13763 selected here for the Project Area.

Additional wind statistics are presented in Labrador Shelf SEA Section 3.4.3 (Sikumiut 2008).

Table 4-10 Extreme 10-Year, 50-Year and 100-Year Wind Speed

Grid Point	Latitude	Longitude	10-Year Maximum (m)	50-Year Maximum (m)	100-Year Maximum (m)
14986	60.0°N	61.0°W	25.4	27.33	28.04
14710	59.0°N	60.0°W	26.52	28.98	29.88
14434	58.0°N	59.0°W	27.42	29.29	29.98
14161	57.0°N	58.0°W	26.99	29.14	29.93
13893	56.0°N	57.0°W	26.8	28.59	29.23
13643	55.0°N	55.0°W	26.98	29.44	30.34
13408	54.0°N	53.0°W	26.9	28.59	29.2
13194	53.0°N	52.0°W	26.79	28.61	29.28
12995	52.0°N	51.0°W	28.22	30.27	31.02
Source: Labrador Shelf SEA Section 3.4.3 (Sikumiut 2008).					

4.5.2 AIR TEMPERATURE

Mean, minimum, and maximum daily hourly temperature data were extracted from Environment Canada's Daily Climate Database for the Cartwright and Cape Harrison weather stations located along the Labrador coast near the Project Area (Environment Canada 2009). It is noted that air temperatures will be somewhat moderated by the sea, cooler in summer, and warmer in winter, and these land stations present a more extreme range of temperatures than would be experienced in the Project Area offshore.

Monthly statistics are summarized in Figure 4-22 and Tables 4-11 and 4-12 for the Cartwright and Cape Harrison weather stations, respectively.

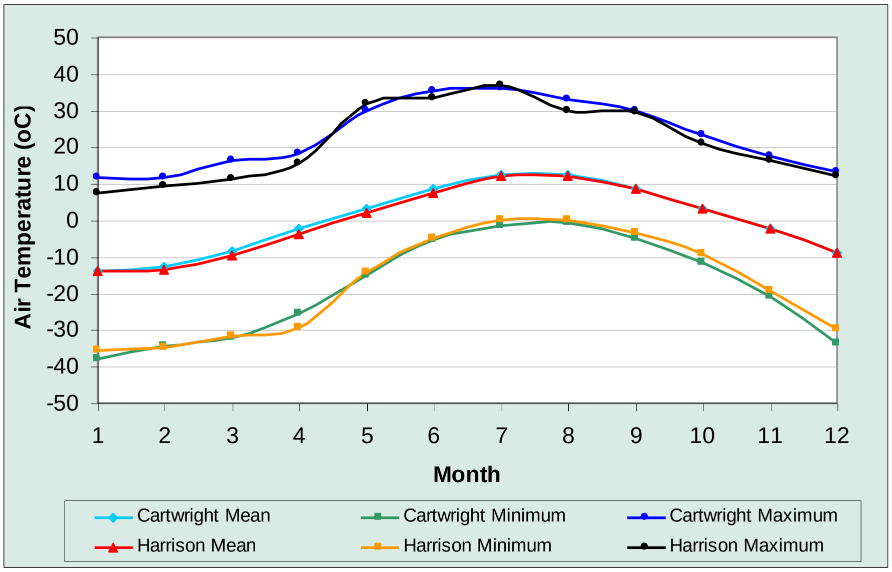


Figure 4-22 Mean, Minimum and Maximum Monthly Air Temperatures for Cape Harrison and Cartwright

Table 4-11 Monthly Air Temperatures for Cartwright (1934 to 2003)

	Average Daily Temperature (^{o}C)		Extreme Daily Temperature (^{o}C)		# of Observations
	Mean	**St.Dev.**	**Min**	**Max**	
January	-13.9	7.36	-37.8	11.8	2108
February	-12.9	7.41	-34.5	11.7	1972
March	-8.5	6.56	-32.2	16.4	2107
April	-2.5	4.66	-25.6	18.2	2040
May	3,0	3.76	-15	30	2108
June	8.34	4.57	-5.6	35.3	2039
July	12.5	4.14	-1.7	36.1	2104
August	12.3	3.58	-0.6	33	2134
September	8.7	3.51	-5	30	2070
October	3.2	3.29	-11.7	23.3	2076
November	-2.2	4.3	-21.1	17.6	2070
December	-9.1	6.44	-33.9	13.3	2108
Source: Environment Canada (2009).					

Table 4-12 Monthly Air Temperatures for Cape Harrison (1943 to 1961)

	Average Daily Temperature (^{o}C)		Extreme Daily Temperature (^{o}C)		# of Observations
	Mean	**St.Dev.**	**Min**	**Max**	
January	-14.1	7.89	-35.6	7.2	558
February	-13.4	7.88	-35	9.4	521
March	-9.6	6.6	-31.7	11.1	544
April	-3.8	5.29	-29.4	15.6	510
May	2.1	4.19	-14.4	31.7	558
June	7.4	4.81	-5	33.3	540
July	12.2	4.66	0	36.7	557
August	12.2	3.84	0	30	558
September	8.5	4.03	-3.3	29.4	509
October	3.1	3.74	-9.4	21.1	558
November	-2.5	4.09	-19.4	16.1	570
December	-8.9	6.41	-30	12.2	585
Source: Environment Canada (2009).					

As expected, the temperatures are warmest during July and August, with mean values just over 12°C, then begin to cool in September, with the coldest values occurring between January and February with temperatures on average approximately -13°C to -14°C. The extreme maximum daily temperature was 36.7°C in July at Cape Harrison and the extreme minimum temperature was -37.8°C in January at Cartwright.

4.5.3 VISIBILITY

4.5.3.1 FOG

The following concise summary is taken from McClintock and Davidson (1995). These observations are generally applicable to the Study and Project Areas.

> *Marine visibility is affected by fog, daylight hours, precipitation, and blowing snow. Visibility at sea is most adversely affected on the Labrador Coast by fog. Sea fog, formed when warm air moves over colder sea water, is most prevalent. Sea fog can form and persist during moderate to strong winds (given a continuous supply of warm air), and is of most concern to mariners in the spring and summer. Arctic sea smoke, formed by cold arctic air moving over warmer sea water, consists of moisture evaporating from the sea and saturating the air. The excess moisture in the cold air condenses to give fog. This is less frequent than sea fog, seldom greater than several feet thick, and not normally a navigational hazard; however, in extreme conditions it may be thick enough and cold enough to create light vessel icing.*
>
> *The frequency of fog along the coast is related to the frequency of onshore winds blowing over the Labrador Current, and hence may differ greatly from one year to the next. Low pressure systems crossing the mid-Labrador coast will yield persistent onshore winds which may keep fog and cooler temperatures on the coast for periods of several days.*
>
> *During the winter months, snow is the usual restriction to visibility near the coast. Fall storms and strong northeasterly winds which sweep along the coast can bring heavy snow and reduce visibility to zero. These snowfalls diminish after December.*

The average number of days per month with fog at coastal stations Nain and Hopedale is provided in Table 4-13.

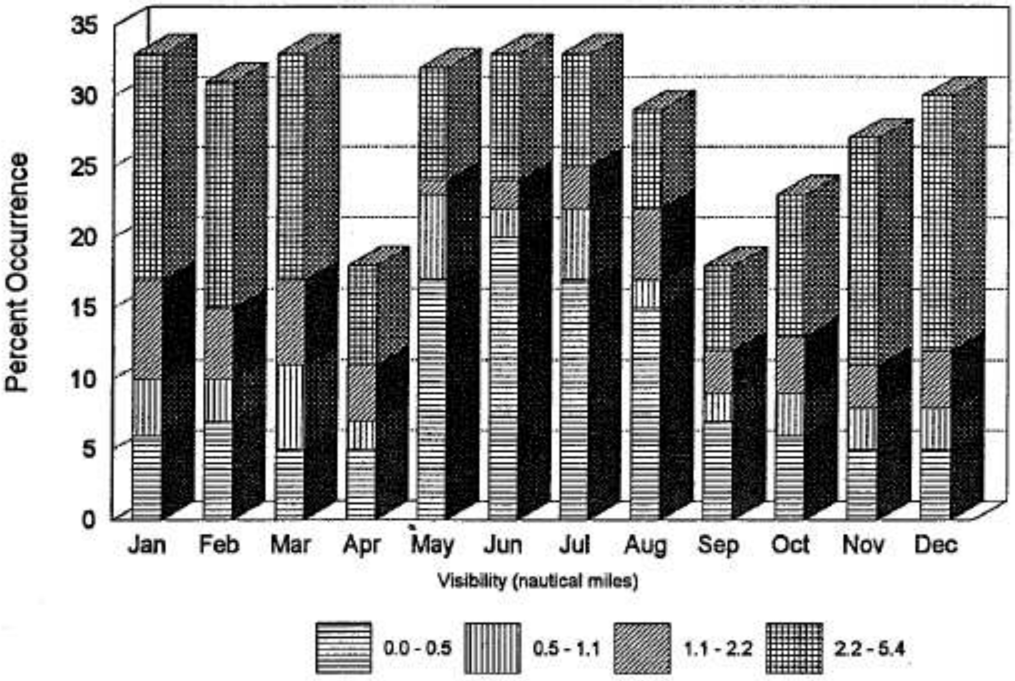
Table 4-13 Labrador Coast, Reduced Visibility (average number of days with fog)

# of Days Fog	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nain	1	2	1	3	5	6	7	8	4	2	2	2
Hopedale	2	0.5	2	0.5	6	6	6	5	2	2	2	1
Source: McClintock and Davidson (1995).												

4.5.3.2 SHIPPING WEATHER

These data were derived from over water observations and should be representative of the Study Area. Shipping weather, quantified in terms of visibility, is presented in Figure 4-23. The average monthly percent occurrence of visibility less than 0.5 nautical miles is 10.1 percent, while June exhibits the highest percent occurrence in this restricted visibility class at 20 percent. The monthly occurrence of severely reduced visibility is summarized in Table 4-14.

A further tabulation quantified good shipping weather in terms of visibility conditions greater than 2 nautical miles and wind speed less than 25 knots. For the South Labrador Sea (Study Area), the monthly mean percentage of good shipping weather is 69.4 percent, and ranges between a maximum of 75.9 percent in April, and a minimum of 63.4 percent in November. In most Canadian East Coast areas, low visibility conditions, rather than wind speed, have the greater adverse effect on good shipping weather (McClintock and Davidson 1995). These evaluations of shipping weather severity do not account for the presence of sea ice, which imposes other restrictions on shipping.



Source: after MEP 1984, in McClintock and Davidson (1995).

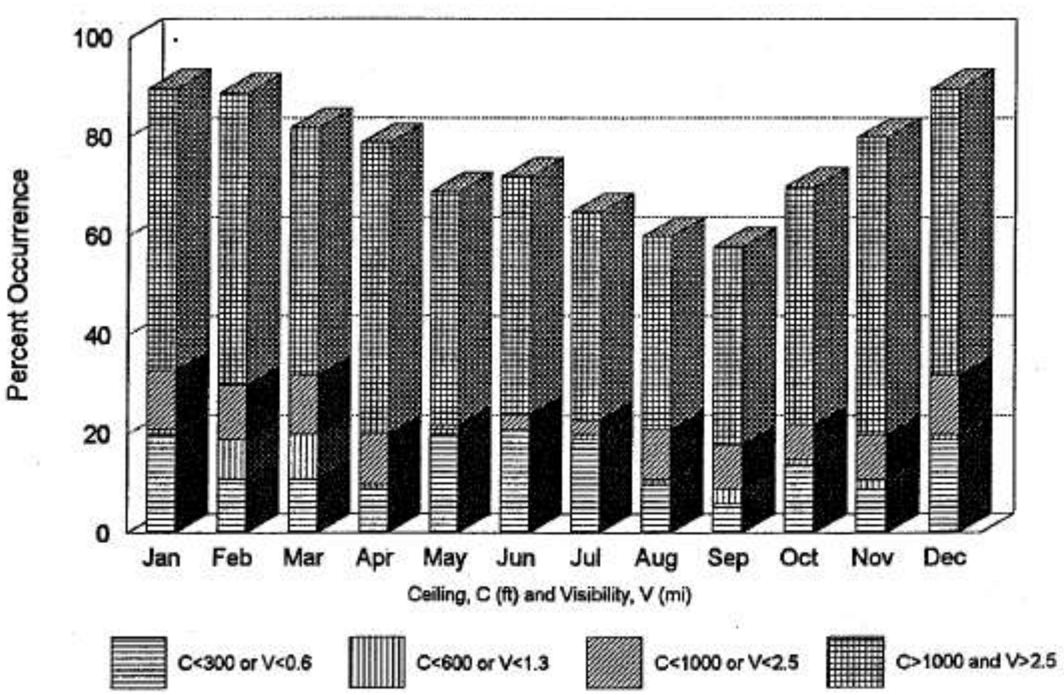
Figure 4-23 **Shipping Weather, South Labrador Sea**

Table 4-14 Labrador Coast, Severely Reduced Visibility

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Reduced Visibility (%)	6	7	5	5	17	20	17	15	7	6	5	5
Note: Frequency of observations with visibility less than 0.5 nautical miles. Source: McClintock and Davidson (1995).												

4.5.3.3 FLYING WEATHER

Flying weather, classified in terms of combined ceiling height and visibility is presented in Figure 4-24. Additional conditions such as wind and icing are not included in this presentation. Poorest flying conditions correspond to the first bin category of values displayed in the figure (ceiling less than 300 feet or visibility less than 0.6 miles). The seasonal variation in poor flying weather closely follows that of visibility conditions. The summer months exhibit the highest occurrence of poor flying conditions. The mean monthly percentage of poor flying conditions is 13.5 percent for the South Labrador Sea. A maximum of 20.8 percent severely restricted flying weather occurs in June, while September conditions are least adverse, exhibiting 5.7 percent poor flying conditions. (McClintock and Davidson 1995). The monthly occurrence of severely restricted flying weather is summarized Table 4-15.



Source: after MEP 1984, in McClintock and Davidson (1995).

Figure 4-24 Flying Weather, South Labrador Sea

Table 4-15 Labrador Coast, Severely Restricted Flying Weather

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Restricted Flying (%)	20	11	11	9	20	21	19	10	6	14	9	19

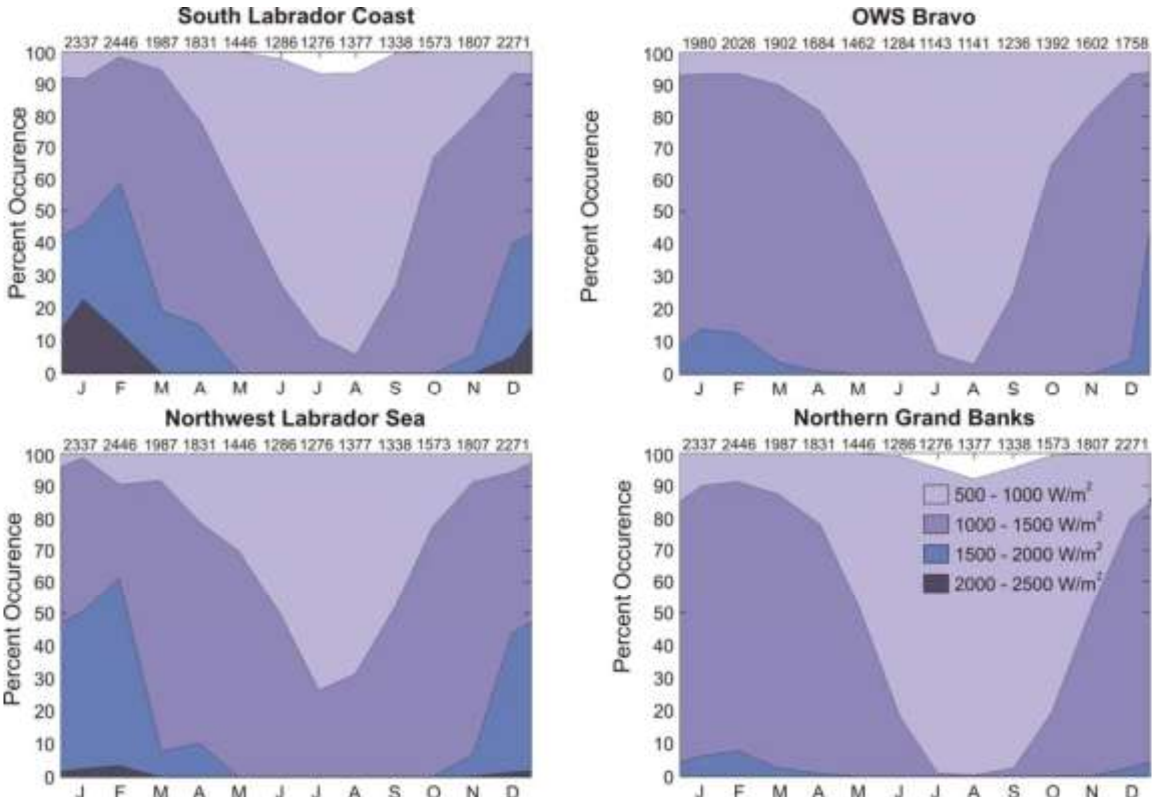
Note: Frequency of observations with ceiling < 300 feet and visibility < 0.6 miles.
Source: McClintock and Davidson (1995).

4.5.4 WIND CHILL

Wind chill is defined as a rate of cooling on an exposed surface due to the combined effects of wind speed and temperature, and is usually measured in Watts/m^2 (W/m^2). It is used to quantify the rate of heat loss from exposed flesh and measures discomfort and/or danger from prolonged exposure to adverse weather conditions. General guidelines are presented in Table 4-16 and monthly wind chill statistics (as presented in Labrador Shelf SEA Section 3.5.2 (Sikumiut 2008)) from the Marine Climatology Atlas-Canadian East Coast are plotted in Figure 4-25.

Table 4-16 General Wind Chill Guidelines

Wind Chill (W/m^2)	Description
700	Comfortable when dressed for skiing
1,200	No longer pleasant for outdoor activities on overcast days
1,400	No longer pleasant for outdoor activities even on sunny days
1,600	Freezing of exposed skin begins for most people
2,300	Outdoor travel becomes dangerous. Exposed flesh may freeze in less than 1 minute



Source: after AES 1985, in Labrador Shelf SEA Section 3.5.2 (Sikumiut 2008).

Figure 4-25 Monthly Percent Occurrence of Wind Chill

4.5.5 VESSEL ICING AND FOG

Vessel icing due to freezing spray accompanied by strong winds, low temperatures, and high seas is a winter hazard, with the potential for moderate or severe icing offshore Labrador up to 30 percent of the time in January, compared with the Grand Banks where the value is about 5 percent. Conversely, fog is less of an occurrence for the Study Area where in July visibility is reduced to 0.5 nautical miles or less 10 to 20 percent or of the time, compared to a 40 to 50 percent of the time on the Grand Banks (Bowyer 1995).

4.6 ICE CONDITIONS

The Labrador Shelf SEA provides description of sea ice occurrence, drift, thickness, and size and iceberg occurrence, drift, size, and scour. Several sources of ice data were drawn upon including the International Ice Patrol (IIP), Canadian Ice Service (CIS), National Ice Center (NIC) and Provincial Aerospace Limited (PAL). This section provides a summary of sea ice and iceberg conditions for the Study and Project Areas from Labrador Shelf SEA Sections 3.6 and 3.7 (Sikumiut 2008).

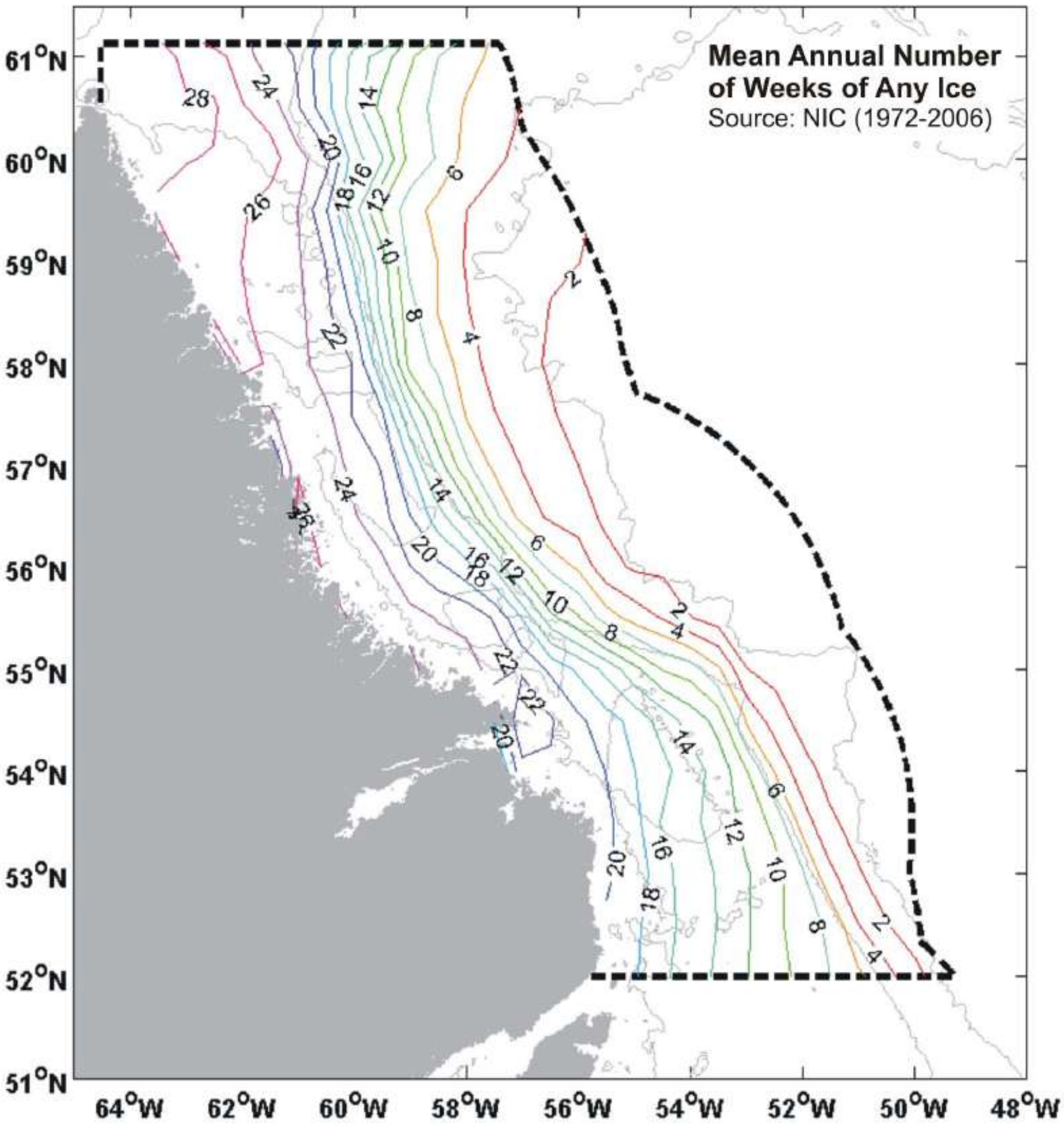
4.6.1 SEA ICE

Seasonal landfast and sea (or pack) ice can occur throughout the Study Area from November through July, and occasionally outside this period.

The mean annual number of weeks of pack ice found on the Labrador Shelf is shown in Figure 4-26 (the 200, 1,000 and 3,000 m bathymetry contours are shown). The dataset covers 35 years from 1972 to 2006 inclusive and is from NIC.

In general, the average start of the ice season ranges from mid-November in the north, to December, in the south. The ice season ends, on average, by late June/early July in the south but extends until late July/early August in coastal and northern regions. The mean annual number of weeks for sea ice presence ranges from one week in the offshore areas to 28 weeks near shore in the north and 20 weeks near shore south of Groswater Bay (Labrador Shelf SEA Section 3.6 (Sikumiut 2008)).

The Special Project Division of the Newfoundland and Labrador Department of Development and Tourism (1985) measured pack ice thickness in the Labrador Sea and reported thicknesses from a minimum of 1.5 m to a maximum of 14 to 17 m with averages from 1 to 9 m. Ross *et al.* (2006) recorded numerous ice ridge keels on Makkovik Bank and the deepest ice keels had 16 to 22 m drafts during the 2002-2003 season and 12 to 16 m during the 2004 to 2005 season. During both periods, the mean ice speed was approximately 25 cm/s (0.45 knots), with a maximum measured speed of 77 cm/s (1.5 knots).



Source: Labrador Shelf SEA Section 3.6.1 (Sikumiut 2008).

Figure 4-26 Mean Number of Weeks per Year that Pack Ice is Present

4.6.2 ICEBERGS

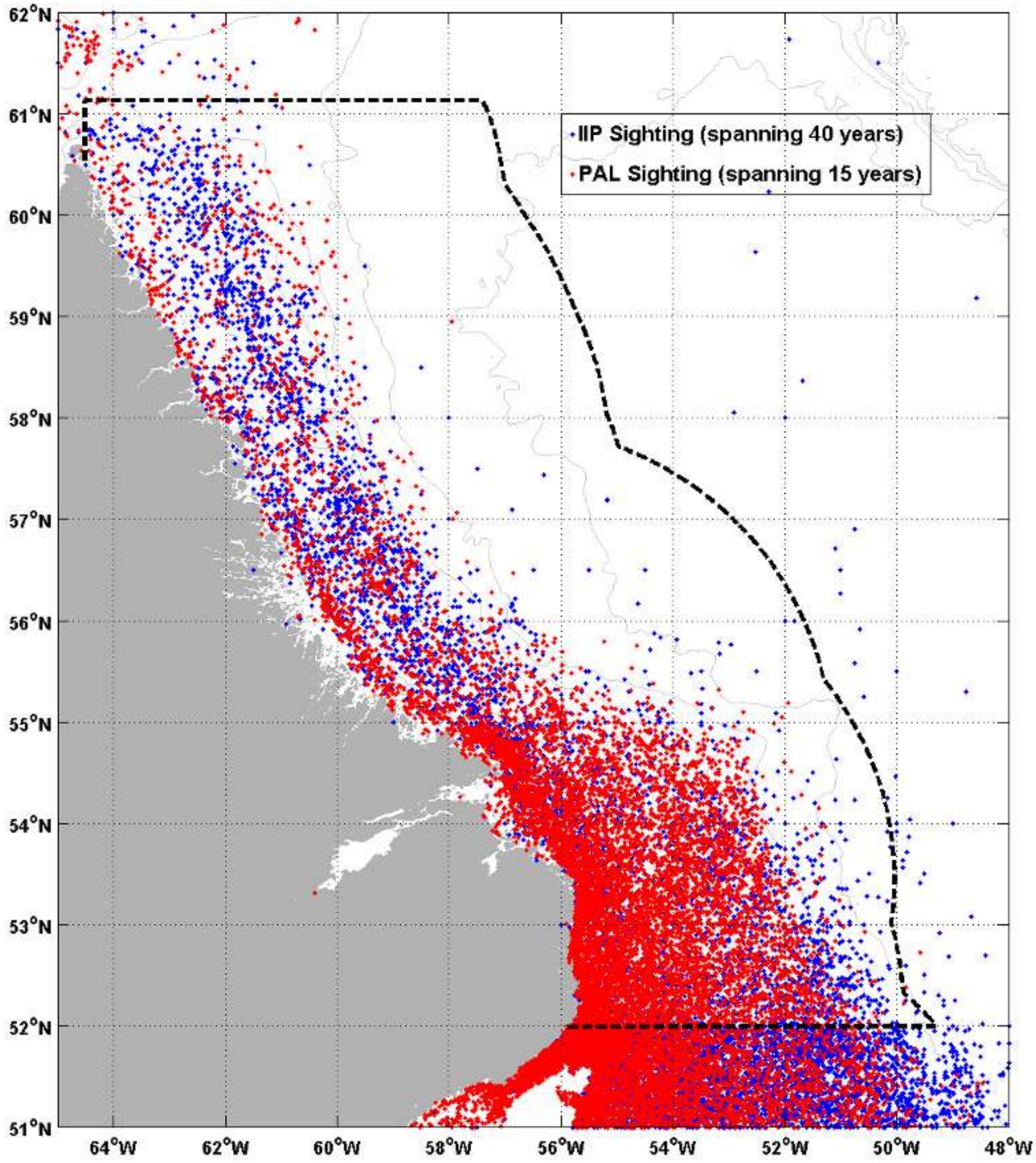
The Labrador Coast can be a high traffic area for many icebergs in their journeys south from the fjords of Greenland. Icebergs are masses of fresh water ice which calve each year from the glaciers along West Greenland. Icebergs are moved by both the wind and ocean currents, and typically spend one to three years travelling a distance up to 2,897 km (1,800 miles) to the waters of Newfoundland. The West Greenland and Labrador Currents (Figure 4-14) are major ocean currents which move the icebergs about the Davis Strait, along the coast of Labrador, through the Strait of Belle Isle, to the northern bays of Newfoundland, and to the Grand Banks.

As one characterization of iceberg occurrence for the Study Area, Labrador Shelf SEA Section 3.7 (Sikumiut 2008) presented the iceberg sightings from the IIP and PAL (Figure 4-27) which provide an indication of iceberg distribution. To then better quantify the occurrence of icebergs, results of a study by Petro-Canada (1983) that created iceberg density maps were also presented (Figure 4-28). The Petro-Canada (1983) study analyzed IIP data from 1963 to 1976 to produce the iceberg density maps. Sightings were grouped into cells measuring one degree of longitude by a half-degree latitude. The total number of sightings for each cell was normalized by the number of flights over each cell and divided into three "seasons": summer (July to October), winter (November to February) and spring (March to June). It is noted (Labrador Shelf SEA Section 3.7 in Sikumiut 2008) these density results may be conservative since some flights may not have sighted any icebergs but were included in the calculation. In the Project Area, of the three "season" survey groupings employed, icebergs are most prevalent during the July to October interval.

Additional iceberg densities were also calculated from CIS iceberg charts from 1988 to 2006 and are presented in Figure 4-29. These mean densities were compiled by averaging monthly CIS iceberg counts for each degree square and then scaling them by a 1.63 factor found from comparison with PAL iceberg sighting data for the period between 1992 and 2006 (C-CORE 2007). For comparison, in reviewing the densities in Figure 4-29, the average annual iceberg density on the northeast Grand Banks is approximately $1\times10^{-4}/\text{km}^2$ (Labrador Shelf SEA Section 3.7 (Sikumiut 2008)).

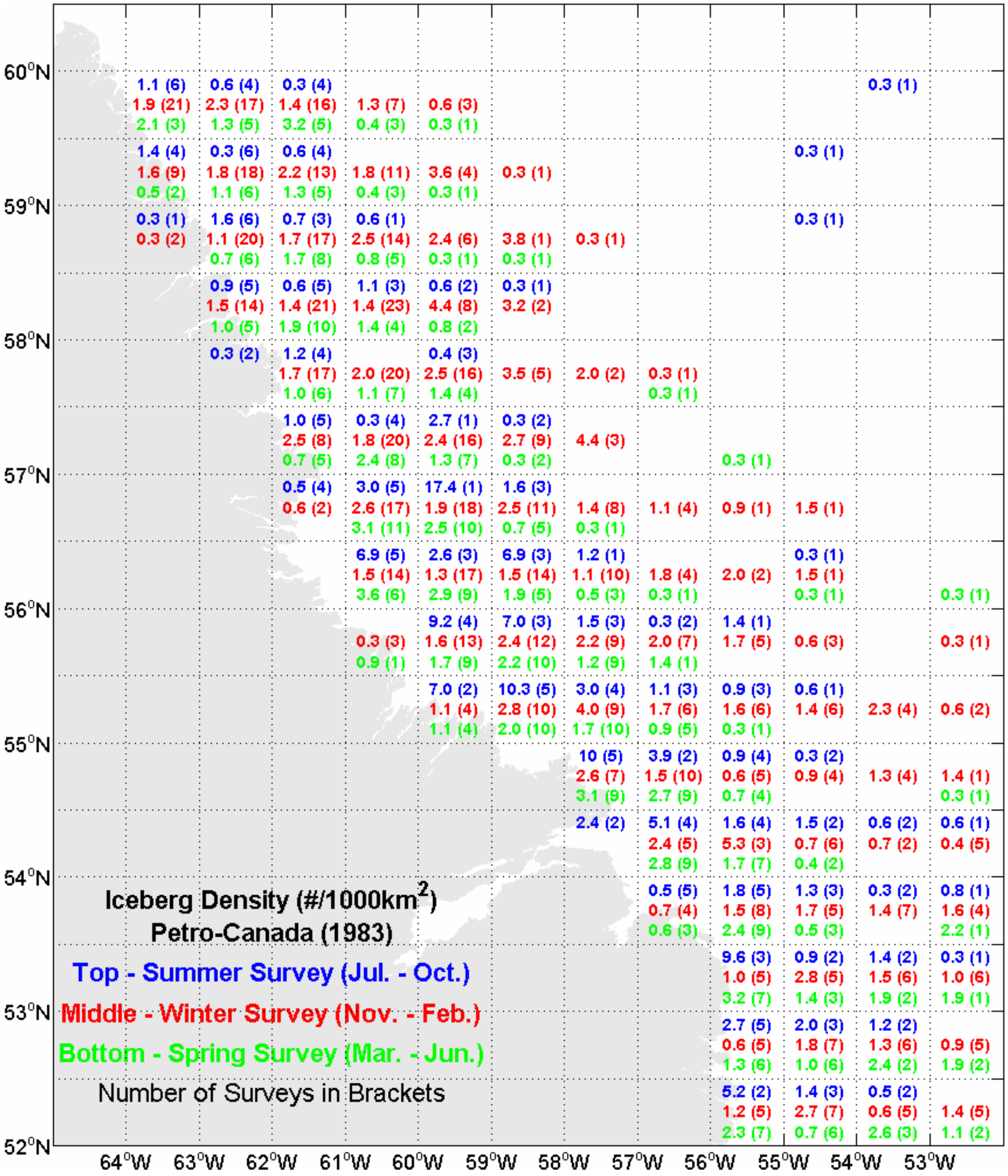
Iceberg drift in this region is from north to south following the shape of the Labrador Current and Coast. CIS has a dynamic model of iceberg drift forecasting and the results show drift is southeast with mean drift speeds from 0.13 to 0.46 m/s, with an overall mean speed of 0.24 m/s.

An analysis of IIP iceberg size data indicated that for the Study Area, 54 percent of icebergs were of "small" length class (16-60 m), 31 percent were of "medium" length class (61-122 m), and 16 percent were of "large and very large" length class (123 m or larger). An overall iceberg mean length of 67 m for the Labrador Shelf is noted (Labrador Shelf SEA Section 3.7.2.5 (Sikumiut 2008)).



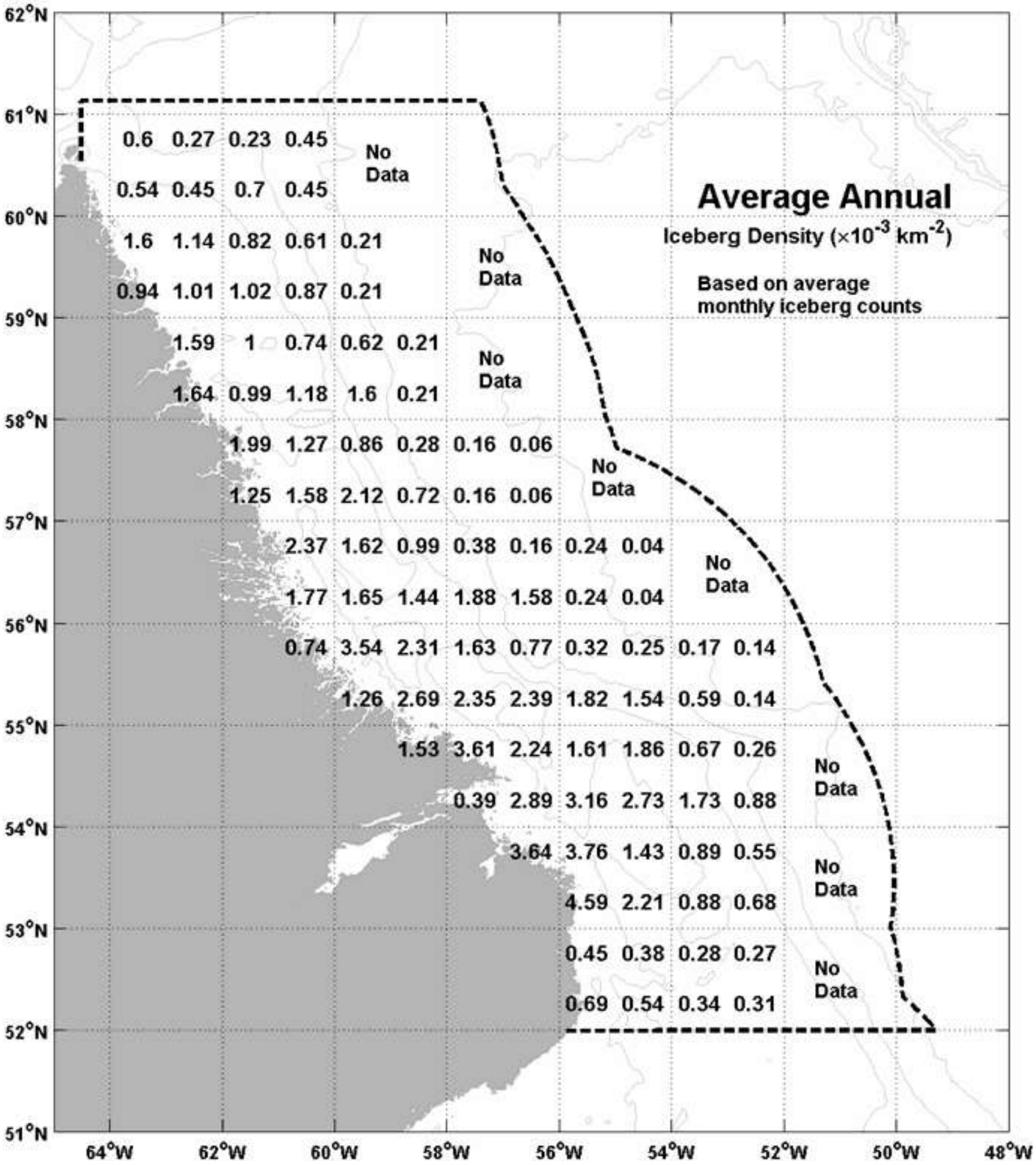
Source: Labrador Shelf SEA Section 3.7 (Sikumiut 2008).

Figure 4-27 Iceberg Sightings in Strategic Environmental Assessment Area by International Ice Patrol and Provincial Aerospace Ltd.



Source: Petro-Canada 1983, in Labrador Shelf SEA Section 3.7 (Sikumiut 2008).

Figure 4-28 Labrador Sea Iceberg Densities



Source: Labrador Shelf SEA Section 3.7 (Sikumiut 2008).

Figure 4-29 Annual Average Iceberg Density Based on CIS Charts

4.7 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

In the Labrador Sea, including the Project Area, marine operations may be affected by wind, waves, currents, visibility and, to a lesser extent. air and sea temperatures. Sea ice, icebergs and vessel icing are also potential seasonal hazards. Time of year is a key factor in determining the level of risk or impact any of these environmental parameters may have on operational efficiency or success. Planning and executing activities safely requires due consideration of the seasonally variable hazards that may be encountered.

The present Project Operations Plan spans July to November. This section characterizes the range of conditions likely to be encountered within this time frame, and some of the associated adverse effects. Vessels, equipment and materials used by the Project must be rated to function within the expected conditions and adhere to all standards and codes for safety and data quality.

4.7.1 METEOROLOGICAL OCEANIC CONDITIONS

Wind and waves have the potential to increase stress on vessel surfaces, disrupt operations and scheduling and affect survey data quality. Vessels and equipment must be able to withstand the range of normal and extreme wind and wave conditions expected. Seismic survey operations are typically limited by wind or sea conditions.

Within the Study Area, wind speeds are highest between October to March and highest sea states occur between October and January. The 100-year maximum for Hs (13 m), and the 100-year maximum wind speed (30.3 m/s) occur in this fall/winter period.

In October and November the mean Hs ranges from 2.3 to 2.8 m with maximum wave heights of 11 m. Winds in October and November reach maximum speeds of approximately 25 m/s.

During July and August, winds are approximately 5 m/s on average, with maximum values of 17 m/s. Corresponding waves are expected to be approximately 1 m on average, and may be as large as 5.4 m. By September, average waves will reach almost 2 m, while maximum heights of 9.4 m are encountered. The summer period poses less extreme wave conditions.

Seismic operations are potentially affected by near-surface ocean currents, depending on the tow-depth of streamers or other equipment. Current magnitudes vary depending on the time of year, depth and location on the Labrador Shelf (as presented in Section 4.3). Average speeds range on the order of 0.05 to 0.3 m/s, with maximum speeds generally ranging from approximately 0.2 m/s to 0.6 m/s, but may be as large as 1 m/s. Currents characteristic of the survey region are not expected to affect Project activities.

In July and August, air temperatures along the coast are approximately 12°C, but may fall as low as 0°C. In October, temperatures have cooled to approximately 3°C on average, with extreme minimum temperatures of approximately -9°C. By November, temperatures have dropped to approximately -3°C on average. Extreme minimum temperatures of -19°C are possible in November.

Sea temperatures will seldom be less than approximately 0.5°C from July to October, while in November they can be as cold approximately -0.8°C. Exposure to water at these temperatures may pose a risk to personnel and equipment. The combination of low air and sea temperature, strong winds and high waves can lead to vessel icing. The vessel itself is also a critical factor for icing potential. The vessel size, hull design (which affects amount of spray produced while under way), superstructure design and the amount of rigging are considerations. For freezing spray to occur, air temperatures must be -2°C (the freezing point of salt water) or colder and sea temperatures generally less than 5°C. There is low likelihood of vessel icing or wind chill potential in July to early fall, and hence negligible risk for personnel safety or performance issues. Freezing spray and ice-forming conditions could be encountered in November, but are not anticipated to affect operations.

While the summer to early fall period generally favours calm seas, visibility may be reduced due to formation of coastal fog. In July and August, when warm air masses move over cold water, reduced visibility of less than 0.9 km (0.5 nautical miles) occurs approximately 20 percent of the time. Visibility and ceiling restrictions may be a factor for shipping or for helicopter support activities. A review of the seasonal range and variation in these conditions would be appropriate for contingency planning.

A weather observation and site-specific forecasting program would be prudent to ensure safe and efficient Project planning and operations, and to better manage weather and sea-related effects.

4.7.2 ICE

Icebergs and sea ice are potential hazards for offshore activities on the Labrador Sea. Ice coverage may limit access to regions of the Project Area. Ice presence, both sea ice and icebergs, can lead to restriction or disruption of vessel activities, cause damage to vessels or equipment and pose safety risk to personnel.

In the northern limit of the Study Area, the normal season for sea ice occurrence can begin by mid-November and extend to July. Sea ice is therefore unlikely to be present in concentrations that could affect the Project.

Icebergs are a normal occurrence in the Project area. As noted in Section 4.6.2, of three “season” survey month groupings spanning the year, icebergs are most prevalent during the July to October interval.

Husky Energy will implement an Ice Management Plan appropriate for the planned Project operations. Since ice conditions can vary greatly from area to area, and season-to-season, or year-to-year within an ice-prone area, the ice management plan should be tailored to the region, period and nature of the operation. The generally accepted elements for consideration in an ice plan include: ice detection; surveillance; data collection; reporting; forecasting; risk determination, response, roles and responsibility, and decision-making; and avoidance or deflection.

As a minimum, a careful review of present (observed) and forecast ice conditions for the summer season prior to operations would be instructive.

4.7.3 CONCLUSION

The physical environment has the potential to affect Project activities during the planned July to November operating period. In particular, icebergs and reduced visibility pose greater risk during the summer, while stronger wind and larger wave conditions, and colder temperatures will occur by November. Appropriate planning measures, which reasonable account for the predicted range of conditions which may be encountered, will be carefully put in place by the Operator. As a result, there should be no adverse or significant effect on Project personnel, equipment, or activities.

5.0 BIOLOGICAL ENVIRONMENT

The biological environment of the Project Area which is contained within the Study Area is a diverse physical and biological environment that has two banks within the Project Area, specifically the Makkovik and the Harrsion Banks (Figure 5-1). The Project Area is bordered by saddles, specifically the Hopedale and Cartwright Saddles.

The Study Area is home to approximately 90 varieties of marine and anadromous fish species, supports large breeding colonies of various birds' species, serves as a staging and overwintering areas for a variety of birds' species, and supports a diverse population of marine mammals, many of which will occur within the Project Area.

The following sections provide an overview of the existing biological environment of the Project Area and uses information contained within the Labrador Shelf SEA (Sikumiut 2008). This description is based upon existing, readily available information gathered through a review of the published literature, unpublished reports and other relevant information sources, including Traditional Knowledge (collected during the compilation of the Labrador Shelf SEA (Sikumiut 2008).

5.1 SPECIES AT RISK

The Project Area is not known to contain any sensitive areas or critical habitats for species listed on Schedule 1 of *SARA*. Notwithstanding this, several species listed on Schedule 1 – three species of wolffish, blue whale, fin whale, leatherback turtle and Ivory Gull – are found in the Project Area. In addition, the potential environmental effects on species currently under assessment by the Committee on the Status of Endangered Species in Canada (COSEWIC) (such as Atlantic cod) that occur in within the Project Area are included in this environmental assessment.

5.1.1 SPECIES LISTED IN THE *SPECIES AT RISK ACT*

The purpose of *SARA* is to: prevent species becoming extirpated, endangered or extinct; allow for the recovery of extirpated, endangered or threatened species; and manage species of special concern, preventing them from becoming endangered or threatened. The official list of wildlife and plant species at risk (extirpated, endangered, threatened, or of special concern) in Canada is provided in *SARA*'s Schedule 1; species on this list are legally protected from being killed, captured and/or having any critical habitat destroyed.

A species listed on Schedule 1 (and its critical habitat) protected by Section 32 of *SARA*, which prohibits killing, capturing and destruction of critical habitat for extirpated, endangered and threatened Schedule 1-listed species; these prohibitions do not apply to those listed as special concern. Recovery strategies are required for endangered, species threatened and extirpated species; management plans are required for special concern species. *SARA* is administered by Environment Canada, Parks Canada and DFO.

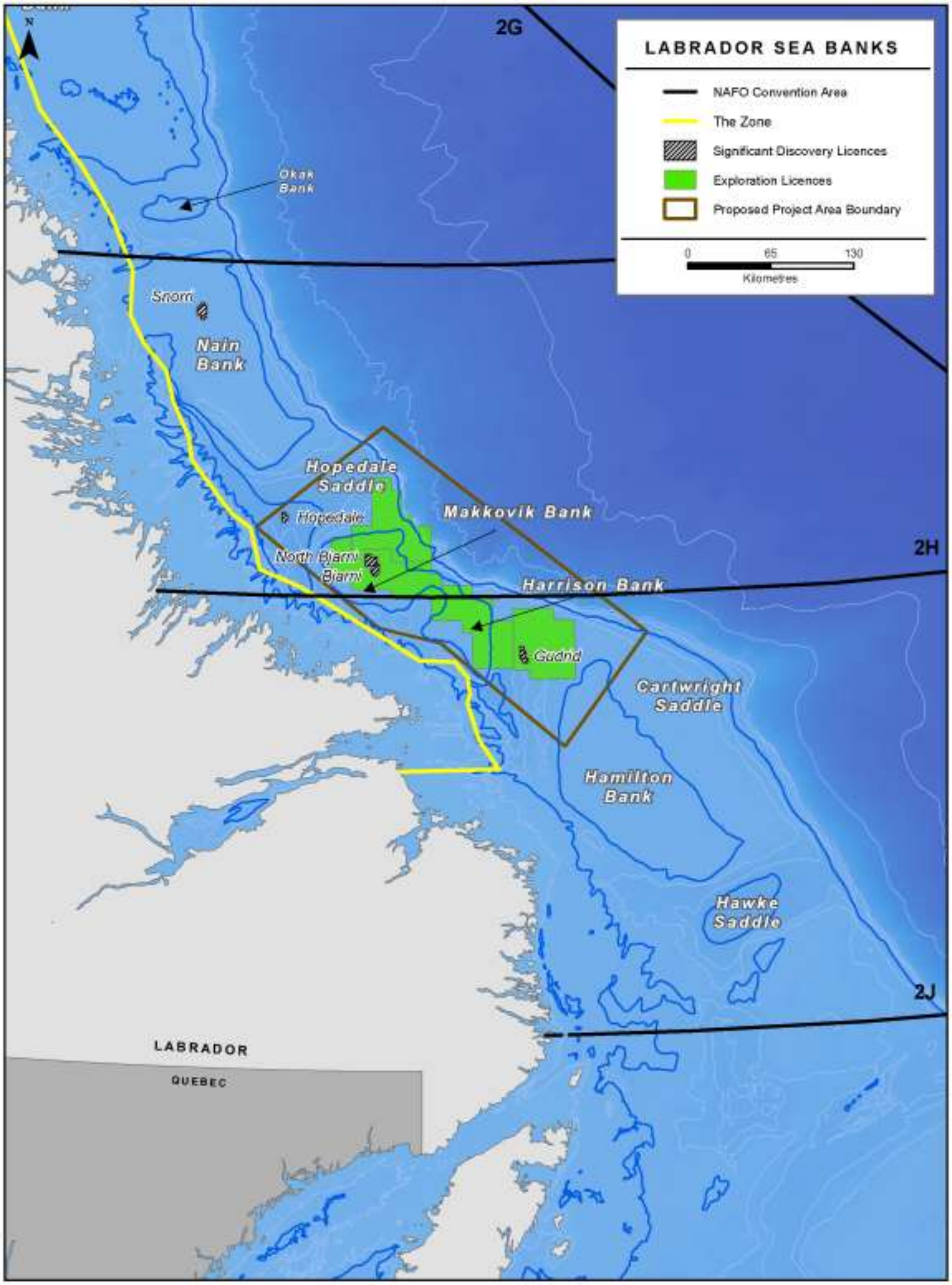


Figure 5-1 Location of Banks within the Study Area

Species within the Study Area listed in Schedule 1 of *SARA* are provided in Table 5-1.

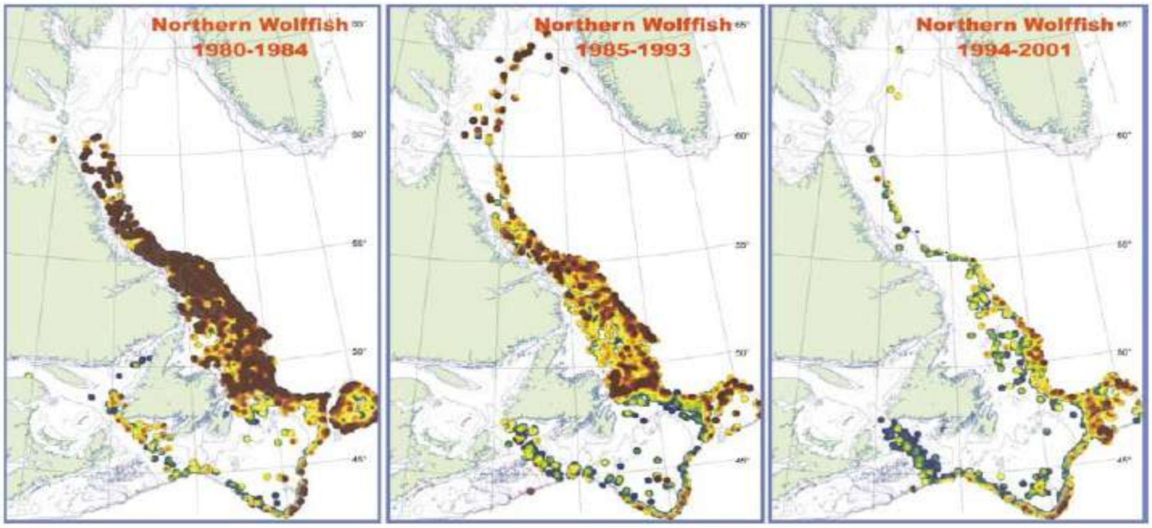
Table 5-1 Species within the Study Area Listed in *Species at Risk Act* Schedule 1

Common Name	Scientific Name	Range/Population	Risk Category
Fish			
Atlantic Wolffish	*Anarhichas lupus*	Atlantic Population	Special Concern
Northern Wolffish	*Anarhichas denticulatus*	Atlantic Population	Threatened
Spotted Wolffish	*Anarhichas minor*	Atlantic Population	Threatened
Marine Mammals			
Blue Whale	*Balenoptera musculus*	Atlantic Population	Endangered
Fin Whale	*Balenoptera physalus*	Atlantic Population	Special Concern
Reptiles			
Leatherback Turtle	*Dermochelys coriacea*	Atlantic and Pacific Populations	Endangered
Birds			
Barrow's Goldeneye	*Bucephala islandica*	Eastern Population	Special Concern
Eskimo Curlew	*Numenius borealis*	Canadian Population	Endangered
Harlequin Duck	*Histrionicus histrionicus*	Eastern Population	Special Concern
Ivory Gull	*Pagophila eburnea*	Northern Population	Endangered
Peregrine Falcon	*Falco peregrinus ssp. anatum*	Various in Eastern Canada including NL	Threatened
Source: Species at Risk 2009.			

The *SARA*-listed species discussed in subsequent sections are based on species listed on Schedule 1 of *SARA* as of August 2009.

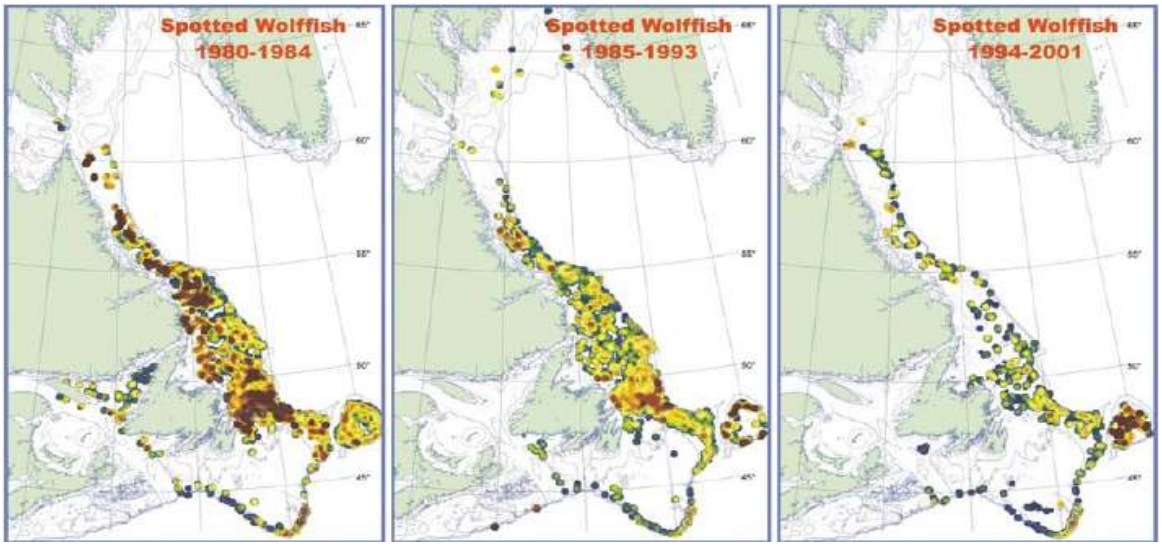
5.1.1.1 MARINE FISH

The only marine fish within the Study Area that is listed on Schedule 1 of *SARA* is the wolffish. Wolffish are solitary bottom-dwelling fish that range from the Davis Strait south to the Gulf of Maine (Kulka and DeBlois 1996; DFO 2002a; Kulka *et al.* 2007). Three species of wolffish are found in the Labrador Shelf Area: northern wolffish (*Anarhichas denticulatus*) (Figure 5-2), spotted wolffish (*Anarhichas minor*) (Figure 5-3); and Atlantic (striped) wolffish (*Anarhichas lupus*) (Figure 5-4). They typically are found in highest concentrations over sand, but occur over all observed bottoms (Kulka *et al.* 2007).



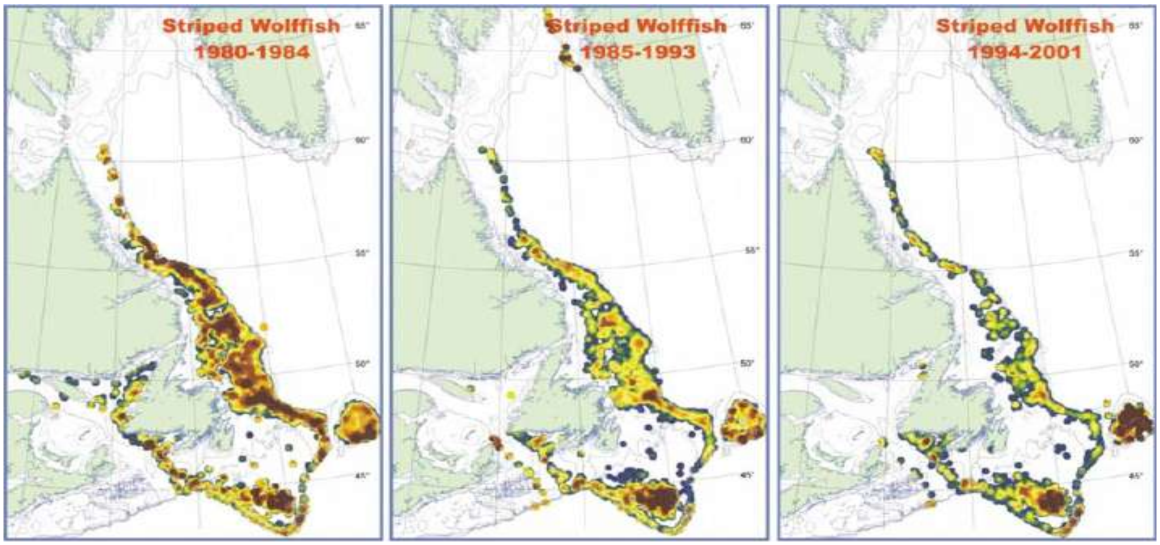
Source: Kulka *et al.* 2007.
Note: Darker shades denote greater distribution.

Figure 5-2 Northern Wolffish Distribution, 1980 to 2001



Source: Kulka *et al.* 2007.
Note: Darker shades denote greater distribution.

Figure 5-3 Spotted Wolffish Distribution, 1980 to 2001



Source: Kulka *et al.* 2007.
Note: Darker shades denote greater distribution.

Figure 5-4 Atlantic (Striped) Wolffish Distribution, 1980 to 2001

Little is known about their life history in Canadian waters as there is no directed commercial fishery for wolffish, although known growth, fecundity and age characteristics suggest that productivity is low. Eggs are fertilized internally and when spawned, are guarded by the male. (Keats *et al.* 1985; Pavlov 1994; Wiseman 1997; Kulka *et al.* 2007). Atlantic wolffish migrate to shallow inshore waters in the spring and spawn in September. Eggs are laid in a mass in burrows or crevices under rocks. The spawning site characteristics for the spotted and northern wolffish are unknown but it is thought they spawn in late fall or early winter (Kulka *et al.* 2004).

Wolffish are bathypelagic and benthic predators, feeding primarily on pelagic fish and invertebrates (although there is some species-specific variety in diets) (Kulka *et al.* 2007); wolffish themselves have few predators. Of the three wolffish species, the northern wolffish occupies the widest and deepest range, while the Atlantic wolffish (also known as the striped wolffish) occupies the narrowest. Temperature is an important factor for wolffish and all three have a narrow thermal range (mainly 1.5°C to 5°C) (Kulka *et al.* 2004, 2007). The spotted and northern wolffish are distributed over a variety of sediment types; Atlantic wolffish avoid muddy substrates (Kulka *et al.* 2004).

Northern and spotted wolffish are estimated to have Atlantic Ocean populations of 1 million and 2.7 million individuals, respectively (Canning and Pitt 2006); and have undergone a 90 and 95 percent decrease in abundance, respectively, over three generations. Atlantic wolffish has also declined in population and distribution, though not in the same order of magnitude as the northern and spotted wolffish. Northern and spotted wolffish are listed as threatened under *SARA* Schedule 1 (and are designated as 'threatened' by COSEWIC); Atlantic wolffish are listed as a species of special concern under *SARA* Schedule 1).

There is a Recovery Strategy for northern and spotted wolffish, and Management Plan for Atlantic wolffish to achieve long term viability of the species. The five primary objectives (Kulka *et al.* 2007) for the long term viability of the three wolffish species are:

- enhance understanding of the biology and life history of wolffish species;
- identify, conserve and/or protect wolffish habitat[1] required for viable population sizes and densities;
- reduce the potential for wolffish population declines by minimizing human impacts;
- promote wolffish population growth and recovery; and
- develop communications and education programs to promote the conservation and recovery of wolffish populations.

For additional information, refer to Labrador Shelf SEA Section 4.2.3 (Sikumiut 2008).

5.1.1.2 MARINE MAMMALS AND SEA TURTLES

Of 23 marine mammal and turtle species that may occur in Study Area, three species are listed on Schedule 1 of the SARA: the blue whale (*Balenoptera musculus*); the fin whale (*Balenoptera physalus*); and the leatherback sea turtle (*Dermochelys coriacea*). A review of known spatial and temporal distribution, abundance, and life history traits relevant to the study area are provided below.

Blue Whale

The blue whale is found globally and occurs in most oceans. A reliable global population estimate does not exist; however, estimates range from 5,000 to 12,000 individuals (Sears and Calambokidis 2002). More specifically, there are no data to provide an accurate estimate of the blue whale population for the western North Atlantic, which is estimated to be in the low hundreds based on photo identifications since 1979 in the Gulf of St. Lawrence (Sears and Calambokidis 2002). The wide distribution and dispersal of blue whales combined with limited sampling effort has resulted in inconsistent population estimates for the North Atlantic (Sears and Calambokidis 2002).

Blue whales have been known to occur along the north shore of the Gulf of St. Lawrence and off eastern Nova Scotia during spring, summer, and fall and have been sighted only sporadically off the Labrador coast (Sears and Calambokidis 2002). In summer, they also occur off the south coast of Newfoundland and in the Davis Strait, between Baffin Island and Greenland. They usually migrate south for the winter, but in years of light ice cover, some whales may remain in the St. Lawrence for much of the winter. Almost nothing is known about the winter distribution of blue whales in the North Atlantic (Sears and Calambokidis 2002).

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[1] DFO is working on defining specific critical habitat areas to meet legal requirements; however, these areas have not yet been defined (nor are they likely to be any time soon). DFO's official recommendations are those indicated in Kulka *et al.* (2007) (the recovery strategy) (S. Forsey, pers. comm.).

On a broad scale, it is known that they inhabit both coastal and pelagic waters off Newfoundland during the summer months and are often found feeding in aggregations at shelf edges, where upwelling results in high concentrations of krill (Sears and Calambokidis 2002). While it is thought likely that blue whales are present within the Labrador Shelf Study Area in all four seasons, there is a distinct paucity of information regarding their movements, both spatially and temporally, and in terms of behavior and habitat use.

Limiting factors and threats to the population include entrapment in wind and current driven ice, shipping traffic (collisions with propeller or hull), displacement from anthropogenic noise, pollution and climate change (Sears and Calambokidis 2002). The Atlantic population of the blue whale is listed as Endangered on Schedule 1 of the *SARA*.

There is a proposed Recover Strategy for the Northwest Atlantic population of the blue whale. The three primary objectives (DFO 2009a) for the long term viability of Northwest Atlantic population of blue whale are:

- define and undertake a long-term assessment of the abundance, structure and trends of the population, and determine the range and critical habitat in Canadian water of blue whales;
- implement control and monitoring measures for activities which could disrupt the blue whale recovery in its Canadian range by
  - reducing anthropogenic noise (e.g., seismic exploration) and protecting food resources, and
  - reducing disturbance from anthropogenic activities (e.g., whale watching), and reducing the risks of accidents associated from collisions and reducing toxic contamination in the marine environment; and
- increase knowledge concerning the threats to the recovery of blue whales in Canadian waters.

For additional information, refer to Labrador Shelf SEA Section 4.2.4 (Sikumiut 2008).

Fin Whale

Fin whales are found in oceans worldwide and make seasonal migrations between low-latitude wintering areas and high-latitude feeding grounds (COSEWIC 2005a). The exact locations of the wintering areas are uncertain. Summer concentrations of fin whales have been reported in the Gulf of St. Lawrence, Scotian Shelf, Bay of Fundy, and in near and offshore waters of Newfoundland and off Labrador.

The best available population estimate for the Western North Atlantic is 2,800 individuals between Georges Bank and the mouth of the Gulf of St. Lawrence (COSEWIC 2005a). There are no complete population estimates for the western Northwest Atlantic Region but a partial estimate was made in 2003 for Newfoundland and Labrador of between 459 to 2,654 (Lawson 2006).

Much of the data on fin whales in the project area are inferred from nearby areas and individual sightings (Sikumiut 2008) (Figure 5-5). For example, fin whales may occur within the Study Area year-round, as they do off Nova Scotia (COSEWIC 2005a), but have been spotted mainly nearshore in Labrador waters during the summer. Fin whales have been described as highly vocal during late August, through the fall and again in mid-winter, off the Scotian Shelf, which could be indicative of their migration southward in the fall and northward in the late winter and spring (COSEWIC 2005a). Based on the presence of their common prey, it has been inferred that fin whales commonly aggregate near ocean fronts and areas of upwelling, such as shelf breaks (COSEWIC 2005a).

Limiting factors and threats to the population include entrapment in wind and current driven ice, shipping traffic (collisions with propeller or hull), displacement from anthropogenic noise, pollution and climate change (COSEWIC 2005a). The Atlantic population of the fin whale is listed as Special Concern on Schedule 1 of the *SARA*.

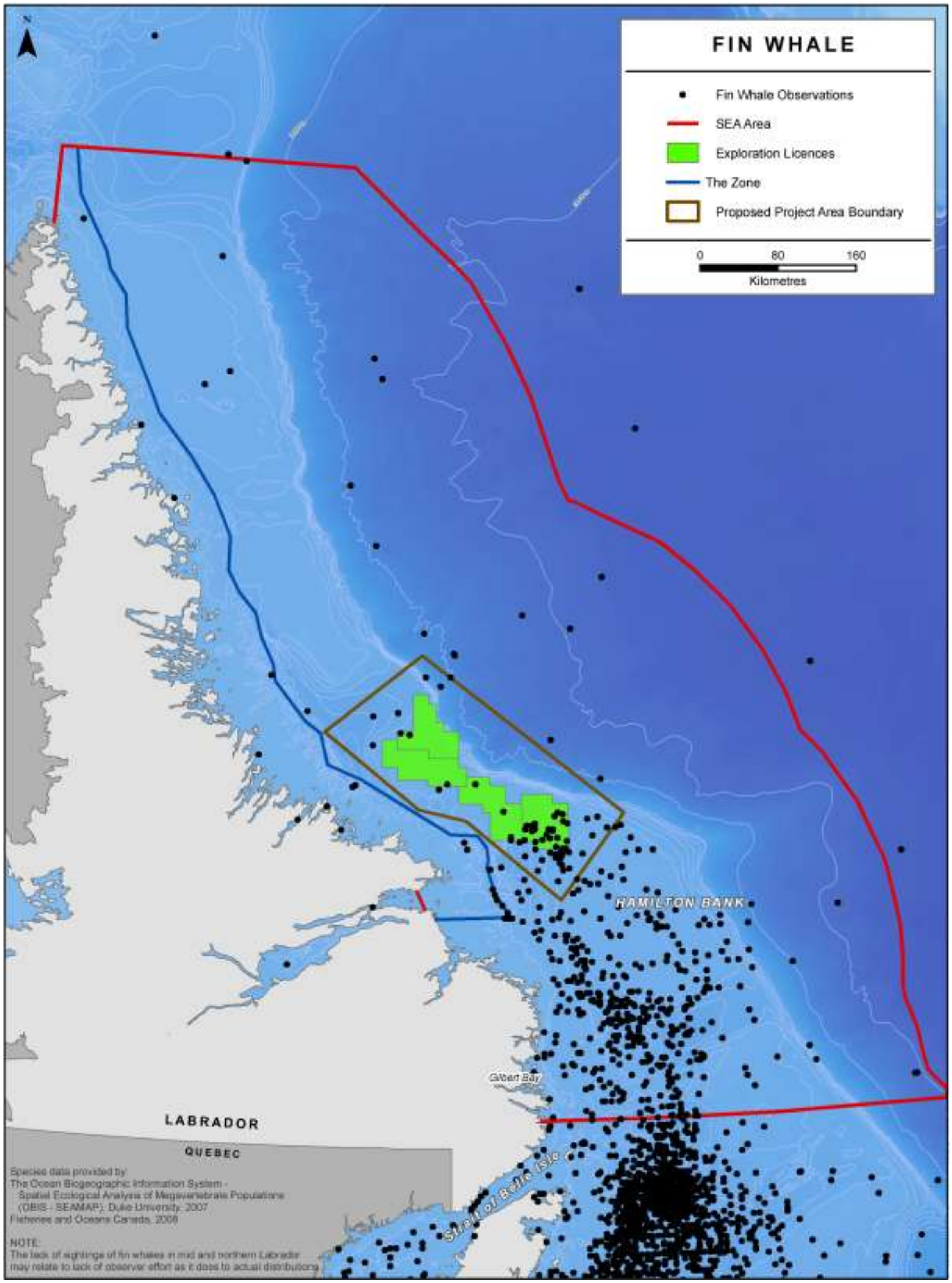
For additional information, refer to Labrador Shelf SEA Section 4.2.5 (Sikumiut 2008).

Leatherback Sea Turtle

Leatherback turtles occur globally and have the largest geographic range of any reptile species since they undertake extensive migrations, including into Canadian Atlantic waters (Sikumiut 2008). There is a high level of discrepancy concerning global population estimates, and no population estimate exists for the Northwest Atlantic. Leatherback turtles are known to migrate into Canadian waters to feed and have an extensive distribution throughout the year (Sikumiut 2008).

Although recovery strategies and vast knowledge gaps have been identified, the largest challenge to mitigating harm to the leatherback turtle in Canadian waters is the complete lack of basic biological, life history, or critical habitat information. The supporting objectives of the Recovery Strategy (Atlantic Leatherback Turtle Recovery Team 2006) outline the need to:

- understand the threats to leatherbacks in Atlantic Canadian waters;
- acquire further information to improve the general knowledge of the species and its habitat;
- take further steps to identify critical habitat so that it may be protected;
- reduce the risk of harm to leatherback turtles from anthropogenic activities;
- educate stakeholders and the general public on ways to support recovery; and
- work collaboratively at an international level to further recovery.



Species data provided by:
The Ocean Biogeographic Information System -
Spatial Ecological Analysis of Megavertebrate Populations
(OBIS - SEAMAP). Duke University. 2007
Fisheries and Oceans Canada. 2008

NOTE:
The lack of sightings of fin whales in mid and northern Labrador
may relate to lack of observer effort as it does to actual distributions

Figure 5-5 **Fin Whale Observations (1945 to 2005) within the Study Area**

In eastern Canadian waters, limiting factors at sea include entanglement in fishing gear, collisions with boats, displacement due to anthropogenic noise and marine pollution such as ingestion of marine debris (Atlantic Leatherback Turtle Recovery Team 2006). Leatherback turtles are listed as Endangered on Schedule 1 of the *SARA*.

For additional information, refer to Labrador Shelf SEA Section 4.2.3 (Sikumiut 2008).

5.1.1.3 BIRDS

Ivory Gull

The Ivory Gull (*Pagophila eburnean*) is a rare, medium sized, long-lived gull species that is associated with polar pack ice at all time of the year (Gilchrist and Mallory 2004), which is unusual for a gull species (Stenhouse *et al.* 2004).

The Ivory Gull is protected under the *Migratory Birds Convention Act (1994)* and *Migratory Bird Regulations* (COSEWIC 2006) and is listed as endangered on *SARA* Schedule 1. In March 1978, 35,000 individuals were observed among the pack ice of the Labrador Sea (Orr and Parsons 1982), which is the bulk of the world population of Ivory Gulls. A recent survey (March 2004) conducted off the coast of Newfoundland and Labrador shows a decrease in Ivory Gull numbers, with sightings of 0.02 individuals per 10 minutes, compared to 0.69 individuals per 10 minutes observed in 1978 (COSEWIC 2006). The abundance and seasonal use of the Labrador Sea by Ivory Gulls is essentially unknown.

In a long-term study of ice cover in eastern Canada (Friedlaender *et al.* 2007), the sea ice cover off Newfoundland and Labrador was found to vary cyclically with periods of above average ice cover followed by periods of below average ice cover. It is postulated that Ivory Gull occurrences in the southern Labrador Sea may coincide with periods of above average ice cover, but currently data are insufficient to confirm this. This scarcity of data may be partially due to the difficulty in completing a census of Ivory Gull (Renaud and McLaren 1982) but it is accepted that Ivory Gull has undergone significant declines (up to 85 percent) in recent years (Stenhouse *et al.* 2004), and the population declines coincide with the diminished sea ice linked to climate change.

For additional information, refer to Labrador Shelf SEA Section 4.2.9 (Sikumiut 2008).

Eskimo Curlew

The Eskimo Curlew (*Numenius boreali*) is a migratory bird that typically migrated through the Labrador Shelf area in the fall. They were once found from Newfoundland and Labrador to Alberta to the Northwest Territories (Environment Canada 2007a). It is possible that this species has become extinct as efforts to locate individuals has been unsuccessful (Environment Canada 2007a). They are under management jurisdiction from the federal government and is covered under the *Migratory Birds Convention Act*, 1994 (Environment Canada 2007a). The Eskimo Curlew is listed as endangered on *SARA* Schedule 1. They are also covered under Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the Bonn Convention

(Convention for the Conservation of Migratory Species of Wild Animals) (Environment Canada 2007a).

The Recovery Strategy for Eskimo Curlew (Environment Canada 2007a) specifies measures that can be implemented under Canadian jurisdiction to promote the recovery goal of achieving the long-term viability. The supporting objectives of the Recovery Strategy (Environment Canada 2007a) currently note that they are not aware of the existence or location of any Eskimo Curlews and as such recovery is not technically or biologically feasible for this species at this time.

For additional information, refer to Labrador Shelf SEA Section 4.2.10 (Sikumiut 2008).

Peregrine Falcon

There are three subspecies of Peregrine Falcon that occur in Canada (*Falco peregrines anatum*, *Falco peregrines tundrius* and *Falco peregrines pealei*). Of the three subspecies found in Canada, only two (*anatum* and *tundrius*) occur and breed in the Labrador Shelf study area (COSEWIC 2007a). Peregrine falcons are often observed flying over large expanses of ocean in search of food and are often associated with offshore islands. Peregrine falcons that inhabit the coast mostly hunt seabirds like Black Guillemot (*Cepphus grylle*). At least one nest site in Labrador has been occupied (not necessarily continuously) for up to 145 years.

The primary factor causing decline of Peregrine Falcon populations was reproductive failure following exposure to organochlorine pesticides, particularly DDT (COSEWIC 2007a). Human disturbances at nest sites may be the cause of recent declines (COSEWIC 2007a). The *anatum* and *tundrius* subspecies have been assessed as a single subspecies by COSEWIC (2007a) and are listed as a species of Special Concern on Schedule 1 of *SARA*; the *falco* subspecies is listed as Threatened on Schedule 1 of *SARA*.

For additional information, refer to Labrador Shelf SEA Section 4.2.11 (Sikumiut 2008).

Harlequin Duck

Harlequin Duck (*Histrionicus histrionicus*) breeding and moulting sites have been known to occur in the Study Area (but not Project Area), specifically at the Gannet Islands (Environment Canada 2007b) and several breeding sites in inland Labrador. Harlequin ducks often breed on rivers and streams near the ocean and are sometimes observed in bays and estuaries throughout the northern areas of their breeding ground. Population trends are not available for the breeding population of eastern North America; however, local Aboriginal knowledge from Innu elders of Utshimassit suggests the Harlequin Duck populations in central Labrador declined considerably in the 1980s and early 1990s (Environment Canada 2007b). Harlequin Duck is listed as a species of special concern on Schedule 1 of *SARA*; it is also listed as vulnerable under the Newfoundland and Labrador *Endangered Species Act (2002)*.

A Management Plan for Harlequin Duck conservation for Atlantic Canada and Québec has been developed. The objectives of the plan (Environment Canada 2007a) are:

- clarify possible threats to the species and outline a regime(s) to address these issues;
- assess population status;
- identify, protect and manage important areas for breeding, moulting, wintering, and staging habitat;
- work with governments, industry, aboriginal groups, and private citizens to identify the threats to the Harlequin Duck, and work toward eliminating or reducing these threats;
- identify targeted groups for education and stewardship initiatives on Harlequin Duck issues, and develop appropriate campaigns and programs;
- conduct gap analysis to determine shortcomings in knowledge of the Harlequin Duck; and
- engage Greenland in further collaboration with Canada regarding Harlequin Duck conservation.

For additional information, refer to Labrador Shelf SEA Section 4.2.7 (Sikumiut 2008).

Barrow's Goldeneye

Barrow's Goldeneye (*Bucephala islandica*) prefer to breed at high elevations on alkaline wetlands around freshwater lakes. Wintering populations in Quebec are found on small fishless lakes above 500 m elevation (Robert *et al.* 1999a, 1999b). Barrow's Goldeneye like to nest in tree holes or cavities within 2 to 3 km of a water body. Studies have confirmed Nain Bay as a molting site (Todd 1963; Robert *et al.* 1999a, 1999b). The eastern population of Barrow's Goldeneye is listed as a species of special concern under Schedule 1 of *SARA*. It is also protected by the *Migratory Birds Convention Act* and is listed as vulnerable on the Newfoundland and Labrador *Endangered Species Act* (Government of Newfoundland 2002).

For additional information, refer to Labrador Shelf SEA Section 4.2.8 (Sikumiut 2008).

5.1.2 SPECIES WITH COMMITTEE ON THE STATUS OF ENDANGERED SPECIES IN CANADA STATUS

COSEWIC develops prioritized candidate lists of species needing assessment, manages the production of species status reports, and holds meetings at which species are assessed and assigned to risk categories. COSEWIC uses the best available information relevant to assessing a species' risk of extinction or extirpation, which it may obtain from any credible source of knowledge of the species and its habitat. The evaluation process is independent and transparent, and the results are reported to Canadian Endangered Species Conservation Council and the public.

COSEWIC's Candidate List is a compilation of species in Canada that have yet to be assessed and are suspected of being at some risk for extinction or extirpation thereby indicating those species that have priority for assessment.

COSEWIC status species (that are not listed on Schedule 1 of *SARA*) that may occur in the Study Area are provided in Table 5-2.

Table 5-2 Species within the Study Area with Committee on the Status of Endangered Wildlife in Canada Designations

Common Name	Scientific Name	Range/Population	COSEWIC Designation[A]
Fish			
Atlantic Cod (NL pop'n)	*Gadus morhua*	Atlantic Ocean around NL	Endangered
Porbeagle Shark	*Lamna nasus*	Atlantic Ocean	Endangered
Roundnose Grenadier	*Coryphaenoides rupestris*	Atlantic Ocean	Endangered
Roughhead Grenadier	*Macrourus berglax*	Atlantic Ocean	Special Concern
American Plaice	*Hippoglossoides platessoides*	Newfoundland & Labrador Population	Threatened
Marine Mammals			
Beluga Whale	*Delphinapterus leucas*	Eastern Hudson Bay, Ungava Bay, Cumberland Sound and Eastern Arctic Pop'n	Endangered
Beluga Whale	*Delphinapterus leucas*	Cumberland Sound Pop'n	Threatened
Beluga Whale	*Delphinapterus leucas*	Western Hudson Bay and Eastern High Arctic – Baffin Bay Pop'n	Special Concern
Sowerby's Beaked Whale	*Mesoplodon bidens*	Atlantic Ocean	Special Concern
Bowhead Whale	*Balaena mysticetus*	Hudson Bay-Foxe Basin Pop'n	Special Concern
Bowhead Whale	*Balaena mysticetus*	Davis Strait – Baffin Island Pop'n	Special Concern
Killer Whale	*Orcinus orca*	Northwest Atlantic Pop'n	Special Concern
Harbour Porpoise	*Phocoena phocoena*	Northwest Atlantic	Special Concern
Atlantic Walrus	*Odobenus rosmarus rosmarus*	Nunavut, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador, Arctic Ocean	Special Concern

Common Name	Scientific Name	Range/Population	COSEWIC Designation^A
Polar Bear	*Ursus maritius*	Yukon, North West Territories, Nunavut, Manitoba, Ontariom Quebec, Newfoundland and Labrador	Special Concern
Birds			
Red Knot	*Calidris canutus rufa*	Canadian Arctic, Atlantic flyway	Endangered
[A] Species that are listed on *SARA* Schedule 1 are not repeated on this list, although they would also be included on the COSEWIC Lists. Source: COSEWIC 2010.			

5.1.2.1 MARINE FISH

Atlantic Cod

The Atlantic cod (*Gadus morhua*) occurring within the Study Area is the Northern cod stock (encompassing NAFO divisions 2GH and 2J3KL). This stock migrates to shallow waters along the coast and onto the plateau of the Grand Bank in the spring and over-winters near the edge of the Continental Shelf at depths greater than 400 m (DFO 2007b). Currently, the offshore biomass remains low and their contribution to inshore biomass during summer is unknown (DFO 2007b). Atlantic cod in Canadian waters are known to spawn extensively throughout the inshore, nearshore, and offshore waters (Hutchings *et al.* 1993; Morgan and Trippel 1996). Cod off Labrador and northern Newfoundland spawn in spring (March to May), along the outer slopes of the Continental Shelf (Brander 1994; Morgan *et al.* 1997; Smedbol and Wroblewski 1997). Spawning occurs at depths of tens to hundreds of metres at temperatures of approximately 2.5 to 4°C (DFO 2006a). A large female cod can produce millions of small pelagic eggs that remain at the surface through incubation. Hatching occurs in approximately 40 days (depending on ambient temperature) when the larvae are 3.3 to 5.7 mm in length. Larvae remain pelagic but move deeper as they grow. When they are 27 to 50 mm in length, they descend to the seabed (Scott and Scott 1988; Lough 2004). Oceanographic features such as water currents appear to play an important role in cod spawning as currents can entrain the buoyant eggs and prevent them from being dispersed to waters poorly suited to larval cod.

The distribution of the cod changes with age with the major nursery being shallow water along the coast of southern Labrador and eastern Newfoundland. As juveniles, cod associate with complex habitats, such as boulders/large rock, cobble, macroalgae and eelgrass, for protection from predators (Laurel *et al.* 2003a). Juvenile cod appeared to differentiate between habitats of varying quality and preferentially occupied eelgrass areas where growth and survival were potentially highest (Laurel *et al.* 2003b). For coastal areas, young of the year are mainly inshore, with year 1 cod starting to appear offshore. By age 3 to 4 they have a distribution overlapping with older fish (Lilly and Murphy 2004). Young cod fry feed mainly on copepods, amphipods, and other small crustaceans. Juveniles feed mainly on shrimp, amphipods, euphausiids and fish and shellfish larvae. Adult cod feed mainly on capelin (*Mallotus villosus*), herring, sand lance

(*Ammodytes* spp.), flounders, young Greenland halibut, crabs, shrimp, brittlestars, comb jellies, and a host of other species of fish and shellfish (DFO 2006a).

Atlantic cod were assessed by COSEWIC as endangered in May 2005 but were not added to *SARA*'s Legal list (COSEWIC 2006b). They are on Schedule 3 of *SARA* as a Species of Special Concern. The primary limiting factor and threat to the Atlantic cod population is population depletion due to resource over-exploitation (Smedbol *et al.* 2002). Limiting factors to the recovery of Atlantic cod south of Cape Chidley, Labrador, include collapsed age structure, reduced area occupied by spawners; below-average recruitment rate for some areas; higher-than-expected natural mortality of adults in some parts of the range of each population; and decline in individual growth rate in some areas within each population (COSEWIC 2003a).

For additional information, refer to Labrador Shelf SEA 4.3.2 (Sikumiut 2008)).

Porbeagle Shark

The porbeagle shark (*Lamna nasus*) is distributed from Greenland to Bermuda and occurs in waters off Newfoundland and Labrador (COSEWIC 2004a). The porbeagle is a large cold-water shark that occupies depths extending from surface to 200 m and prefers temperatures between 1°C to 18°C (Grimm *et al.* 2004). Mating occurs annually from September through November and the gestation period is eight to nine months. On average, a female gives birth to four live young (Jensen *et al.* 2002). Porbeagle has an estimated lifespan of 25 to 46 years. The mean age of female parents (generation time) is 18 years (Campana *et al.* 1999; Natanson *et al.* 2002, in COSEWIC 2004a). Porbeagle shark are active and strong in cooler waters (Campana 2007a) due to its ability to regulate its body temperature 2.7°C to 8.3°C above its surroundings. Porbeagle feed on herring, lancet fish (*Alepisaurus* spp.), mackerel (*Scomber scombrus*), cod, redfish, haddock, squid and shellfish (Campana 2007a).

The porbeagle was targeted commercially in the 1990s and its abundance has declined greatly since that time (COSEWIC 2004a). It is especially vulnerable to overexploitation due to its late maturity and low fertility (COSEWIC 2004a). The most abundant age-class off southern Newfoundland in the fall months was 10 to 15 years old prior to 1991; between 1998 and 2000, the most abundant age classes in this area were less than three years old (Campana *et al.* 2002). Porbeagle are designated as endangered by COSEWIC. Resource over-exploitation remains the primary limiting factor, with its low productivity also limiting its recovery (COSEWIC 2004a).

For additional information, refer to Labrador Shelf SEA Section 4.3.3 (Sikumiut 2008).

Roundnose Grandier

Roundnose grenadier (*Coryphaenoides rupestris*) is a deep-water resident of the North Atlantic continental shelves and slopes, commonly found at 400 to 1,000 m (but has been reported to 2,500 m). It is found at depths of 500 m and greater off northern Newfoundland and Labrador, at temperatures of 3.5°C to 4.5°C (Scott and Scott 1988).

Spawning occurs year round, with different areas experiencing more intense spawning at different times. The male to female ratio (which can vary depending on season and year) is high, up to 65 percent. Roundnose grenadier have a life span of approximately 17 years; females are generally larger than males (COSEWIC 2008).

Roundnose grenadier feed on crustaceans (northern areas of the Northwest Atlantic), euphausiids, myctophids (northeastern slope of the Grand Banks), squid and small fish. They are a slow-moving fish and have been found in the stomachs of whales; they are easy prey for larger predatory fish such as Greenland halibut (*Reinhardtius hippoglossoides*) (COSEWIC 2008).

Roundnose grenadier are designated as endangered by COSEWIC; susceptibility to resources exploitation as a result of life history characteristics is the primary limiting factor (COSEWIC 2008).

American Plaice

American plaice (*Hippoglossoides platessoides*) is a bottom dwelling flatfish that resides on both sides of the Atlantic (DFO 2006b), ranging from Baffin Island to the Gulf of Maine and Rhode Island in the western Atlantic (Scott and Scott 1988). Plaice prefer water temperatures of 0°C to 1.5°C and are typically harvested at depths of 125 to 200 m but have been found as deep as 713 m. In Newfoundland waters, American plaice spawn during the spring at an age of approximately eight years (Busby *et al.* 2007). On average, females typically produce 250,000 to 300,000 eggs (Johnson 2004). Eggs are buoyant and drift near the surface. A wide dispersion allows for some stock intermingling; however, there is minimal adult intermingling. Hatching time is dependent upon temperature and occurs within 11 to 14 days at temperatures of 5°C (Scott and Scott 1988). Phytoplankton and zooplankton are the main food source of larval plaice while in the upper water column (Pitt 1989). With settlement to the seabed and increasing size, the diet changes to include larger benthic organisms, including small echinoderms and crustaceans. Adult plaice feed on large quantities of capelin, sand lance and other fish and feeding intensity is highest during the spring and summer (Zamarro 1992).

Plaice occur both inshore and offshore over a wide variety of bottom types (Morgan 2000) and salinities (they have been observed in estuaries) (Scott and Scott 1988; Jury *et al.* 1994). While the species is relatively sedentary (Pitt 1969), older plaice have been known to move up to 160 km (Powles 1965). Hebert and Wearing-Wilde (2002, in Johnson 2004) observed a migration between deep offshore (winter) and shallow (spring) waters.

American plaice are designated as threatened by COSEWIC (as of April 30, 2009). The fishery for plaice on Newfoundland’s Grand Banks was once the largest fishery for flatfish in the world. Overfishing led to a moratorium on directed harvest in 1994 for the Newfoundland population. American plaice has suffered declines of approximately 90 percent in some areas along Canada’s east coast (COSEWIC 2009a). Ongoing threats include fishing mortality caused by by-catch and under-reported catch.

For additional information, refer to Labrador Shelf SEA Section 4.8.5 (Sikumiut 2008).

Roughhead Grenadier

Roughhead grenadier (*Macrourus berglax*) has a continuous distribution along the slope of the Continental Shelf from the Davis Strait to the southern Grand Bank (COSEWIC 2007b). While it can occur at depths up to 2,700 m, it is most common at depths of 800 to 1,500 m, in temperatures of -0.5°C to 5.4°C (González-Costas and Murua 2007). Roughhead grenadier biology and population dynamics are not well understood (González-Costas and Murua 2007). There is evidence of a prolonged reproductive period that could extend over an entire year (FAO 2007a; COSEWIC 2007b), but most spawning is thought to take place between late winter and early summer. Roughhead grenadier have a life span of at least 25 years (FAO 2007a); females grow faster than males (González-Costas and Murua 2007). Small roughhead grenadier feed primarily on amphipods, but polychaetes, crustaceans, bivalves, echinoderms and ctenophores are also an important part of their diet (FAO 2007a; COSEWIC 2007b). Large roughhead grenadier feed on larger bivalves, shrimp, squid and small fish (COSEWIC 2007b). However, they are a slow moving fish and have been found in the stomachs of cod (COSEWIC 2007b); they are potentially easy prey for larger predatory fish.

Roughhead grenadier is designated as a species of special concern by COSEWIC; susceptibility to resource exploitation as result life history characteristics is the primary limiting factor (COSEWIC 2007b).

For additional information, refer to Labrador Shelf SEA Section 4.3.4 (Sikumiut 2008).

5.1.2.2 MARINE MAMMALS

Eight additional species of marine mammal and sea turtle have been assessed by COSEWIC: the beluga whale (*Delphinapterus leucas*), the humpback whale (*Megaptera novaeangliae*), Sowerby's beaked whale (*Mesoplodon bidens*), the bowhead whale (*Balaena mysticetus*), the killer whale (*Orcinus orca*), the harbour porpoise (*Phocoena phocoena*), the Atlantic walrus (Odobenus rosmarus rosmarus), and the polar bear (*Ursus maritimus*). The following provides a review of known spatial and temporal distribution, abundance, and life history traits relevant to the study area.

Beluga Whale

Beluga whales have a circumpolar distribution and prior to the 1950s were common along the northern Labrador coast in summer. More recently, beluga sightings in this area have become rare and the Labrador Inuit Association only receives reports of approximately a dozen sightings per year (COSEWIC 2004b). No data were located on the spatial or temporal distribution of this species within or near the project area.

Beluga whale habitat varies seasonally. In late spring, as the fast-ice breaks up, beluga whales mass along the ice edges and penetrate the leads that provide access into the ice-covered areas (COSEWIC 2004b). Belugas often appear in their traditional river estuaries several weeks before the sea ice has completely broken up. In the summer, belugas are found in relatively shallow water along the coastlines (COSEWIC 2004b; DFO 2005a). During this period, belugas will frequent specific river estuaries and glacier fronts (COSEWIC 2004b). In the autumn, belugas leave the estuarine habitat to migrate long distances to their winter habitats.

Limiting factors include natural mortality from killer whales and polar bears, ice entrapment, human hunting, disturbances due to anthropogenic noise, pollution and loss of habitat. Belugas within the Study Area are designated by COSEWIC as either Endangered, Threatened, or Special Concern, depending on the exact population in question.

For additional information, refer to Labrador Shelf SEA Section 4.3.5 (Sikumiut 2008).

Sowerby's Beaked Whale

Sowerby's beaked whales are believed to be endemic to the North Atlantic. Good information on the distribution, abundance and biology of this species does not exist. The distributional data that does exist is based on very limited data from strandings and opportunistic sightings, and includes Atlantic Canada (MacLeod *et al.* 2006). Confirmed sightings are rare because this species is extremely difficult to distinguish from other beaked whales (COSEWIC 2006c). No estimate of population size exists (COSEWIC 2006c). Despite the lack of data, beaked whales are known to be extremely sensitive to acoustic pollution (COSEWIC 2006c). Like other beaked whales, their habitat is believed to be deep water, as whales are generally sighted at the Continental Shelf and slopes and nearshore sightings are more rare. Sowerby's beaked whale is designated as Special Concern by COSEWIC, and also listed as Special Concern on Schedule 3 of the *SARA*.

For additional information, refer to Labrador Shelf SEA Section 4.3.6 (Sikumiut 2008).

Bowhead Whale

Bowhead whales have a nearly circumpolar distribution in the Northern Hemisphere and presumably includes the Labrador Sea, although they are infrequently observed (DFO 2006c). The Davis Strait Baffin Island Population is most likely to have individuals that may frequent habitat near the Labrador Shelf (COSEWIC 2005b) and is designated as Threatened by COSEWIC.

Bowhead whales are slow swimmers and thus are vulnerable to ship collisions (COSEWIC 2005b). They have developed a sophisticated acoustic sense for ice navigation and long range communication (COSEWIC 2005b) and are among the more vocal of baleen whales (Clark and Johnson 1984). Bowhead whales are particularly sensitive to anthropogenic noise, and diving and avoidance behavior have been observed after exposure to aircraft, drillships and seismic vessels (COSEWIC 2005b).

For additional information, refer to Labrador Shelf SEA Section 4.3.9 (Sikumiut 2008).

Killer Whale

The killer whale is a cosmopolitan species and can be sighted in all oceans of the world. There were 363 sighting events of over 1,710 whales reported in Atlantic Canada between 1864 and 2007, with most records occurring since 1950 and over 30 percent of the total sightings recorded occurred in the last seven years (Lawson *et al.* 2007).The largest portion of sightings recorded in Atlantic Canada was during the June to September period with a majority of them in Newfoundland and Labrador waters (Lawson *et al.* 2007). There have been no clear patterns of distribution or movement documented for this population. The limited surveys that have been conducted would suggest that the killer whales in the North Atlantic are not abundant (COSEWIC 2009b). The Northwest Atlantic population is designated as Special Concern, based largely on a population estimate of fewer than 1,000 mature individuals and likely less than 250 (COSEWIC 2009b). The eastern Arctic killer whales are thought to hunt beluga whales.

For additional information, refer to Labrador Shelf SEA Section 4.9.2.3 (Sikumiut 2008).

Harbour Porpoise

There are three sub-populations of harbour porpoise in Atlantic Canadian Waters, totaling over 50,000 individuals (COSEWIC 2003b). In general, harbour porpoise are most commonly found over continental shelves, frequenting bays and harbours. Very little is known about the movements of the Newfoundland and Labrador and Gulf of St. Lawrence sub-populations (COSEWIC 2003b). Although a harbour porpoise survey has never been conducted in Labrador, by-catch and incidental observation data suggest that they occur in southern Labrador (COSEWIC 2003b) and may occur within the SEA Area during spring, summer and fall (Lawson and McQuinn 2004). It is assumed that harbour porpoises winter along the coast of the US and move through the Cabot Strait during fall and return in the spring (COSEWIC 2003b).

Limiting factors for this species include gear entanglement and bycatch, hunting, anthropogenic noise disturbances and habitat degradation. The northwest Atlantic population of harbour porpoise is designated as special concern by COSEWIC, and listed as Threatened on Schedule 2 of the *SARA*.

For additional information, refer to Labrador Shelf SEA Section 4.3.7 (Sikumiut 2008).

Atlantic Walrus

In Canada, the Atlantic walrus is rare south of the Hebron-Okak Bay (57°28'N, 62°20' W) area of the Labrador coast (Mercer 1967; Born *et al.* 1995) with only a few sightings south to Nova Scotia over the past decade (Kingsley 1998; Camus 2003).

Their limited ecological niche, restricted seasonal distribution, size and cultural significance have resulted in walrus being vulnerable to exploitation pressures and sensitive to environmental changes. Presently, hunting is the main threat to walrus. Other threats include contaminant uptake, industrial development, noise disturbance, and climate change. The Atlantic walrus is designated as special concern by COSEWIC.

There is a proposed Recovery Strategy for the Northwest Atlantic population of the Atlantic walrus; however, it determined that Recovery of this species is considered not technically or biologically feasible at this time (DFO 2008a).

For additional information, refer to Labrador Shelf SEA Section 4.3.8 (Sikumiut 2008).

Polar Bear

Polar bears are prominent in Canada's Arctic ecosystem, which supports approximately 50 percent of the world's population (COSEWIC 2002). They range into Labrador including the Study Area (COSEWIC 2002). In Labrador, they are specifically found in more northerly regions, especially during winter and spring on pack ice. They were once more common in southern Labrador, but this population has decreased due to human habitation and associated hunting. Polar bears are designated as special concern by COSEWIC.

The polar bear distribution is closely tied to the distribution and abundance of ringed seals, their preferred prey (COSEWIC 2002). During the summer, polar bears may remain on the sea ice as it melts and retreats northward. Once the sea ice melts polar bears are forced to spend the summer on land, where they live off stored body fat. They return to the sea ice when sea ice reforms in the fall.

For additional information, refer to Labrador Shelf SEA Section 4.9.5 (Sikumiut 2008).

5.1.2.3 BIRDS

Red Knot

The Red Knot (*Calidris canutus rufa*) population is currently estimated at 13,500 to 15,000 adults (COSEWIC 2007c). The Red Knot does not breed in the Study Area. It probably passes through the Study Area during fall migration between its breeding range in the central Canadian Arctic to its wintering grounds in Tierra del Fuego in South America. Red Knots forage for invertebrates in sandy intertidal marine areas during its migration (Harrington 2001). There are traditional staging areas along the Labrador coast, but the migration flyway is known to occur along the Maritime Provinces and Quebec and not as far east as Labrador. It is unlikely that the red knot *rufa* subspecies would use the Study Area during migration. Red knot is designated as endangered by COSEWIC. It is not listed under *SARA*; however, it is pending public consultation for addition to Schedule 1.

For additional information, refer to Labrador Shelf SEA Section 4.3.1 (Sikumiut 2008).

5.2 MARINE FISH AND FISH HABITAT

5.2.1 PLANKTON

All free-floating organisms that drift in the water column are referred to as plankton; including bacteria, fungi, phytoplankton (marine algae), zooplankton (invertebrates), macroinvertebrate eggs and larvae and ichthyoplankton (eggs and larvae of fish). Abundance and diversity of plankton varies according to season, with the highest abundance and diversity exhibited in summer.

5.2.1.1 PHYTOPLANKTON

The principal factors limiting phytoplankton distribution, productivity and growth is light availability, nutrient availability and herbivore grazing. The Labrador Sea and adjacent shelves (Husky Energy Project Area) are a highly productive ecosystem influenced by all the factors that mediate phytoplankton growth (Harrison and Li 2008). The timing of the spring phytoplankton bloom (which is the driving force of high-latitude marine ecosystem dynamics) is a critical factor regulating ecological cycles (Wu *et al.* 2008). The spring bloom in the southern Labrador Sea starts in March as a continuation of the bloom that starts on the Grand Banks and spreads northward with the increasing irradiance. However, recent work conducted by (Wu *et al.* 2008) suggests that the timing of the spring bloom may vary regionally and be linked to surface freshening by precipitation. river input and ice melt, as these factors can contribute to the ocean stratification that triggers the spring blooms.

The presence of sea ice in the Project Area can have an important effect on phytoplankton dynamics as ice melting can affect the temperature and salinity of the upper mixed layer and can promote increased stratification. As well, persistent sea ice can reduce primary production by blocking solar radiation, preventing a phytoplankton bloom, whereas an early ice retreat can result in an early and prolonged spring phytoplankton bloom. The spring bloom in the Labrador Shelf area usually occurs from May to June (Drinkwater and Harding 2001). In the Labrador Shelf Area, the lowest productivity occurs in December due to a reduction in light intensity.

The high productivity of the Labrador Shelf area is also influenced by upwelling that occurs along the slopes of the offshore banks and the outflow of nutrient rich water from the Hudson Strait (Drinkwater and Harding 2001; Breeze *et al.* 2002). Work conducted by Harrison and Li (2008) has demonstrated that during peak summer months, nutrient availability (nitrate and silicate) and irradiance may both limit overall phytoplankton biomass. Nutrient sources for summer primary productivity in the Labrador Sea include; cross shelve mixing, vertical mixing and advection; with the major nutrient contribution coming from the Hudson straits and areas with large riverine inputs, via advection (Sutcliffe *et al.* 1983).

Work conducted in the area in 1997 (Head *et al.* 2000) indicated similar species composition to previously reported boreal spring assemblages (Spies 1987). In Newfoundland and Labrador waters, the spring bloom tends to be dominated by diatoms while the fall bloom is dominated by flagellates and dinoflagellates (DFO 2007c;

Buchanan and Foy 1980). Common phytoplankton found in the Labrador Shelf Area from July to September, 1997 are listed in Table 5-3.

Table 5-3 Common Phytoplankton in the Study Area

Common Name	Genus	Common Name	Genus
Centric Diatoms	*Thalassiosira*	Tecate Dinoflagellates	*Schripsiela*
	Chaetosceros		*Dinophysis*
Pennate Diatoms	*Naviluca*		*Heterocapsa*
	Fragillaris		*Prorocentrum*
Naked Dinoflagellates	*Gymnodinium*		*Pavillardia*
	Gyrodinium		*Protoperidinium*
Ciliates	*Tibtinopsis*		*Alexandrium*
Source: Petro-Canada 1982; VBNC 1997, in Sikumiut 2008 (Labrador Shelf SEA Section 4.5.1).			

For additional information, refer to Labrador Shelf SEA Section 4.5.1 (Sikumiut 2008).

5.2.1.2 EPONTIC COMMUNITY

The epontic community refers to sea ice biota at all trophic levels, both plant and animal, that are associated with sea ice during all or part of their life cycle (Horner *et al.* 1992). Organisms can be autochthonous (regularly found in the ice and spend most of their life cycles there) or allochthonous (only temporarily associated with ice). Horner *et al.* 1992 have described these communities based on where they are located within the ice (surface communities, interior communities, bottom communities and sub-ice community), with each of these communities further subdivided based on method of formation. The epontic algal communities may act as a possible source the spring phytoplankton bloom (Anderson 1977), as the epontic community contributes an important proportion of the total annual primary productivity in the Antarctic, Bering Sea and Chukchi Sea (Alaska) and is the primary source of algae available to grazers during late winter and early spring time (Booth 1984). Epontic algae contribute approximately 10 percent of the annual production of coastal embayments and extends the food available to grazers that use it, since it blooms prior to the phytoplankton bloom (Booth 1984).

For additional information, refer to Labrador Shelf SEA Section 4.5.2 (Sikumiut 2008).

5.2.1.3 MICROFLORA

Microbiota are comprised of bacteria, mould and yeast. They serve a dual role in marine ecosystems as a food source and playing a key role in decomposition of complex organic molecules. Microflora are the link between detritus, dissolved organic matter and higher trophic levels (Bunch 1979) and sequester carbon into the deep ocean (Li and Dickie 1996). The abundance of micoflora is limited to the upper layers of the water column and typically decreases with depth; numbers may decrease one order of magnitude from one to 200 metres depth (Bunch 1979). Microflora in high latitudes have been shown to increase approximately one order of magnitude is response to phytoplankton blooms (Bunch 1979: Li and Dickie 1996).

For additional information, refer to Labrador Shelf SEA Section 4.5.3 (Sikumiut 2008).

5.2.1.4 ZOOPLANKTON

Zooplankton provide the link by which organic carbon is transferred from primary producers (phytoplankton) to higher level organisms (fish, mammals, birds). Zooplankton is a food source for a broad spectrum of marine species. Fecal matter and dead zooplankton are also an important food source for benthic community species. The Labrador Shelf Area (particularly the northern Labrador Sea) is dominated by a relatively few number of species (Huntley *et al.* 1983). The Labrador Sea is hydrographically complex due to the interaction of water masses from both the Arctic and Atlantic Oceans.

Zooplankton reproduction either coincides or immediately follows phytoplankton blooms (Huntley *et al.* 1983; Head *et al.* 2000; Head and Pepin 2008). Thus, zooplankton reproduction would be expected to vary somewhat for the different portions of the Labrador Sea (zooplankton reproduction in the northern and southern Labrador Sea would be expected to occur in or around May with the central Labrador Sea lagging until sometime in June). The central Labrador Sea area has had the highest egg production rates ever observed for *Calanus finmarchicus* for the low ambient temperatures that occur there (Head *et al.* 2000). Work conducted by Huntley *et al.* (1983) within the Davis Strait and northern Labrador Sea indicated that copepods accounted for 88 percent of the zooplankton community, with *Calanus finmarchicus*, *Oithona similis*, *Calanus glacialis* and *Pseudocalanus minutus* accounting for 72 percent of the copepod species. DFO (2007b) found that copepod abundance for the Labrador Sea area were at near record highs and significantly above the long-term average, based on a transect near Seal Island.

For additional information, refer to Labrador Shelf SEA Section 4.5.4 (Sikumiut 2008).

5.2.2 BENTHIC INVERTEBRATES

Benthic invertebrates are organisms without a backbone that live on, in, or in close proximity to the seabed. Benthic invertebrate species composition and abundance can vary spatially based on physical habitat characteristics such as water depth, substrate type, currents and sedimentation. The structure and function of benthic communities can be affected by water mass differences, sediment characteristics and ice scour (Carey 1991). Benthic invertebrates are classified in three categories:

- infaunal species - organisms that live on or buried in soft substrates and include bivalves, polychaetes, amphipods, sipunculids, ophiuroids and some gastropods;
- sessile species - organisms live attached to hard substrates and would include barnacles, tunicates, bryzoans, holothurians and some anemones; and

- epibenthic species - organisms that are active swimmers that remain in close association to the seabed and include mysiids, amphipods and decapods.

Carey (1991) identified five benthic distributional zones in the Arctic.

1. 0 to 2 m (nearshore) is barren, as it is annually depopulated by freezing and ice scour;
2. 2 to 20 m (inshore), strongly influenced by riverine and runoff inputs;
3. 15 to 30 m (transitional), subject to intense scouring by ice keels;
4. 30 to 100 m (Continental Shelf), where the biomass is higher at the shelf edge; and
5. Greater than 100 m (Upper Slopes), where the biomass begins to decrease.

Biomass is often low between 5 to 10 m due to the low salinity and ice scour during summer open water season and the presence of fast ice during winter (Carey 1991), which is a widespread phenomenon in Arctic areas. Biomass also decreases with depth at depths greater than 106 m. Stewart *et al.* (1985) separated the northern Labrador shelves into two major groups, water depth of less than 300 m and water depths greater than 300 m and that the groups of marine benthic organisms were associated with particular water masses and temperature distributions, rather than substrate distributions. Stewart *et al.* (1985) found that polychaetes were the most prevalent in a predominantly sand substrate, accounting for 16 of 45 species, and that five of the species were the most abundant. Benthic polychaete structure in the Labrador Sea is strongly influenced by large-scale topographical features (Gagnon and Haedrich 1991). Other types of substrates had distinct benthic assemblages (Barrie *et al.* 1980; Barrie and Steele 1979), such as bivalves (which appear to be distributed across inner shelves at approximately 5 to 25 m depths according to functional groupings of deposit (generally associated with fine sediments around 25 m) and suspension feeders (Carey 1991)), barnacles and sea urchin. The nearshore zone may have a higher bivalve richness due to ice damping effects, which result in decreased wave action and lowered environmental disturbances (Carey 1991). Traditional knowledge and public consultation identified that mussels, clams, sea urchins, whelks were fished within the Study Area.

For additional information, refer to Labrador Shelf SEA Section 4.6 (Sikumiut 2008).

5.2.3 DEEP SEA CORALS

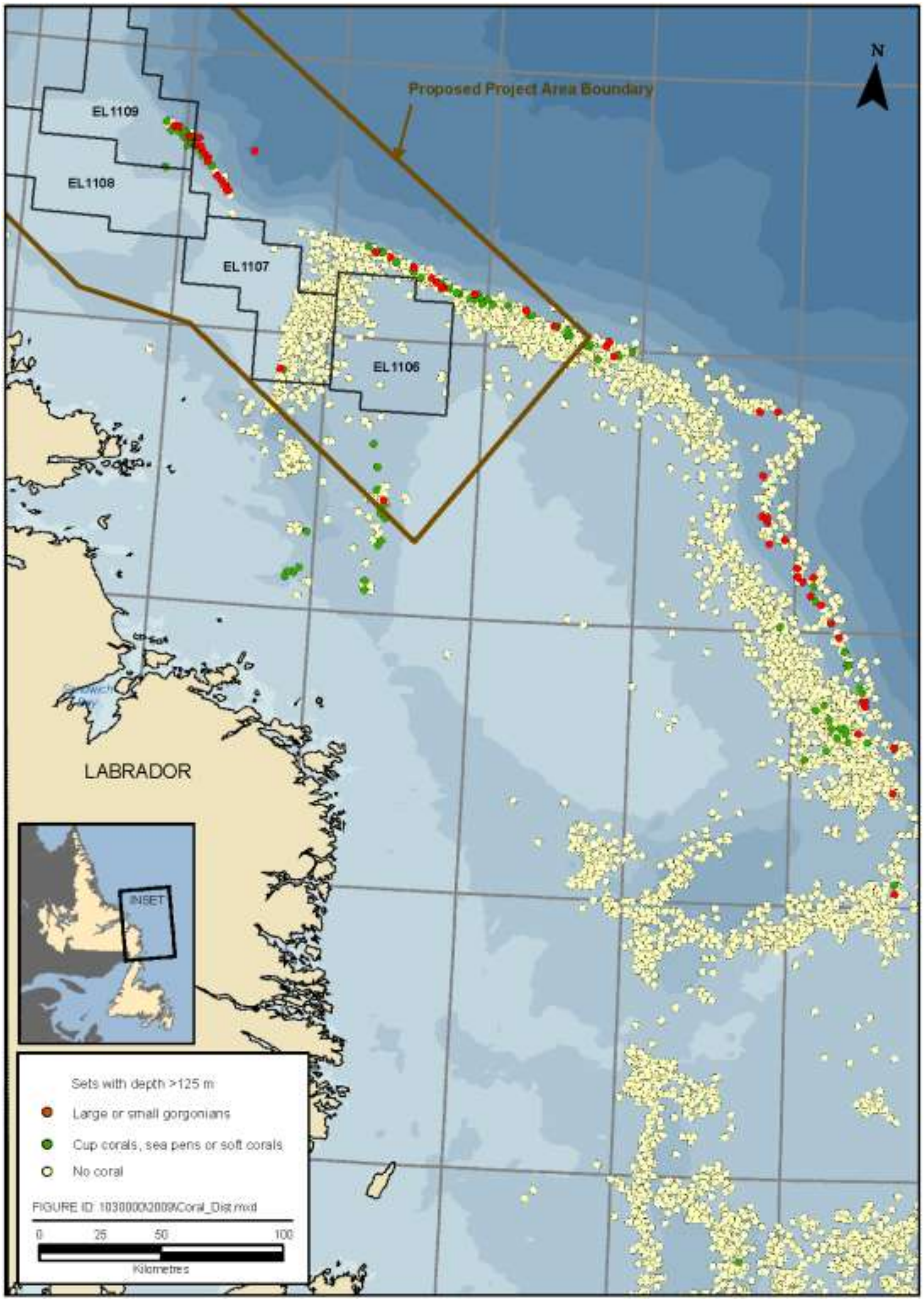
Stony corals (scleractinians), sea anemones (actinarians), soft/leather corals (alcyonaceans), horny corals (gorgonaceans) and sea pens (pennatulaceans) are all included in the generic term “coral” (Gass 2003). Corals are typically found deeper than 200 m in canyons and along the edges of channels along the edge of the Continental Shelf and slope (Breeze *et al.* 1997). Hard (horny and stony) corals are restricted to deep water only; soft corals are distributed in both shallow and deep waters. Congregations of coral in the Study Area are referred to as coral “forests” or “fields” and most grow on hard substrate (Gass 2003). Others prefer sand or mud substrates (Edinger *et al.* 2007). The southeastern region between Makkovic Bank and Belle Isle

Bank has the most dense populations, with a peak occurrence of coral at the mouth of the Hawke Saddle (Edinger *et al.* 2007). Gass (2003), Gilkinson *et al.* (2006) and Edinger *et al.* (2007) identified 23 species of coral within the Newfoundland and Labrador region (Table 5-4). The distribution of various corals (based on observer-collected data) along the southern region of the Labrador coast (Edinger *et al.* 2007; Wareham and Edinger 2007) is shown in Figure 5-6.

For additional information, refer to Labrador Shelf SEA Section 4.7 (Sikumiut 2008).

Table 5-4 Coral Species in the Study Area

Definition	Species Included
Large gorgonians (typically >1 m height) or antipatharian corals (horny corals/hard corals)	*Primosa resedaeformis*
	Paragorgia arborea
	Keratoisis ornata
	Acanthogorgia armata
	Paramuricea spp.
	P. placomus
	P. grandis
	Bathypathes arctica
Small gorgonian (horny corals/hard corals) corals (typically <1 m height)	*Acanella arbuscula*
	Radicipesgracilis
	Anthothela grandiflora
Cup corals (hard corals)	*Flabellum alabastrum*
	Vaughanella margaritata
	Desmophyllum dianthus
	Desmosmilia lymani
Sea pens; various pennatulaceans (soft corals)	*Distichophyllum gracile*
	Funiculina qradrangularis
	Halipteris finmarchia
	Pennatula spp.
	P. grandis
	Umbellula lindahli
	5 Unidentified species
Soft corals	*Gersemia rubiformis*
	Anthomastus grandiflorus
Source: Eddinger *et al.* 2007, in Labrador Shelf SEA Section 4.7 (Sikumiut 2008).	



Source: Edinger *et al.* 2007, in Labrador Shelf SEA Section 4.7 (Sikumiut 2008).

Figure 5-6 Coral Distribution in Project Area

5.2.4 SHELLFISH

5.2.4.1 ICELAND SCALLOP

Iceland scallop (*Chlamys islandica*) are widely distributed throughout the subarctic. The spawning season for Iceland scallops is short and varies geographically, but mainly occurs from April to August, (Wallace 1981; Crawford 1992). The sexes are separate and are distinguishable by gonad coloration. After fertilization, larvae remain in the water column for approximately five weeks. The juveniles then settle to the seafloor and attach to the seabed in proximity to the adults (DFO 2007d). Iceland scallop are suspension feeders and tend to be most abundant in areas with substantial water movements (Naidu 1997). Adults are sedentary and occur in aggregations (beds) on good substrate for attachment where currents retain larvae (DFO 2007d). Commercial-sized beds occur on hard substrates consisting of sand, gravel, shells and stones usually at depths of 50 to 180 m (DFO 2006d). There is little scientific information on the scallop resources in Labrador (DFO 2000a).

For additional information, refer to Labrador Shelf SEA Section 4.8.1 (Sikumiut 2008).

5.2.4.2 SNOW CRAB

Snow crab (*Chionoecetes opilio*) occur from Greenland to the Gulf of Maine over a broad range of depths. Females lay between 20,000 to 150,000 eggs and carry the eggs on hairy appendages under the abdomen for approximately two years. The eggs remain in the water column from two to eight months before settling to the seabed (DFO 2002b; Fisheries Resources Conservation Council (FRCC)) 2005). Once on the bottom, snow crabs go through a series of moults as the crab increases in size. Males achieve legal size (95 mm carapace width) in 5 to 10 years. Females cease moulting upon achieving sexual maturity, between 40 to 95 mm carapace widths. Snow crab live for approximately 15 years (FRCC 2005). Commercial-size crabs commonly occur at depths of 70 to 280 m (Elner 1985) on mud or sand substrates (DFO 2005b) at temperatures of -1°C to 5°C (FRCC 2005). Smaller crabs are also found on harder substrates (DFO 2002b). Snow crab feed on fish, clams, benthic worms, brittle stars, shrimps and crustaceans, including smaller snow crabs. Feeding activity is apparently higher at night. Predators include various groundfish and seals (DFO 2002b).

For additional information, refer to Labrador Shelf SEA Section 4.8.2 (Sikumiut 2008).

5.2.4.3 NORTHERN SHRIMP

Northern or pink shrimp (*Pandalus borealis*) occur from the Davis Strait in the north to the Gulf of Maine in the south. Northern shrimp are a protandric hermaphrodite, meaning that it first functions sexually as a male, undergoes a brief transitional period, and spends the rest of its life as a female (DFO 2006e). On average, females typically produce 2400 eggs (Haynes and Wigley 1969). Eggs are laid in summer and remain attached to the female until the following spring, when the female migrates to shallow coastal waters to spawn (Nicolajsen 1994, in Ollerhead *et al.* 2004). The hatched larvae float to the surface feeding on planktonic organisms (DFO 2006e). Adults typically prefer temperatures of 1°C to 8°C, soft muddy substrates and depths up to 600 m. Shrimp undergo a diel vertical migration, moving off the bottom into the water column during the day to feed on small pelagic crustaceans. As with most crustacea, northern shrimp grow by moulting their shells. Predators of Northern shrimp include Greenland halibut (turbot), cod (DFO 2006e), Atlantic halibut, skates, wolffish and harp seals (*Phoca groventandica*) (DFO 2000b).

For additional information, refer to Labrador Shelf SEA Section 4.8.3 (Sikumiut 2008).

5.2.4.4 WHELK

Whelk (*Buccinum undatum*) are gastropod molluscs that range from the Arctic to New Jersey. They occur on a wide range of substrates but are most common on mud and sand (Newfoundland and Labrador Department of Fisheries and Aquaculture (NLDFA) 2006). Young are common in tide pools and shallow water. Adults commonly grow to approximately 6.4 cm in length and can inhabit depths to 200 m (Gosner 1978). Whelks are carnivorous and feed on polychaetes, bivalves and urchins. They are also opportunistic scavengers as evidenced by their ability to detect and locate dead animals on the seabed. They have been frequently observed approaching seastars feeding on bivalves, preying on the remains left by the seastars (Himmelman and Hamel 1993).

For additional information, refer to Labrador Shelf SEA Section 4.8.18 (Sikumiut 2008).

5.2.4.5 TOAD CRAB

Toad crab (spider crab) is comprised of two species, *Hyas araneus* and *H. coarctatus*. Toad crab are widespread on both sides of the north Atlantic and occur in Newfoundland and Labrador from low water to approximately 1,650 m. They are very common at intermediate depths, overlapping rock crab and snow crab zones. Toad crab is common on all types of substrate, with *H. araneus* preferring soft bottom while *H. coarctatus* is more common on hard bottom (Squires 1990). Toad crab have a maximum carapace width of approximately 100 mm and a maximum weight of approximately 0.7 kg.

For additional information, refer to Labrador Shelf SEA Section 4.8.19 (Sikumiut 2008).

5.2.4.6 PORCUPINE CRAB

The porcupine crab (*Neolithodes grimaldii*) ranges from North Carolina to Greenland and often occurs in association with the continental slope at depths between 800 to 2000 meters (Squires 1965). The porcupine crab is a large red crab that is covered in large, sharp spines. Males can have a carapace length of 180 mm and weigh as much as 2.28 kg. Females are generally smaller but carapace lengths of up to 160 mm have been recorded. The right claw is larger and is used for crushing while the left is reduced in size and is used for food handling. It is believed that the porcupine crab is carnivorous, feeding on snails and mussels (Squires 1965).

For additional information, refer to Labrador Shelf SEA Section 4.8.20 (Sikumiut 2008).

5.2.5 FINFISH

5.2.5.1 REDFISH

Redfish (*Sebastes* spp.) or ocean perch are benthic fish that occur along the slopes of banks and in deep channels at depths of 100 to 700 m. Redfish prefer temperatures of 3°C to 8°C and areas with rocky or clay-silt substrates. Female redfish typically produce up to 40,000 eggs and mature between 10 to 12 years of age (DFO 2006f). Mating likely occurs during the late fall and early winter and females carry developing embryos until spring (St. Pierre and de Lafontaine 1995; Gascon 2003; Morin *et al.* 2004). Redfish are ovoviviparous, which means eggs are fertilized internally and they give birth to live young (Scott and Scott 1988; Gascon 2003). Larvae remain in shallow waters until they are approximately 25 mm, after which they move to deep waters over mud and rock substrates.

The three species of redfish are found in the Northwest Atlantic (*Sebastes fasciatus*, *S. marinus* and *S. mentella*) are nearly impossible to distinguish by appearance and as such, are managed as a single fishery (Power and Mowbray 2000; Gascon 2003). Both *S. mantella* and *S. fasciatus* may be found in subdivision 2J; however, *S. mentella* is found exclusively in subdivision 2GH. Redfish are a slow growing and long-lived species, with specimens having been aged at least to 75 years (Campana *et al.* 1990). S. fasciatus grows slower than *S. mentella*, with females of the species growing faster than males. Growth is usually faster in southern areas as compared to northern areas (Branton *et al.* 2003).

Populations of redfish are allopatric (separated geographically) for *S. mentella* and *S. fasciatus*. *S. mentella* is the northern range species off Labrador and Greenland. *S. fasciatus* is the southern range species on the Scotian shelf and the Gulf of Maine (Scott and Scott 1988; Gascon 2003). The ranges for *S. mentella* and *S. fasciatus* overlap in the Laurentian Channel and the Grand Banks (Gascon 2003).

Redfish are pelagic or bathypelagic feeders, rising off the bottom and feeding on pelagic organisms in the water column, mainly at night (Scott and Scott 1988). Prey items include copepods, amphipods and euphausiids with fish and crustaceans becoming more important as the fish increases in size. Redfish larvae feed almost exclusively on calanoid copepods (Runge and de Lafontaine 1996). Variability in the annual production cycle of these copepods can be an important factor in interannual differences in growth and survival of redfish larvae (Anderson 1994).

For additional information, refer to Labrador Shelf SEA Section 4.8.4 (Sikumiut 2008).

5.2.5.2 GREENLAND HALIBUT

Greenland halibut (*Reinhardtius hippoglossoides*), commonly known as turbot, is a deep-water flatfish with a range that extends from Greenland to the Scotian Shelf. Greenland halibut occur over a wide range of depths (90 to 1,600 m), with larger individuals occurring in deeper waters. Its preferred temperature is 0°C to 4.5°C (FAO 2007b). A great deal of variability exists in the maturation and spawning of Greenland halibut both temporally and geographically. This variability appears to be a feature common to all areas within its range, with large immature fish and fish skipping spawning seasons being a regular occurrence. The spawning grounds of Greenland halibut are believed to be located southwest of Iceland and extend to south of the Flemish Pass off Newfoundland (Junquera and Zamarro 1994). Greenland halibut eggs are benthic, but upon hatching, the young move up into the water column and remain at depths near 30 m until they are approximately 70 mm in length. As they grow, young halibut move down the water column and are transported by the currents (Scott and Scott 1988). While maturing, Greenland halibut are thought to move to deep water and migrate north to the spawning area, suggesting a continuous stock throughout the range (Bowering 1982). Greenland halibut in the Northwest Atlantic are thought to be a relatively homogenous genetic stock; however, there is some evidence that genetic mixing does occur.

For additional information, refer to Labrador Shelf SEA Section 4.8.6 (Sikumiut 2008).

5.2.5.3 ATLANTIC SALMON

Atlantic salmon (*Salmo salar*) are anadromous fish, living in freshwater rivers for the first two years of life before migrating to sea. Most Atlantic salmon return annually to their natal river or tributary for spawning. Unlike Pacific salmon, which die after spawning, Atlantic salmon can spawn in successive years. Juvenile Atlantic salmon or smolt migrate to the ocean in spring and travel north to waters off Labrador to overwinter. In the ocean, Atlantic salmon occupy the upper portion of the water column (Reddin 2006). Tagging studies of post-smolts also showed them spending most of their time near the surface, but undergo deep dives, likely in search of prey (Reddin *et al.* 2006). While still in the river, smolts mainly eat aquatic insect larvae, including caddisflies and blackflies. Adults at sea consume euphausiids, amphipods and fish such as herring, capelin, small mackerel, sand lance and small cod. Predators of Atlantic salmon include seals, sharks, pollock and tuna (Scott and Scott 1988).

For additional information, refer to Labrador Shelf SEA Section 4.8.7 (Sikumiut 2008).

5.2.5.4 ARCTIC CHAR

Arctic char (*Salvelinus alpinus*) have a circumpolar distribution in the northern hemisphere. Char are either anadromous or resident fish, with anadromous populations being more common in northerly regions and resident fish being more common further south (DFO 2001). Seaward migration of first time and repeat migrants commences with spring runoff and ice break-up in coastal rivers (DFO 2001). Both juveniles and adults spend only one to four months at sea before returning to fresh water (DFO 2001). The return migrations occur from July to September, with large mature char returning first followed by non-mature adults then juveniles. Spawning takes place in the fall (usually commencing by mid-October) and occurs in either lakes or streams. In Labrador, females begin to mature at approximately six years, with most spawning at least once by the age of nine. Females lay approximately 290 eggs per 100 g of body mass (DFO 2001). Arctic char are opportunistic predators while at sea, with a diet consisting mainly of sand lance, capelin, sculpins and hyperiid amphipods (DFO 2001).

For additional information, refer to Labrador Shelf SEA Section 4.8.8 (Sikumiut 2008).

5.2.5.5 SAND LANCE

Sand lance are found in the North Atlantic from Greenland to the Gulf of St. Lawrence usually at depths of less than 91 m. They are found in association with sandy substrate where they can often be found partially buried in the sand. The species of sand lance present in the Study Area is the northern sand lance (*Ammodytes dubius*); however, there is speculation about whether the American sand lance (*A. americanus*) also occurs there. Sand lance typically spawn in shallow water in winter (DFO 2004a). The species is not commercially fished, but is an important part of the marine food-web as it is a food source for marine mammals and several species of fish, including cod.

For additional information, refer to Labrador Shelf SEA Section 4.8.9 (Sikumiut 2008).

5.2.5.6 CAPELIN

Capelin (*Mallotus villosus*) is a small pelagic species that has a circumpolar distribution in the Northern Hemisphere and is especially abundant along the coasts of Newfoundland and Labrador and on the Grand Bank (DFO 2006g). Capelin spawn on sandy or fine gravel beaches or in deeper waters (DFO 2006g). Beach spawning is more prevalent at night at temperatures of 2°C to 10°C, but deepwater spawning most likely occurs from 2°C to 5°C (Rose 2005). Capelin typically spawn in late June and early July, although it was somewhat later in the 1990s (Carscadden *et al.* 1997, 2001). Male capelin die after spawning. Eggs are small (1-mm diameter) and are attached to the substrate. Incubation varies with ambient temperature and lasts approximately 15 days at 10°C. Larval capelin remain near the surface until the onset of winter. Capelin have been observed to freeze to death off Labrador, presumably when they contact ice crystals in super-cooled water (Rose 2005).

Capelin is a major component of marine ecosystem dynamics as they facilitate the transfer of energy between trophic levels, principally between primary and secondary producers to higher trophic levels (DFO 2006g). Capelin are an important food source for most major fish species including Atlantic cod, haddock, herring, flatfish species, dogfish and others. Several marine mammal species, including minke whales (*Balaenoptera acutorostrata*), fin whales, harp and ringed seals (*Phoca hispida*) as well as a variety of seabirds also prey on capelin. During the early 1990s, capelin exhibited large-scale changes in distribution, size and maturity at age, and time and duration of spawning that have been linked to colder ocean temperatures (Carscadden *et al.* 2002). Changes in capelin distribution may be expected to have a direct impact on the many species that feed on them, thus management of capelin fisheries tends to be conservative because of the prominent role of capelin in the marine ecosystem.

For additional information, refer to Labrador Shelf SEA Section 4.8.10 (Sikumiut 2008).

5.2.5.7 HERRING

Herring (*Clupea harengus*) are a pelagic, schooling fish, which occurs in shallow inshore waters and offshore waters from the surface to depths of 200 m. Most herring stocks spawn in spring or fall, but some variation exists between stocks (Scott and Scott 1988), with spring spawning usually occurring in shallower water than fall spawning (LGL

Limited 2005b). Eggs are deposited on stable substrates and on hatching the larvae remain in the upper layers of the water column. The length of time it takes for larvae to metamorphose into juvenile herring is dependent on water temperature and the food availability (MI 2007a). The larval stage of fall-spawned herring is much longer than spring spawned herring, lasting through the winter months (Scott and Scott 1988).

For additional information, refer to Labrador Shelf SEA Section 4.8.11 (Sikumiut 2008).

5.2.5.8 ARCTIC COD

Arctic cod (*Boreogadus saida*) are circumpolar in distribution (DFO 2006h). They are common along the Labrador coast, eastern Newfoundland coast, and the northern and eastern Grand Banks. Temperatures of 0°C to 4°C are believed to be optimal for the survival of Arctic cod. Arctic cod are often found in association with ice floes and at depths of greater than 900 m. In northern Canadian waters, spawning is thought to occur in late autumn and winter (DFO 2006h). Both male and female Arctic cod are mature when about 20 cm long and three years of age. Arctic cod produce 9,000 to 21,000 eggs (DFO 2006h). Spawning occurs under the Arctic ice cover and fertilization is external. Arctic cod are large consumers of plankton, mainly copepods, euphausiids. Large Arctic cod are known to be cannibalistic, feeding on smaller members of their own kind (DFO 2006h). The abundance of Arctic cod in the Canadian Arctic is unknown.

For additional information, refer to Labrador Shelf SEA Section 4.8.12 (Sikumiut 2008).

5.2.5.9 ROCK COD

Rock cod (*Gadus ogac*) (Greenland cod) is an Arctic to subarctic species whose distributions includes the Study Area; they are found inshore at depths ranging from 0 to 200 m depth (FAO 2007c; Nielsen and Andersen 2001) and are tolerant of low salinities (although there is no evidence that rock cod enter freshwater) (FAO 2007c). Rock cod mature at approximately three to four years of age and spawning occurs from February to May in shallow waters; eggs sink to the substrate after fertilization. Juveniles rock cod associate with eelgrass and other complex habitats (Laurel *et al.* 2004). Rock cod seldom live beyond nine years and rarely exceed 60 cm total length rarely (50 cm is the normal length of five- to six-year-old fish) (FAO 2007c). Crustacea, polychaeta, mollusca and echinodermata are important for juvenile and small rock cod and become less important as the fish grows; adult rock cod feed mainly of capelin (Neilsen and Andersen 2001).

For additional information, refer to Labrador Shelf SEA Section 4.8.13 (Sikumiut 2008).

5.2.5.10 WITCH FLOUNDER

Witch flounder (*Glyptocephalus cynoglossus*) or greysole is a deep water flatfish which occurs from Hamilton Inlet (the species northern limit) to Cape Hatteras. Spawning occurs in late spring to late summer and is rather extensive throughout the Northwest Atlantic (DFO 2006i). The spawning period is less extensive in the north areas than in the south and usually takes place in deep waters, where temperature conditions are relatively high. Witch flounder larvae are pelagic and they may remain in the water column from four months to one year (DFO 2006i). Larvae drift southward in Labrador Current over great distances to settle in areas where temperatures are suitable for survival. Witch flounder prefer living in gullies at depths of 45 to 275 m and water temperatures of 2°C to 6°C. The preferred substrate is clay, sand or mud. They usually move up onto the soft mud in summer and down into the deeper gullies in winter. Witch flounder are slow-growing, with a long life span (they have been aged over 20 years old) (Maddock-Parsons 2005a, 2005b). Prey items include marine worms as well as small crustaceans or shellfish similar in shape to shrimp and occasionally small fish (DFO 2006i).

For additional information, refer to Labrador Shelf SEA Section 4.8.14 (Sikumiut 2008).

5.2.5.11 LUMPFISH

Lumpfish (*Cyclopterus lumpus*) range from Greenland to Chesapeake Bay. Lumpfish migrate to the coast for spawning, which takes place in May and June (DFO 2006j). The male lumpfish (which is considerably smaller than the female) arrive on the spawning grounds several weeks in advance of the females to establish their territories. The females lay as many as 130,000 eggs in one to three egg masses over an 8- to 14-day period. Once deposited, the males guard and fan the egg masses (females migrate back to deeper water) (DFO 2002c; 2006j). Juveniles remain in the top 1 m of the water column for their first year, often associated with floating algae. Lumpfish are benthic, living on rocky substrates between 50 and 150 m (and occasionally deeper). Lumpfish adhere to the bottom or other solid objects with the aid of a sucking disc. Lumpfish primarily eat small shrimp and crustaceans, jelly fish, small fish and worms (MI 2007b).

For additional information, refer to Labrador Shelf SEA Section 4.8.17 (Sikumiut 2008).

5.2.6 SKATE

5.2.6.1 THORNY SKATE

The range of the Thorny skate (*Raja radiate*) extends from Greenland to South Carolina. They are predominantly found from 50 to 150 m, but can occur from near shore to 1,700 m (Kulka *et al.* 2006). They are primarily associated with mud, sand and pebble substrates (Kulka and Miri 2003). There is not a lot of information on most aspects of thorny skate population dynamics. Female thorny skate deposit 6 to 40 egg cases per year and mature at a larger size than males, with size at maturity increasing from north to south. Prey items of thorny skate include polychaetes, crabs, whelks, sculpins, redfish, sand lance and small haddock. Thorny skate are likely opportunistic bottom feeders, given that considerable amounts of fish offal have occasionally been found in their stomachs. Little is known about what preys on thorny skate.

For additional information, refer to Labrador Shelf SEA Section 4.8.15.1 (Sikumiut 2008).

5.2.6.2 SMOOTH SKATE

Smooth skate (*Malacoraja senta*) range from the Gulf of St. Lawrence and Labrador Shelf to South Carolina (Packer *et al.* 2003). Little is known about the life history of the smooth skate. They are most common at depths greater than 110 m, but have been found at depths up to 450 m (Swain and Benoit 2001), on soft mud and clay (Scott and Scott 1988). Smooth skate eat amphipods, mysiids, decopods, euphausiids and other fish, including yellowtail flounder (*Limanda ferruginea*), hake, witch flounder and sand lance (Packer *et al.* 2003).

For additional information, refer to Labrador Shelf SEA Section 4.8.15.2 (Sikumiut 2008).

5.2.7 SHARKS

5.2.7.1 SPINY DOGFISH

The spiny dogfish (*Squalus acanthias*) ranges from Labrador to Florida, but are most abundant between the southern Scotian Shelf and Cape Hatteras. Spiny dogfish prefer depths of 10 to 200 m and temperatures between 7°C to 15°C. Surveys indicate an absence of young juveniles and a high variability in abundance in Newfoundland and Labrador waters, indicating that pupping and juveniles occur elsewhere and that the Newfoundland and Labrador population is not an independent stock. The spiny dogfish feeds opportunistically on capelin, cod, haddock, hake herring and invertebrates (from krill to squid and octopus) (Campana 2007b). Spiny dogfish are included in the diet of larger sharks and marine mammals (Grimm *et al.* 2004).

For additional information, refer to Labrador Shelf SEA Section 4.8.16.1 (Sikumiut 2008).

5.2.7.2 BLACK DOGFISH

Black dogfish (*Centroscyllium fabricii*) range from Greenland to Cape Hatteras and possibly into the Gulf of Mexico (Kulka 2006). They prefer depths greater than 500 m (although they do occur up to 300 m); this makes relative abundance estimates problematic. Black dogfish distribution is highly structured based on life stage. Pupping is known to occur in the shallow waters of the Laurentian Channel. As the young mature, they migrate to deeper waters of the channel and larger fish may migrate considerable distances to the Labrador Shelf, continuing to move into deeper waters as they grow. Black dogfish are primarily by-catch in various Greenland fisheries.

For additional information, refer to Labrador Shelf SEA Section 4.8.16.2 (Sikumiut 2008).

5.3 MARINE MAMMALS AND SEA TURTLES

Cetaceans are common in the Study Area, especially in the summer months, when whales, porpoises and dolphins migrate north through the area. Twenty-three marine mammal and turtle species are known to occur within the Study Area (Sikumiut 2008). Three species are listed on Schedule 1 of the *SARA* (blue whales, fin whales, and leatherback sea turtles) and these are reviewed and assessed in the sections on Species at Risk (Sections 5.1.1.2 and 7.1.5.2). Eight additional species are designated at risk by COSEWIC (beluga whale, humpback whale, Sowerby's beaked whale, bowhead whale, killer whale, harbour porpoise, Atlantic walrus, and polar bear) and are reviewed and assessed in Sections 5.1.2.2 and 7.1.5.2. The final 12 species known to occur in the study area, and not designated as Endangered, Threatened or Special Concern by either COSEWIC or listed in *SARA*, are discussed below.

Some animals are more likely than others to be present in the Study Area. Because there are more data available for some species than others, a generalized summary of species likely to be present in the Study Area is provided in Table 5-5. A rating of abundant signifies a relatively large amount of data and/or recorded sightings. A rating of occasional signifies some data are known and/or the animals have been recorded on occasion in the study area. A rating of rare signifies very little is known about the animal and/or it has rarely been recorded.

Table 5-5 General Abundance of Each Species within the Study Area

Species	Rare	Occasional	Abundant
Humpback Whale			×
Minke Whale		×	
Blue Whale	×		
Fin Whale		×	
Bowhead Whale	×		
Sei Whale		×	
Beluga Whale	×		
Long-finned Pilot Whale	×		
Sowerby's Beaked Whale	×		
Killer Whale	×		
Atlantic White-sided Dolphin	×		
Harbour Porpoise			×
Harp Seal		×	
Harbour Seal			×
Grey Seal		×	
Hooded Seal	×		
Ringed Seal		×	
Bearded Seal	×		
Walrus	×		
Atlantic Loggerhead Turtle			
Kemp's Ridley Turtle	×		
Leatherback Turtle	×		
Polar Bear	×		

5.3.1 WHALES

Minke Whale

Minke whales (*Balaenoptera acutorostrata*) occur worldwide and are the most common of the baleen whales. Minkes arrive in the inshore waters of Newfoundland and Labrador in April. Most stay only for the summer and fall as late as October or November; however, some individuals remain into the winter. Minke whales are common in shallow water, less than 200 m deep, but may also occur offshore in deeper waters. They are often solitary in the western North Atlantic, but may occur in groups of two or three. Although the population is considered abundant and numbers in the thousands along the North American coast, there are currently no overall estimates of the minke whale population in the western North Atlantic (Labrador Shelf SEA Section 4.9.1.2 (Sikumiut 2008)).

Humpback Whale

Humpback whales (*Megaptera novaeanglise*) (are found in tropical, temperate and sub-polar waters throughout the world (COSEWIC 2003c) and are common in most coastal waters. Humpback whales undergo seasonal migrations from high-latitude feeding areas, including east coast Canadian waters, in the summer, to low-latitude breeding and calving grounds in the winter (COSEWIC 2003c). In the western North Atlantic, humpback whales feed during spring, summer and fall (Katona and Beard 1990). Not all whales migrate south for the winter as significant numbers of whales are seen in mid- and high-latitude areas during that time (Clapham *et al.* 1993). It has been suggested that these areas are becoming increasingly important habitat for juvenile humpback whales (Wiley *et al.* 1995).

The most recent (1992/1993) population estimate of North Atlantic humpback whales is over 11,570 individuals (Stevick *et al.* 2001). A comprehensive data set of spatial and temporal distributional information on humpback whales in the western North Atlantic was initiated in 1992 (Allen *et al.* 1993) and is successively added to each year.

Potential threats to humpback whales include reductions in prey base, incidental fisheries mortalities, vessel collisions and disturbance or injury associated with vessel traffic and/or high-intensity underwater sounds (COSEWIC 2003c). Although the western North Atlantic population of humpback whales was down-designated to Not at Risk by COSEWIC in 2003, it is currently still listed as a species of Special Concern on Schedule 3 of the *SARA*.

For additional information, refer to Labrador Shelf SEA Section 4.9.1.1 (Sikumiut 2008).

Sei Whale

Sei whales (*Balaenoptera borealis*) are located in all oceans and make seasonal migrations from low latitude wintering areas to high-latitude summer feeding areas (COSEWIC 2003d). Wintering ground locations are unknown and summer distributions exhibit dramatic year-to-year variation. There are no population estimates for the

Northwest Atlantic sei whales based on recent data. Sei whales are known to use deep pelagic water as habitat and appear to be associated with the Continental Shelf edge in the Northwest Atlantic (COSEWIC 2003d) (Labrador Shelf SEA Section 4.9.1.3 (Sikumiut 2008)).

Long-finned Pilot Whale

Long-finned pilot whales (*Globicephala macrorhynchus*) are commonly seen in small pods of approximately 10 to 20 individuals. Long-finned pilot whales have been sighted in the offshore waters of Labrador from May to July (Abend and Smith 1999) and are common off the southwest coast of Newfoundland during the summer (Kingsley and Reeves 1998). They are frequently observed along shelf breaks, offshore, but may occur coastally as well. They commonly come close to shore, especially if squid are abundant in the area. The long-finned pilot whale has not been assessed by COSEWIC and is not listed under *SARA* (Labrador Shelf SEA Section 4.9.2.1 (Sikumiut 2008)).

Atlantic White-sided Dolphin

Atlantic white-sided dolphins (*Lagenorhynchus acutus*) number in the hundreds of thousands in the North Atlantic (Reeves *et al.* 1999). Distinct sub-populations of Atlantic white-sided dolphins may occur in the Gulf of Maine, Gulf of St. Lawrence and Labrador Sea (Palka *et al.* 1997). They are often seen in groups of 50 to 60 individuals and groups of several hundred may occur. Their primary food is squid and herring. The Atlantic white-sided dolphin has not been assessed by COSEWIC and is not listed under *SARA* (Labrador Shelf Study Section 4.9.2.2 (Sikumiut 2008)).

5.3.2 SEALS

Harp Seal

The harp seal (*Phoca groenlandica*) population in the Northwest Atlantic was estimated to be approximately 5.9 million and has been stable since 1996 (DFO 2005c). The harp seal summers in the Canadian Arctic and Greenland (DFO 2005c). In the fall most of the seals migrate southward either to the Gulf of St. Lawrence or to the area off southern Labrador and northern Newfoundland where they give birth in late February or March (DFO 2000c; DFO 2005c). A substantial proportion of the harp seals pupping in Newfoundland and Labrador would be located in the southern portion of the Study Area. Pups are nursed for approximately 12 to 14 days on the ice and then disperse to areas throughout the northern-most Gulf of St. Lawrence, northeastern Newfoundland and southern Labrador. Some individuals may remain in southern waters throughout the summer; however, the majority of the population migrates north to summer feeding grounds in Hudson Bay, Baffin Island and north western Greenland (DFO 2000c). Harp seals are common in the Study Area.

For additional information, refer to Labrador Shelf SEA Section 4.9.3.2 (Sikumiut 2008).

Harbour Seal

Harbour seals (*Phoca vitulina*) are year-round residents along the coast of Newfoundland and Labrador (including the Study Area) (Baird 2001). Harbour seals are common in nearshore shallow waters near river mouths or at particular haul-out sites. The eastern Canadian population of harbour seals was estimated at 30,000 to 40,000 individuals in 1993 (Burns 2002). A COSEWIC review in 1999 indicates that available data are insufficient to determine the status of the population; however, the east coast population appears to be increasing (Baird 2001). Potentially limiting factors from anthropogenic sources include oil spills, accumulation of persistent toxins, and disturbance by coastal development, vessel traffic, or acoustic harassment (Baird 2001).

For additional information, refer to Labrador Shelf SEA Section 4.9.3.1 (Sikumiut 2008).

Grey Seal

The Northwest Atlantic stock of grey seals (*Halichoerus grypus*) occurs in the Gulf of St. Lawrence, off Nova Scotia, Newfoundland and Labrador. The largest pupping colony occurs on Sable Island, with a range of 208,000 to 223,000 individuals (Trzcinski *et al.* 2005); the Gulf of St. Lawrence population (which pups on the ice in the southern Gulf of St. Lawrence) is estimated at 52,500 (Hammill 2005). The Sable Island population will move north during July to September, returning to Sable Island in October to December (Stobo and Zwaneburg 1990).

Grey seals may be born from September to March, but peak pupping occurs in January (Hall 2002). Pups are weaned in approximately three weeks and disperse throughout the Gulf, the Scotian Shelf, and along southern Newfoundland. Although the population is centered in the Gulf of St. Lawrence, grey seals are present along the Labrador Shelf (the SEA Area) in the summer and fall.

For additional information, refer to Labrador Shelf SEA Section 4.9.3.5 (Sikumiut 2008).

Hooded Seal

The majority of the hooded seal (*Cystophora cristata*) population in the Atlantic give birth in the area off southern Labrador and northern Newfoundland in mid-to late March. In most years, a substantial proportion of the hooded seals pupping in Newfoundland and Labrador do so in the southern region of the SEA Area. This is followed by dispersal and migration to summer moulting grounds in the waters off Greenland. Hooded seals are widely distributed throughout the western North Atlantic in the winter and spring (Stenson and Sjare 1996; Kovacs 2002); however, some individuals may remain in Atlantic waters year round.

Population estimates of 535,800 individuals were produced based on models developed for harp and grey seals, which have similar biological characteristics (Hammill and Stenson 2006).

For additional information, refer to Labrador Shelf SEA Section 4.9.3.3 (Sikumiut 2008).

Ringed Seal

Ringed seals (*Phoca hispida*) have a circumpolar distribution, and occur in all seas of the Arctic Ocean (King 1983), including the Study Area. Ringed seals prefer annual landfast ice with good snow cover in fjords and bays with complex coastlines (McLaren 1958), but they also range widely in offshore pack ice (e.g., Finley *et al.* 1983). Adult ringed seals tend to winter under stable nearshore ice, whereas subadults are often found at the edges of the landfast ice (McLaren 1958). In winter, ringed seals spend most of their time in the water or in subnivean lairs on the stable ice. The movement of ringed seals can be highly variable. Individual movement was significantly greater during the open-water season than during winter and spring (Teilmann *et al.* 1999).

There is little information on trends in abundance for most areas, due to the difficulties in deriving estimates of abundance and most counts are considered underestimates (Reeves 1998). A rough estimate of the abundance of ringed seals in Area 1 (which includes the Study Area) is approximately 1.3 million seals.

For additional information, refer to Labrador Shelf SEA Section 4.9.3.6 (Sikumiut 2008).

Bearded Seal

Bearded seals (*Erignathus barbatus*) are associated with sea ice and have a circumpolar distribution (Burns 1981). They range as far south as the Gulf of St. Lawrence in the western Atlantic; however there are no current population data available. Among the largest of the northern seals, the bearded seal makes its home on moving inshore ice, in shallow coastal waters where the seabed is rich in food. During the open-water period, bearded seals occur mainly in relatively shallow areas less than 130 m, because they are predominantly benthic feeders (Burns 1981). Although the seasonal movements of bearded seals may be related to the advance and retreat of sea ice and to water depth, there are some seals that remain in coastal water during the summer instead of following the receding ice (Kelly 1988).

For additional information, refer to Labrador Shelf SEA Section 4.9.3.4 (Sikumiut 2008).

5.3.3 POLAR BEAR

Polar bears are designated as Special Concern by COSEWIC and are presented in Section 5.1.2.2.

5.3.4 SEA TURTLES

There are three species of sea turtle which may be found in the Study Area, the leatherback, the Atlantic loggerhead, and the Kemp’s ridley. The leatherback sea turtle is listed as Endangered under *SARA* and is therefore reviewed and assessed under the Species at Risk sections (Sections 5.1.1.2 and 7.1.5.2).

Atlantic Loggerhead Sea Turtle

Atlantic loggerhead sea turtles (*Caretta caretta*) are the most common sea turtle in North American waters and the largest hard-shelled sea turtles in the world (Ernst *et al.* 1994). They are found from coastal areas to more than 200 km out to sea. The North American population is declining, and has been estimated to be between 9,000 and 50,000 adults (Ernst *et al.* 1994). Information from fishery bycatch suggests the loggerhead is present in waters on and east of the 200-m isobath off the Grand Banks (captures peak in September), where there is a high concentration of their prey species (Witzell 1999) (Labrador Shelf SEA Section 4.8.16.2 (Sikumiut 2008)).

5.4 SEABIRDS

The Labrador Current heavily influences the avian biodiversity in the marine environment off Labrador. The Labrador coast is used by numerous species of seaducks, shorebirds and seabirds use for breeding (many of the breeding marine species nest on the 4,000+ islands off the coast), overwintering, or as a migratory or moulting stopover. The waters off Labrador are the limits of ranges of several seabird species; Razorbill (*Alca torda*), Common Murre (*Uria aalga*), Leach's Storm Petrel (*Oceanodroma leucorhoa*) and Atlantic Puffin (*Fratercula arctica*) are all at their northern limits, while substantial colonies of Thick-billed Murre and Glaucous Gull are at their southern range limits (Labrador Shelf SEA Section 4.9.9 (Sikumiut 2008)).

5.4.1 SEASONALITY

The Labrador coast is used by millions of seabirds and shorebirds for migration from the Arctic and Greenland. Birds are obtaining breeding condition and are concentrated in high numbers, especially along ice edges in the spring, making this migration period a time of high sensitivity. Although all areas of the shelf are used, the shelf edge and Hawke Channel show notably high densities during the breeding season. Some species will overwinter off Newfoundland and others will migrate to southern climes. The Harlequin Duck breeds in inland Labrador, moults off the Labrador coast, and then winters off Greenland (Russell and Fifield 2001). Other bird species like the Black Guillemot and some of the gull species that use the Labrador coast are resident birds.

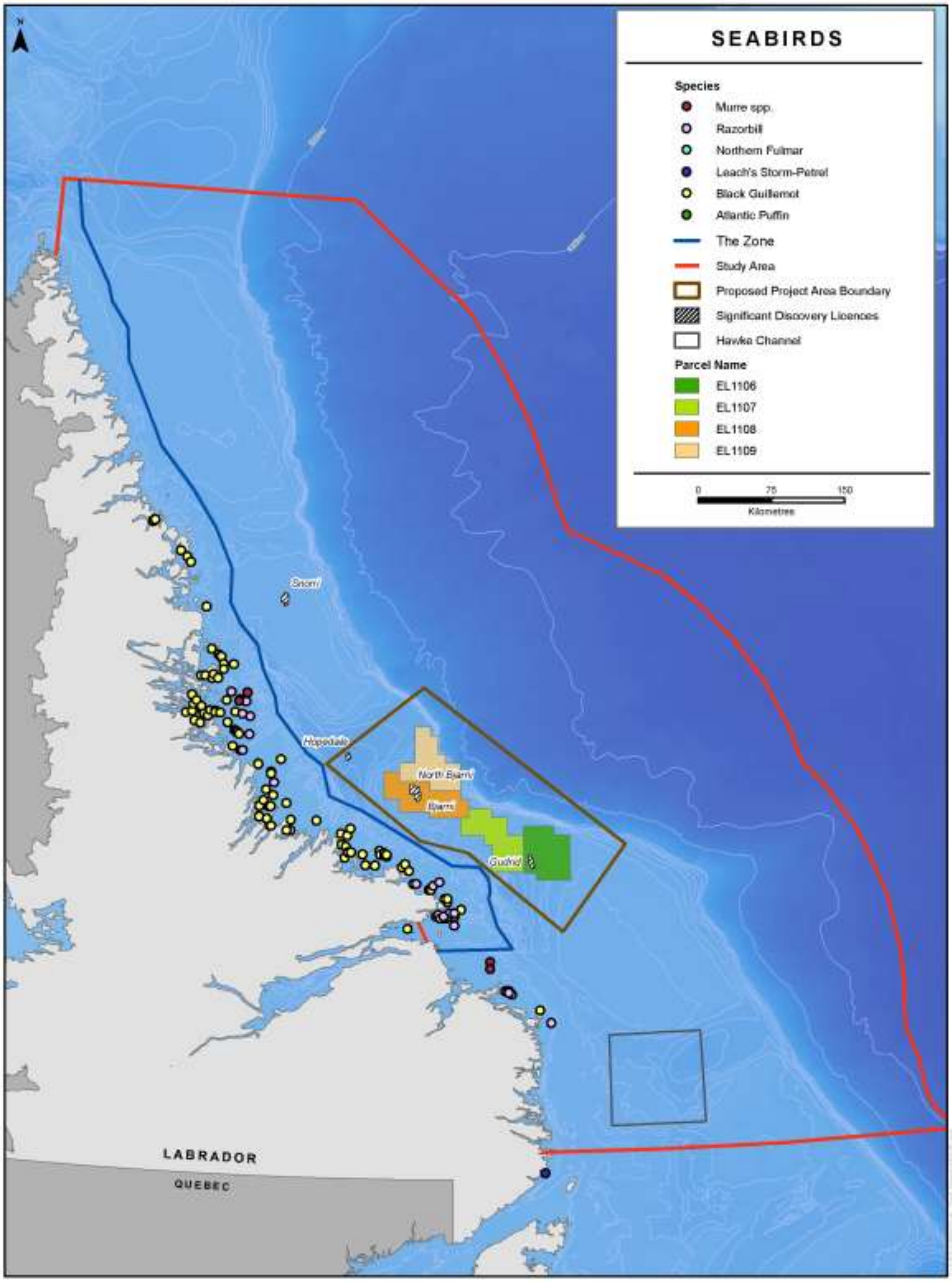
During summer, there are two main seabird communities in Labrador: the surface-feeding omnivorous gulls; and the mostly fish-eating diving auks. Some species use the area for breeding in summer while some use the area during migration, for moultings, or for overwintering during other times of the year. These two seabird communities are linked with a wide variety of physical marine features, primarily those that affect the abundance or availability of prey, such as large-scale regimes that affect temperature and primary production and small-scale features that affect prey dispersion (Balance *et al.* 2001). The primary diet for seabirds in the Study Area includes fishes, crustaceans, cephalopods, copepods and offal (Labrador Shelf SEA Section 4.9.9 (Sikumiut 2008)).

The summary table for species that are known from the Study Area includes all the species that may use the Study Area at any time of year (Table 5-6). Recorded seabird (including alcids, storm-petrels, fulmars and shearwaters) sightings in the Study Area from 1994 to 2005 are illustrated in Figure 5-7. Recorded tern and gull (including kittiwake) sightings in the Study Area from 1994 to 2005 are illustrated in Figure 5-8. The data for this species list (from the Labrador Shelf SEA Report (Sikumiut 2008)) and for the Study Area were provided by the Canadian Wildlife Service (CWS) from three databases: a collection of observations from multiple data sources; species at risk incidental sightings; and the Atlantic Coastal Block database. Other sources of data for this environmental assessment included the Important Bird Areas (IBA) of Canada (2004) online database, the Newfoundland and Labrador Department of Environment and Conservation (NLDEC), and various journal articles and reference materials. This summary covers only the bird species that are likely to occur within the Study Area and are not *SARA*-Listed or have COSEWIC status as endangered, threatened or special concern (Labrador Shelf SEA Section 4.9.9 (Sikumiut 2008)).

Table 5-6 Seabird Species Known from the Study Area

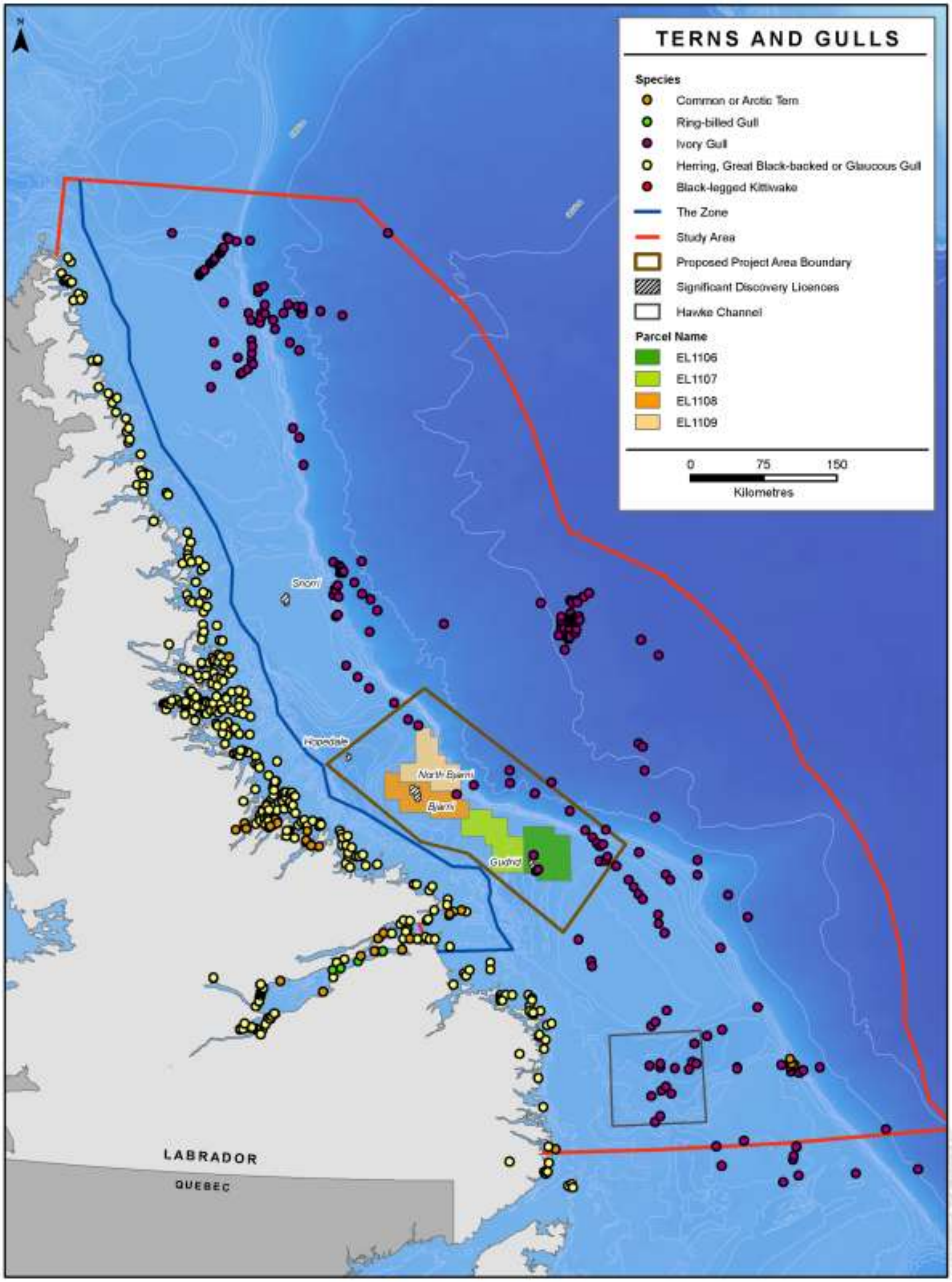
Common Name	Species Name	Common Name	Species Name
Order Anseriformes (Ducks and Geese)		**Order Charadriiformes (Shorebirds, Gulls, and Alcids)**	
Canada Goose	*Branta canadensis*	Black-bellied Plover	*Pluvialis squatarola*
American Black Duck	*Anas rubripes*	American Golden Plover	*Pluvialis dominica*
Green-winged Teal	*Anas crecca*	Semipalmated Plover	*Charadrius semipalmatus*
Common Eider	*Somateria mollissima*	Solitary Sandpiper	*Tringa solitaria*
King Eider	*Somateria spectabilis*	Greater Yellowlegs	*Tringa melanoleuca*
Harlequin Duck	*Histrionicus histrionicus*	Spotted Sandpiper	*Actitis macularius*
Black Scoter	*Melanitta nigra*	Ruddy Turnstone	*Arenaria interpres*
Surf Scoter	*Melanitta perspicillata*	Sanderling	*Calidris alba*
White-winged Scoter	*Melanitta fusca*	Dunlin	*Calidris alpina*
Long-tailed Duck	*Clangula hyemalis*	Semipalmated Sandpiper	*Calidris pusilla*
Common Goldeneye	*Bucephala clangula*	Least Sandpiper	*Calidris minutilla*
Barrow’s Goldeneye	*Bucephala islandica*	White-rumped Sandpiper	*Calidris fuscicollis*
Common Merganser	*Mergus merganser*	Whimbrel	*Numenius phaeopus*
Red-breasted Merganser	*Mergus serrator*	Red-necked Phalarope	*Phalaropus lobatus*
Hooded Merganser	*Lophodytes cucullatus*	Red Phalarope	*Phalaropus fulicaria*
Order Gaviiformes (Loons)		Long-tailed Jaeger	*Stercorarius longicaudus*
Red-throated Loon	*Gavia stellata*	Parasitic Jaeger	*Stercorarius parasiticus*
Common Loon	*Gavia immer*	Pomarine Jaeger	*Stercorarius pomarinus*
Order Procellariformes (Tube-nosed Seabirds)		Great Skua	*Stercorarius skua*
Northern Fulmar	*Fulmarus glacialis*	Ivory Gull	*Pagophila eburnea*
Sooty Shearwater	*Puffinus griseus*	Ring-billed Gull	*Larus delawarensis*

Common Name	Species Name	Common Name	Species Name
Greater Shearwater	*Puffinus gravis*	Herring Gull	*Larus argentatus*
Wilson's Storm-Petrel	*Oceanites oceanicus*	Iceland Gull	*Larus glaucoides*
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Glaucous Gull	*Larus hyperboreus*
Order Falconiformes (Raptors)		Great Black-backed Gull	*Larus marinus*
Osprey	*Pandion haliaetus*	Sabine's Gull	*Xema sabini*
Golden Eagle	*Aquila chrysaetos*	Black-legged Kittiwake	*Rissa tridactyla*
Bald Eagle	*Haliaeetus leucocephalus*	Arctic Tern	*Sterna paradisaea*
Merlin	*Falco columbarius*	Common Tern	*Sterna hirundo*
Rough-legged Hawk	*Buteo lagopus*	Caspian Tern	*Sterna caspia*
Red-tailed Hawk	*Buteo jamdicensis*	Thick-billed Murre	*Uria lomvia*
Order Strigiformes (Owls)		Common Murre	*Uria aalge*
Short-eared Owl	*Asio flammeus*	Razorbill	*Alca torda*
Snowy Owl	*Nyctea scandiaca*	Black Guillemot	*Cepphus grylle*
Great-horned Owl	*Bubo virginianus*	Atlantic Puffin	*Fratercula arctica*
		Dovekie	*Alle alle*
		Great Cormorant	*Phalacrocorax carbo*
		Double-crested Cormorant	*Phalacrocorax aurilus*
Source: Labrador Shelf SEA Section 4.9.9 (Sikumiut 2008).			



Source: Labrador Shelf SEA Section 4.9.9.2 (Sikumiut 2008).

Figure 5-7 Recorded Seabird Sightings in the Study Area (1994 to 2005)



Source: Labrador Shelf SEA Section 4.9.10.1 (Sikumiut 2008).

Figure 5-8 Recorded Tern and Gull Sightings in the Study Area (1994 to 2005)

5.4.2 FORAGING AND FEEDING

Different species occupy different foraging niches (both in strategy and habitat) in the marine ecosystem. Foraging strategies of seabirds in the Study Area include plunge diving, using flight-like movements below the surface (e.g., shearwaters), pursuit diving (typical of murres), dipping, or surface feeding (i.e., gulls and phalaropes), kleptoparasitism (i.e., stealing food from other animals as done by jaegers and skuas) and surface plunging (e.g., terns). Diet and foraging strategies by species group is outlined in Table 5-7. For more information about seabird foraging ecology and diet, see Sections 4.9.9.1 and 4.9.10.1 of the Labrador Shelf SEA (Sikumiut 2008).

Table 5-7 Foraging Strategy and Diet for Seabirds in the Study Area

Species (Group)	Foraging Strategy	Diet
Procellariiformes		
Northern Fulmar	D	Fish, cephalopods, crustaceans, offal
Sooty Shearwater	D, PP	Fish, squid, crustaceans, offal
Leach’s Storm-Petrel	D	Fish, amphipods
Wilson’s Storm-Petrel	D	Fish, amphipods
Pelecaniformes		
Double-crested Cormorant	PD	Fish, squid
Great Cormorant	PD	Fish, squid
Charadriiformes		
Black-legged Kittiwake	D	Fish, cephalopods, crustaceans, offal
Glaucous Gull	D, SC	Fish, cephalopods, crustaceans, offal
Great Black-backed Gull	D, SC	Fish, cephalopods, crustaceans, offal, eggs, chicks, birds
Herring Gull	D, SC	Fish, cephalopods, crustaceans, offal, eggs, chicks, birds
Ring-billed Gull	D, SC	Fish, cephalopods, crustaceans, offal
Iceland Gull	D, SC	Fish, cephalopods, crustaceans, offal
Ivory Gull	D, SC	Fish, cephalopods, crustaceans, offal
Long-tailed Jaeger	D, K, SC	Fish, invertebrates, offal, vertebrates, chicks
Parasitic Jaeger	D, K, SC	Fish, crustaceans, invertebrates, offal, vertebrates, chicks
Pomarine Jaeger	K, SC	Fish, birds, vertebrates, chicks
Great Skua	K, SC	Fish, vertebrates, chicks
Red-necked Phalarope	D	Copepods, invertebrates, crustaceans
Terns	D, SP	Fish, crustaceans
Atlantic Puffin	PD	Fish, invertebrates
Black Guillemot	PD	Fish, invertebrates
Dovekie	PD	Amphipods, copepods

Species (Group)	Foraging Strategy	Diet
Common Murre	PD	Fish, invertebrates
Thick-billed Murre	PD	Fish, invertebrates
Razorbill	PD	Fish, invertebrates
Source: The Birds of North America Online (http://bna.birds.cornell.edu), in Labrador Shelf SEA Section 4.9.9.1 (Sikumiut 2008); CWS data, in Labrador Shelf SEA Section 4.9.9.1 (Sikumiut 2008); Sibley 2000, in Labrador Shelf SEA Section 4.9.9.1 (Sikumiut 2008). Foraging Strategy: D - Dipping (Surface Foraging); SP - Surface Plunging; PP - Pursuit Plunging; AP - Aerial Dive Plunging; K - Kleptoparasitism; PD - Pursuit Diving; SC –Scavenging.		

Waterfowl and loons have varied diets, depending on their niche (Table 5-8). Many of these species usually dive to the bottom to forage on mollusks and crustaceans (e.g., Common Eider (*Somateria mollissima*), Harlequin Duck and scoter species). Others will dive under the surface and chase their prey (i.e., mergansers and loon species).

Shore birds use a variety of foraging strategies, including pecking, probing, routing (manipulation of seaweed or stones by “bulldozing” or turning), plunging (head and neck enter the water), sweeping (side to side movements of bill introduced in water) and walking and stopping (Barbosa and Moreño 1999) to obtain their prey.

5.4.3 NESTING AND BREEDING DISTRIBUTION

Most of the seabirds in the Study Area are colonial nesters; they share breeding space with others of their own species and often with other species, resulting in increased density during breeding season. Egg-laying for these species occurs from mid-June to July, depending on the species. Incubation lasts from three to six weeks (depending on species) and eggs hatch in early summer (Labrador Shelf SEA Section 4.9.9.2 (Sikumiut 2008)).

Certain waterfowl will use the Study Area as a staging area for migratory purposes, such as Canada Goose (*Branta canadaensis*), American Black Duck (*Anas rubripes*), Harlequin Duck, the three scoter species, Long-tailed Duck (*Clangula hyemalis*), Common Goldeneye (*Bucephala clangula*), Barrow’s Goldeneye (*Bucephala islandica*), three merganser species and both loon species. These species are either migrating south from northerly climes or migrating from inland freshwater areas to open water area for winter. Canada geese use the coastal estuaries of the Study Area, and they also use these areas for staging during migration (Labrador Shelf SEA Section 4.9.10.2 (Sikumiut 2008)).

Table 5-8 Foraging Strategy and Diet for Waterfowl and Loons in the Study Area

Species (Group)	Foraging Strategy	Diet	Source
Order Anseriformes (Ducks and Geese)			
Canada Goose	Grazing	Grasses, sedges, grains and berries	Mowbray *et al.* 2002
American Black Duck	Dabbling	Aquatic insects, crustaceans, mollusks, and fish	Longcore *et al.* 2000
Green-winged Teal	Dabbling	Aquatic insects, seeds of grasses and sedges	Johnson 1995
Common Eider	Diving	Mollusks, crustaceans, echinoderms	Goudie *et al.* 2000
King Eider	Diving	Mollusks, crustaceans, echinoderms	Bustnes and Erikstad 1988
Harlequin Duck	Diving	Mollusks, crustaceans, barnacles, fish roe	Goudie and Ankney 1986
White-winged Scoter	Diving	Mollusks, crustaceans, insects	Brown and Frederickson 1997
Black Scoter	Diving	Mollusks, crustaceans	Bordage and Savard 1995
Surf Scoter	Diving	Mollusks, crustaceans	Vermeer 1981
Long-tailed Duck	Diving	Mollusks, crustaceans	Robertson and Savard 2002
Barrow's Goldeneye	Diving	Insects, mollusks, crustaceans	Eadie e*t a.*. 1995
Common Goldeneye	Diving	Insects, mollusks, crustaceans	Eadie *et al.* 1995
Red-breasted Merganser	Pursuit diving	Fish, crustaceans	Titman 1999
Common Merganser	Pursuit diving	Fish, crustaceans	Mallory and Metz 1999
Hooded Merganser	Pursuit diving	Fish, aquatic insects, crustaceans	Dugger *et al*. 1994
Order Gaviiformes (Loons)			
Red-throated Loon	Pursuit diving	Fish, crustaceans, mollusks, insects	Barr *et al*. 2000
Common Loon	Pursuit diving	Fish, crustaceans, leeches	Barr 1973
Source: Labrador Shelf SEA Section 4.9.10.1 (Sikumiut 2008).			

5.4.4 NON-BREEDING DISTRIBUTION

There is a strong relationship between seabird distribution and water masses, primarily through temperature and/or salinity profiles (Balance *et al.* 2001). Physical gradients (e.g., shelves) are often sites of elevated seabird abundance, especially seasonally. These physical gradients influence nutrient levels and primary productivity, resulting in a concentration of zooplankton and fish, and consequently attracting seabirds. For more information on seabird distributions, nesting populations and breeding biology refer to Sections 4.9.9.2 and 4.9.10.2 of the Labrador Shelf SEA (Sikumiut 2008).

Many North American shorebirds overwinter in southerly climes, spending only the breeding season in the north. The Study Area is used primarily as migratory stopover habitat for several species of shorebirds; a few species use the area for breeding habitat, including interior tundra ponds or various rivers and lakes. Most shorebird species do not nest on the coast, and many species do not nest in the Study Area, they use it as a migratory route. Refer to Section 4.9.11.2 of the Labrador Shelf SEA (Sikumiut 2008) for more information on shorebird distributions, nesting populations and breeding biology.

There is a variety of birds that use the Study Area for breeding, staging, or overwintering. Vulnerability to disturbance is primarily dependent upon the species and their breeding cycle. Some species are most sensitive during spring/summer nesting time (alcids), while others are most sensitive while congregating together in winter (e.g., Harlequin Duck).

5.5 COMMERCIAL AND TRADITIONAL FISHERIES

The area of the Labrador Shelf that contains the Project Area supports a variety of commercial fisheries to be described in this environmental assessment based on latest available DFO data. The most important fisheries, in terms of landed value, in and adjacent to the Project Area, are northern shrimp (mobile trawl fishery) and snow crab (fixed gear fishery).

The primary focus of the commercial fisheries section was the description of domestic Canadian harvest for which datasets (described below) were available.

This section describes species harvested, locations and seasonality of the harvest, harvest methods focusing on principal commercial fish species including northern shrimp, snow crab, striped shrimp, turbot (Greenland halibut), Iceland scallops and Atlantic cod. The biological status of the main commercial species are described in Sections 5.2.4 and 5.2.5.

5.5.1 DATA AND INFORMATION SOURCES

In this discussion of commercial fishing activities, a number of fisheries management data areas are referenced. These are for the management areas that most closely approximate study area.

To provide historical context which includes past foreign fishing effort, NAFO datasets for the study area were used. Maps showing harvest data, which were based on georefererenced DFO datasheets, were also included. These maps show known areas of concentrated fishing.

For the georeferenced catch data, the location information was reported by degree and minute of latitude and longitude, in the vessel's fishing log. It is noted that gear such as mobile gear towed over an extensive area, or for extended gear, such as longlines, the georeferenced point did not represent the full distribution of the gear or activity on the water. However, over many data entries, the reported locations create an accurate indication of where fishing activities occurred.

Where harvests were quantified, weight of the harvest (landings in tonnes) is given rather than value, since these quantities are directly comparable from year to year. Values (for the same quantity of harvest) often varied annually with respect to species, negotiated prices, changes in exchange rates and fluctuating market conditions.

The maps in the following sections show the harvesting locations as dark points. The points are not “weighted” by quantity of harvest, but show where some fishing effort was reported.

Other sources consulted for this section include fisheries management plans, quota reports and other related DFO documents.

5.5.2 HISTORICAL OVERVIEW OF COMMERCIAL FISH

The fishery associated with NAFO Areas 2J, 2G and 2H (referred from here on as the Study Area) has undergone significant changes over the past two decades largely because of the collapse of the groundfishery and related moratorium. After large groundfish catches in these Divisions in the 1970s and 1980s, the fishery was considerably curtailed in the early 1990s at the time of the moratorium. Since then, much lower quotas have been allowed, varying over the years based on scientific advice and other considerations. Harvest for NAFO-regulated species by foreign and domestic harvesters, based on NAFO (2009) statistics, is shown in Figure 5-9. Within the past 20 years (1985 to 2005), the NAFO Area 2 groundfish fishery has been considerably reduced while the crustacean (particularly northern shrimp) fisheries have increased in their importance. In 1985, groundfish landings dominated study areas’ harvest (Figure 5-10), comprising 92 percent of the fishery. However, in 2006, the Study Area was dominated by the northern shrimp fishery, which comprised up to 83 percent of total landings.

The composition of NAFO Area 2’s harvest, based on the 2006 to 2008 average catch is shown in Table 5-9. As indicated, the domestic commercial fisheries in the NAFO Area 2 were comprised of approximately 85 percent northern shrimp. Snow crab makes up approximately five percent of the total harvest. The most important groundfish fishery was Greenland halibut, accounting for approximately five percent of the overall harvest.

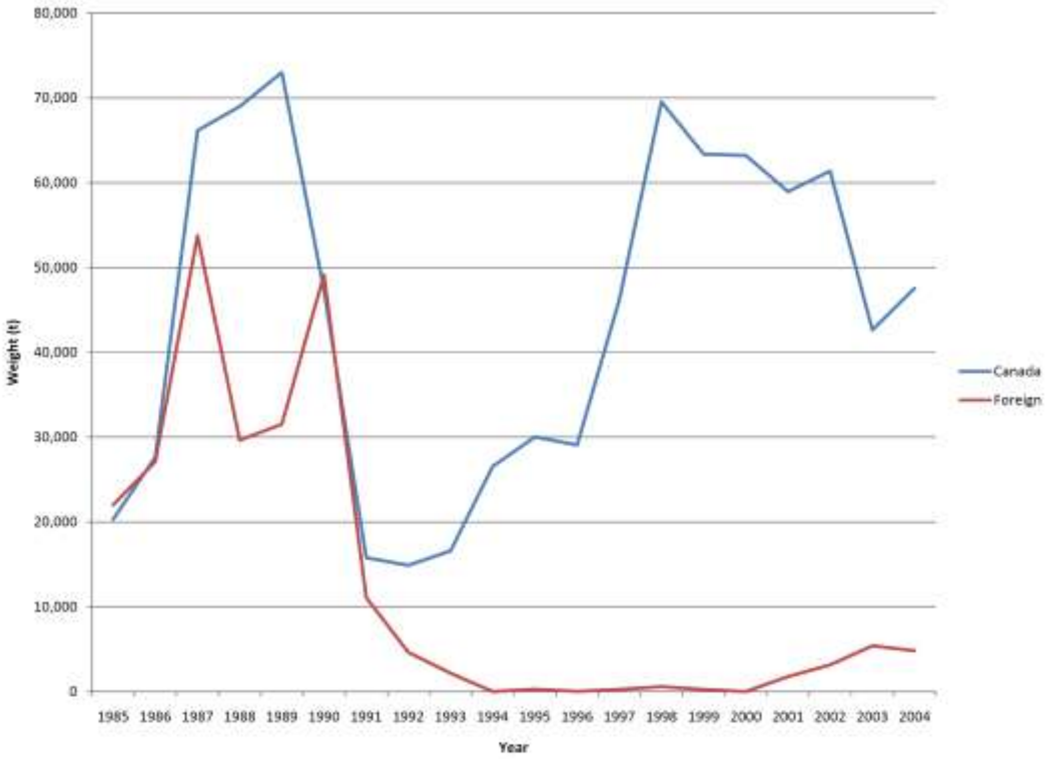
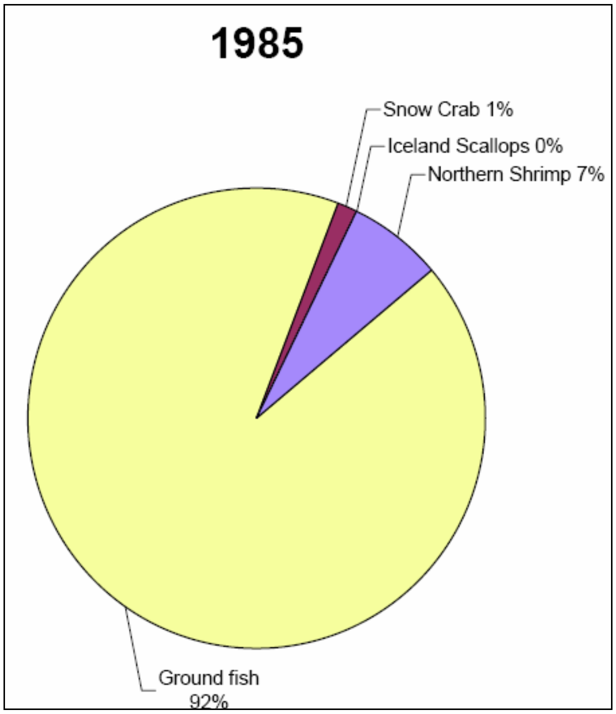


Figure 5-9 Northwest Atlantic Fisheries Organization 2GHJ Harvest, 1985 to 2004, Foreign and Domestic



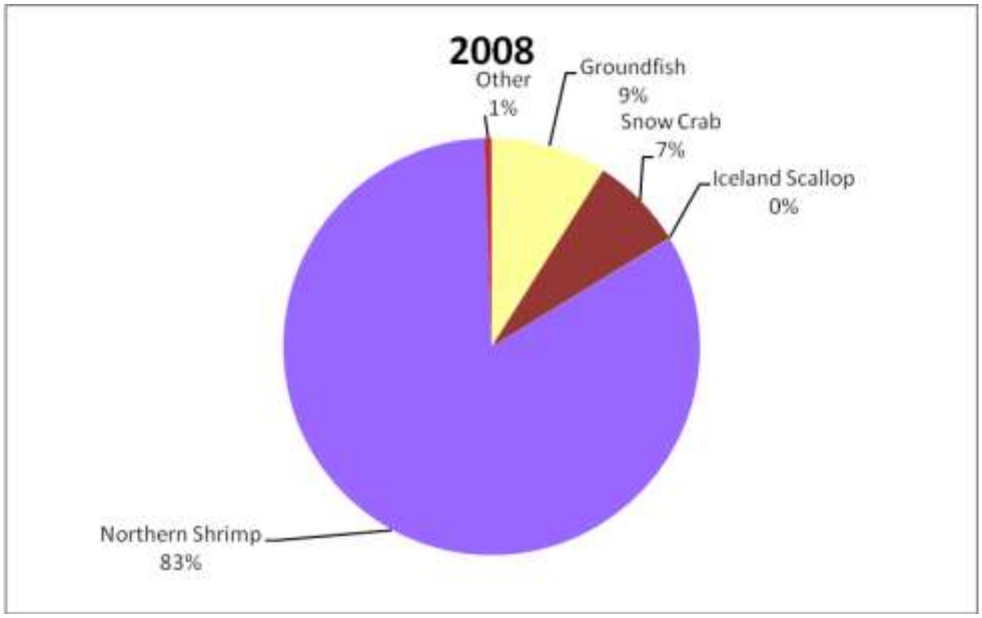


Figure 5-10 **Northwest Atlantic Fisheries Organization Area 2 Composition of Harvest, 1985 and 2008**

Table 5-9 Domestic Harvest by Species in the Study Area, 2006 to 2008 Average

Species	Total (tonnes)	% of Total
American plaice	20.141	0.02
Arctic char	85.676	0.07
Cod, Atlantic	176.402	0.14
Cod, rock	75.087	0.06
Crab, Queen/Snow	7,191.598	5.58
Grenadier, rough-head	33.354	0.03
Greysole/witch	15.981	0.01
Groundfish Heads	769.551	0.60
Halibut	0.358	0.00
Redfish	16.484	0.01
Scallop, Iceland	742.573	0.58
Seal fat	97.209	0.08
Seal meat	6.369	0.00
Northern Shrimp, *Pandalus borealis*	109,479.19	84.98
Striped Shrimp, *Pandalus montagui*	3,524.988	2.74
Skate	4.242	0.00
Turbot/Greenland halibut	6,083.494	4.72
Whelks	502.757	0.39
Total	128,825.45	100.00

The relative distributions of the harvest over the 2006 to 2008 period for the Study Area, are illustrated in Figure 5-11. Detailed information on the composition of the catch for each NAFO Subarea from 2006 to 2008 is provided in Table 5-10. This provides an indication of the difference in relative importance of certain species within the different NAFO Unit Areas located in the Environmental Assessment Area. For instance, snow crab is not harvested from NAFO Subarea 2G but accounts for approximately nine percent of the harvest in 2J.

The location of harvesting activities as recorded in the georeferenced DFO data are shown in Figure 5-12.

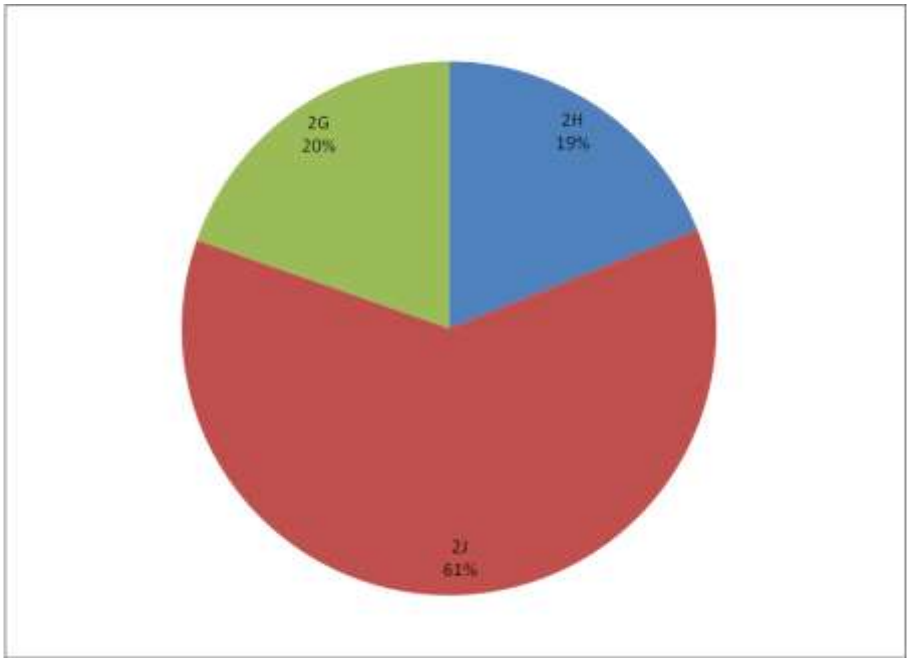


Figure 5-11 Northwest Atlantic Fisheries Organization Subareas Study Area, Relative Quantity of Harvest

Table 5-10 Domestic Harvests by Subarea by Species, 2006 to 2008 Average

NAFO Unit Area	Species	Total Tonnes	Percent Total	Percent Grand Total
2H	Arctic Char	85.68	0.35	0.07
	Snow Crab	468.90	1.92	0.36
	Rough-head Grenadier	1.00	0.00	0.00
	Iceland Scallop	597.54	2.45	0.46
	Shrimp, *Pandalus borealis*	22,560.91	92.33	17.51
	Shrimp, *Pandalus montagui*	16.55	0.07	0.01
	Skate	1.11	0.00	0.00
	Turbot/Greenland Halibut	704.55	2.88	0.55
2H Total		24,436.23	100.00	18.97
2J	American Plaice	20.14	0.03	0.02
	Atlantic Cod	176.40	0.22	0.14
	Rock Cod	75.09	0.09	0.06
	Snow Crab	6,722.70	8.50	5.22
	Rough-head Grenadier	31.93	0.04	0.02
	Greysole/Witch Flounder	15.98	0.02	0.01
	Groundfish Heads	769.55	0.97	0.60
	Halibut	0.22	0.00	0.00
	Redfish	16.48	0.02	0.01
	Iceland Scallop	145.04	0.18	0.11
	Seal Fat	97.21	0.12	0.08
	Seal Meat	6.37	0.01	0.00
	Shrimp, *Pandalus borealis*	65,090.81	82.32	50.53
	Shrimp, *Pandalus montagui*	136.66	0.17	0.11
	Skate	2.67	0.00	0.00
	Turbot/Greenland halibut	5,263.91	6.66	4.09
	Whelks	0.50	0.00	0.00
2J Total		79,073.91	100.00	61.38
2G	Grenadier, rough-head	0.43	0.00	0.00
	Halibut	0.14	0.00	0.00
	Shrimp, *Pandalus borealis*	21,827.47	86.22	16.94
	Shrimp, *Pandalus montagui*	3,371.78	13.32	2.62
	Skate	0.47	0.00	0.00
	Turbot/Greenland halibut	115.04	0.45	0.09
2G Total		25315.31	100.00	19.65
Grand Total		128825.45		100.00

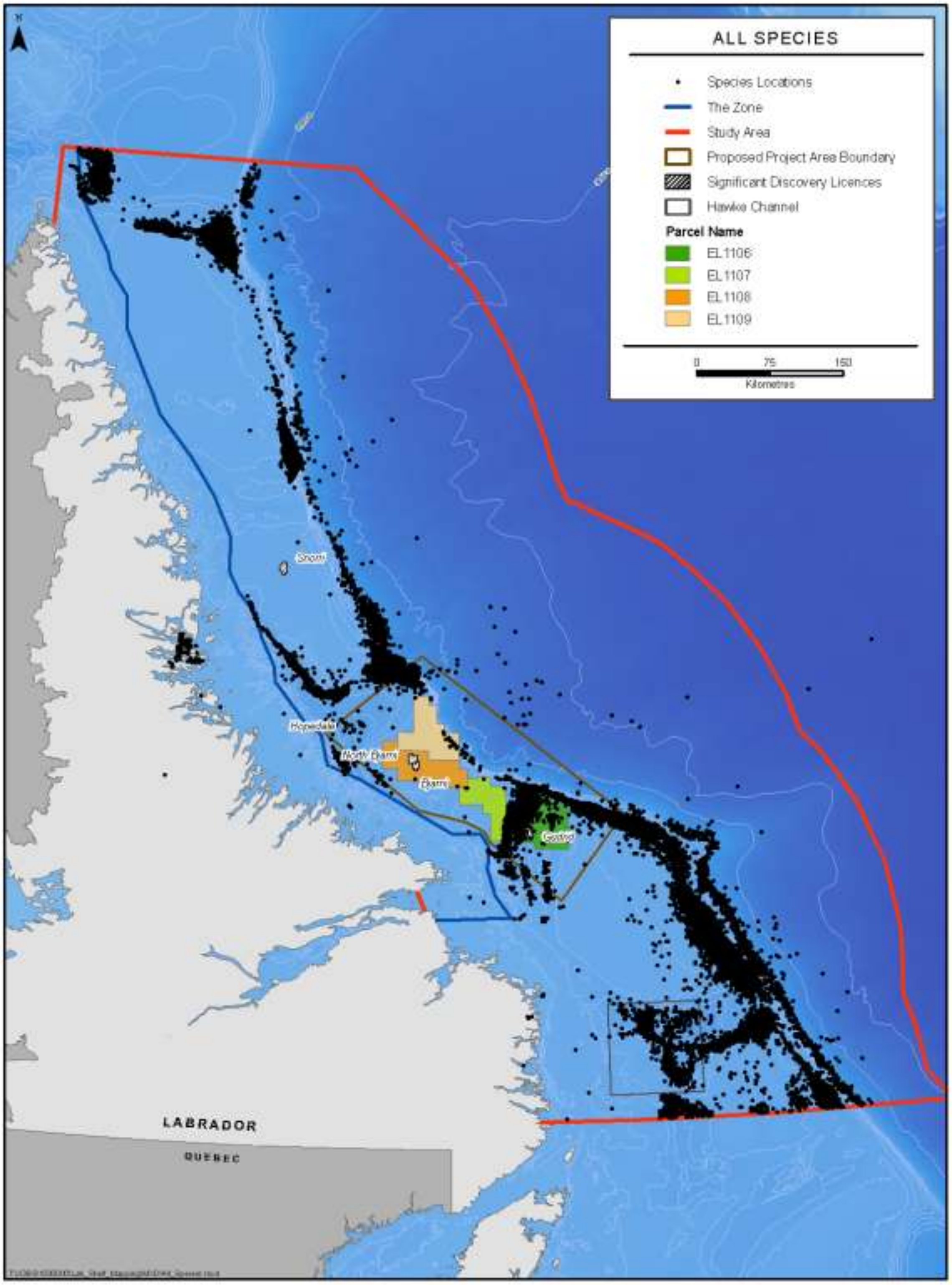


Figure 5-12 **Northwest Atlantic Fisheries Organization Area 2 and Georeferenced Harvest Locations (all species), 2006 to 2008**

5.5.3 SEASONALITY

Harvesting times vary annually, depending on seasons and regulations set by DFO, harvesting strategies of fishing enterprises, or on the availability of fish. The 2006 to 2008 average catch by month (all species) is shown in Figure 5-13.

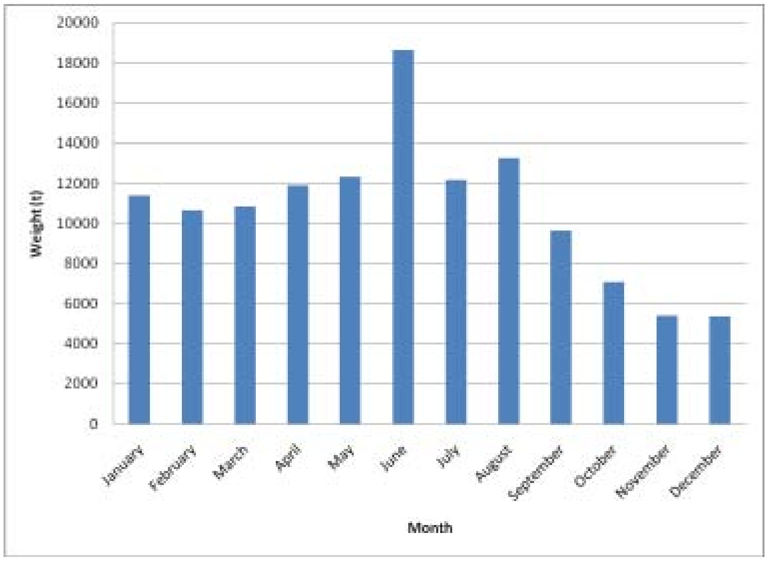


Figure 5-13 Study Area, Average Monthly Harvest, 2006 to 2008

Within the study area harvest takes place year-round, with highest concentrations being landed between April and August (Figure 5-13).

5.5.4 FISHING VESSELS

Harvesting within the Study Area is largely pursued (greater than 80 percent) by mid-sized to large vessels, with vessel between 55 to 64 feet in length, taking approximately 47 percent of the harvest by quantity (Table 5-11).

Table 5-11 Domestic Harvests by Home Port and Vessel Size, 2006 to 2008 Average

Vessel Home Port	Vessel Length	Weight (t)	Percent Total
Newfoundland and Labrador	1 to 34 Feet	2,354.43	1.83
	35 to 44 Feet	118.84	0.09
	45 to 54 Feet	68.63	0.05
	46 to 54 Feet	13,523.95	10.50
	55 to 64 Feet	61,138.98	47.46
	75 to 99 Feet	909.70	0.71
	100 to 124 Feet	3,543.70	2.75
	125 to 149 Feet	764.46	0.59
	150 to 199 Feet	17,907.70	13.90

Vessel Home Port	Vessel Length	Weight (t)	Percent Total
	200 Feet and Over	224.70	0.17
Newfoundland and Labrador Total		*100,555.26*	*78.06*
Maritimes	200 Feet and Over	3,653.97	2.84
Maritimes Total		*3,653.97*	*2.84*
Nova Scotia	76 to 99 Feet	21,382.80	16.60
	200 Feet and Over	113.35	0.09
Nova Scotia Total		*21,496.15*	*16.69*
Quebec	47 to 54 Feet	982.48	0.76
	56 to 64 Feet	1,795.32	1.39
	65 to 74 Feet	342.28	0.27
Quebec Total		*3,120.08*	*2.42*
Grand Total		128,825.45	100.00

Harvest within the study area is taken predominately by harvesters based in Newfoundland and Labrador (approximately 78 percent) with harvesters based out of Nova Scotia taking approximately 17 percent of the total harvest. Harvesters from the Maritimes and Quebec each total approximately 2 percent of the harvest based on quantity (Table 5-11).

5.5.5 FISHING GEAR

Several different types of gear are used to harvest commercial species from the study area, including both fixed and mobile gears. Certain fisheries are associated with specific gear types, such as scallops using dredges, while other fisheries employ multiple harvesting methods such as cod, using both stern otter trawls and gillnets. The harvest by type of fishing gear for the study area is shown in Table 5-12.

Table 5-12 Harvest in the Study Area by Gear Type, 2006 to 2008 Average

Gear	Weight (t)	Percent Total
Bottom Otter Trawl (stern)	4,793.604	3.72
Dredge (Boat)	742.573	0.58
Gill Net (Set or Fixed)	2,204.708	1.71
Hand Line (Baited)	116.972	0.09
Longline	165.48	0.13
Pot	7,694.361	5.97
Seal Hunting	103.578	0.08
Shrimp Trawl	113,004.18	87.72
Total	128,825.45	100.00

The following sections describe the primary gear types used by harvesters in the study area.

5.5.5.1 STERN OTTER TRAWLS

This is a mobile gear that is used to harvest a variety of ground fish species in the area. It is comprised of a large cone-shaped net towed along the ocean bottom. Large rectangular "doors" (otterboards) are attached to cables between the ship and the net keeping the net open horizontally while being towed. Similarly, floats on the top and weights at the bottom of the net maintain the vertical opening in the otter trawl. The net is pulled along the seabed via wheel-like "bobbins". Fish enter through the large opening and are funneled to the end of the net which is bag-like and referred to as the "cod end". The nets mesh size allows smaller fish to escape.

Shrimp trawls are modified otter trawls encompassing a range of designs and sizes. Shrimp trawls have relatively small meshes, with 20 to 60 mm in the cod end while the mesh size in the belly part of the trawls seldom exceeds 80 mm. Its vertical opening typically ranges from less than 1 to 20 m.

5.5.5.2 GILLNETS

This fishing gear is used for various groundfish species. Fixed or set gillnets are anchored to the seabed to keep the gear stationary, with buoys on each end that float on the surface. The net itself is either kept open or full with weights attached to the bottom. A fleet may consist to 50; each net is approximately 91 m (300 feet) long, for a length of 4,550 m (15,000 feet) per fleet. Fishers may fish 8 to 10 fleets at once. The nets are constructed of monofilament netting.

5.5.5.3 LONGLINES (BAITED TRAWL)

Groundfish longlines consist of buoyed lines from which a series of fishhooks are suspended. Large buoys are generally attached to the ends of a longline. Longlines are set behind a vessel and left to fish. After a specified time it is hauled in to retrieve the catch, re-baited and set again. In some cases, longlines are not anchored but are suspended by buoys at either end when then set to drift for a time (when longlines are set in this way, it is referred to by some fishers as "fly and set"). Length of the longline is a factor of the fisher's preference or other factors.

5.5.5.4 SCALLOP DREDGES

Scallop rakes or drags (dredges) are typically operated by mid-sized vessels with powerful engines, designed to pull the heavy equipment along the sea floor (i.e., on scallop beds). The dredges have a frame mouth, which leads to a large bag or net made of metal rings or mesh. Scallop draggers may pull one or more dredges behind the vessel and/or from side-rigged booms.

5.5.5.5 CRAB POTS

Crab pots are set on the seabed in strings buoyed at the surface. Crab gear generally has a highflyer (radar reflector) at one end and a large buoy at the other. Some fishers use highflyers at both ends. Depending on weather, they may be left unattended for several days at a time, or frequently longer.

Fishers typically try to leave approximately 36.5 m (20 fathoms (120 feet)) on the seabed between each pot, thus, allowing slack for the anchor ropes on either end of the string to extend upwards at an angle. The distance between the typical highflyer and end-buoy of a 50- to 60-pot string of crab gear for example, would be 6,000 feet to 7,500 feet, or approximately 1.8 to 2.3 km.

5.5.6 PRINCIPAL SPECIES FISHERIES

As indicated in Table 5-9, the domestic harvest within the Study Area consists largely of northern shrimp (Figure 5-14). Other species of importance include snow crab, turbot, striped shrimp and Iceland scallop. This section describes the principal Study Area fisheries in more detail.

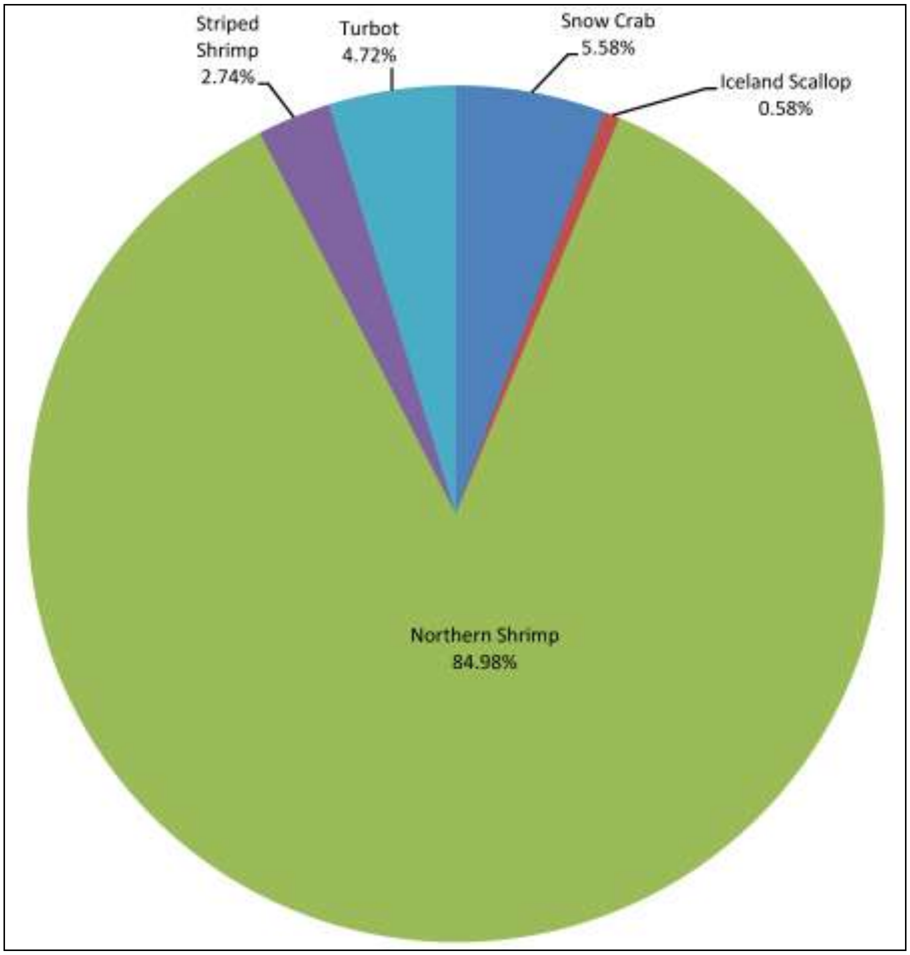


Figure 5-14 **Important Commercial Fish Species in the Study Area, by Percent**

5.5.6.1 NORTHERN SHRIMP

Within the Study Area, Northern shrimp accounts for approximately 85 percent of the total harvest (Table 5-9). Of the major landings (greater than 1 percent on the total harvest by weight) in the Study Area, 59 percent of the harvest was taken from 2J, while 21 and 20 percent was harvested from 2H and 2G, respectively. Landings (Figure 5-15) occurred year round and are relatively high from January to a peak in June before declining to a low in December.

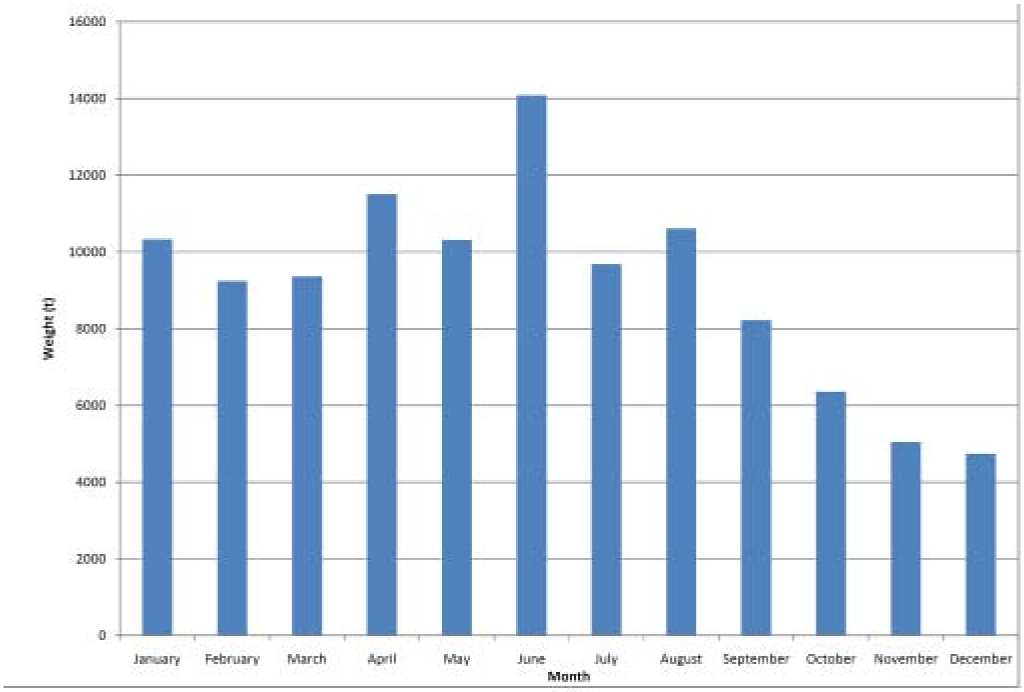


Figure 5-15 **Study Area Northern Shrimp Harvest by Month, 2006 to 2008 Average**

Reported Northern shrimp harvesting locations, averaged for 2006 to 2008, and based on the DFO georeferenced data in relation to the study area are shown in Figure 5-16.

In NAFO Division 2J, a total quota of 43,362 t was set for 2008. Of this a total, 33,863 t (78 percent of the quota) of Northern shrimp was harvested (DFO 2009b). In NAFO Division 2G, a total quota of 9,351 t was set for 2008, with 7,585 t (81 percent) being landed (DFO 2009b). In NAFO Division 2H, a total quota of 22,424 t was set for 2008, with 13,211 t (59 percent) being harvested (DFO 2009b).

Shrimp Fishing Area 6 (Hawke Channel + Division 3K)

For SFA 6 (Figure 5-17), the TAC and catch rates have increased over the past two decades, with landings peaking in 2004 at 77,800 t (DFO 2008b). In SFA 6, specifically, the TAC was set at 23,100 t for 1997. The TAC was more than doubled between 1997 to 2002 and increased further to 77,932 t in 2003. Since 2004, a TAC of 77,932 t was maintained through to the 2007/08 management, with that quota anticipated to be taken (Figure 5-18).

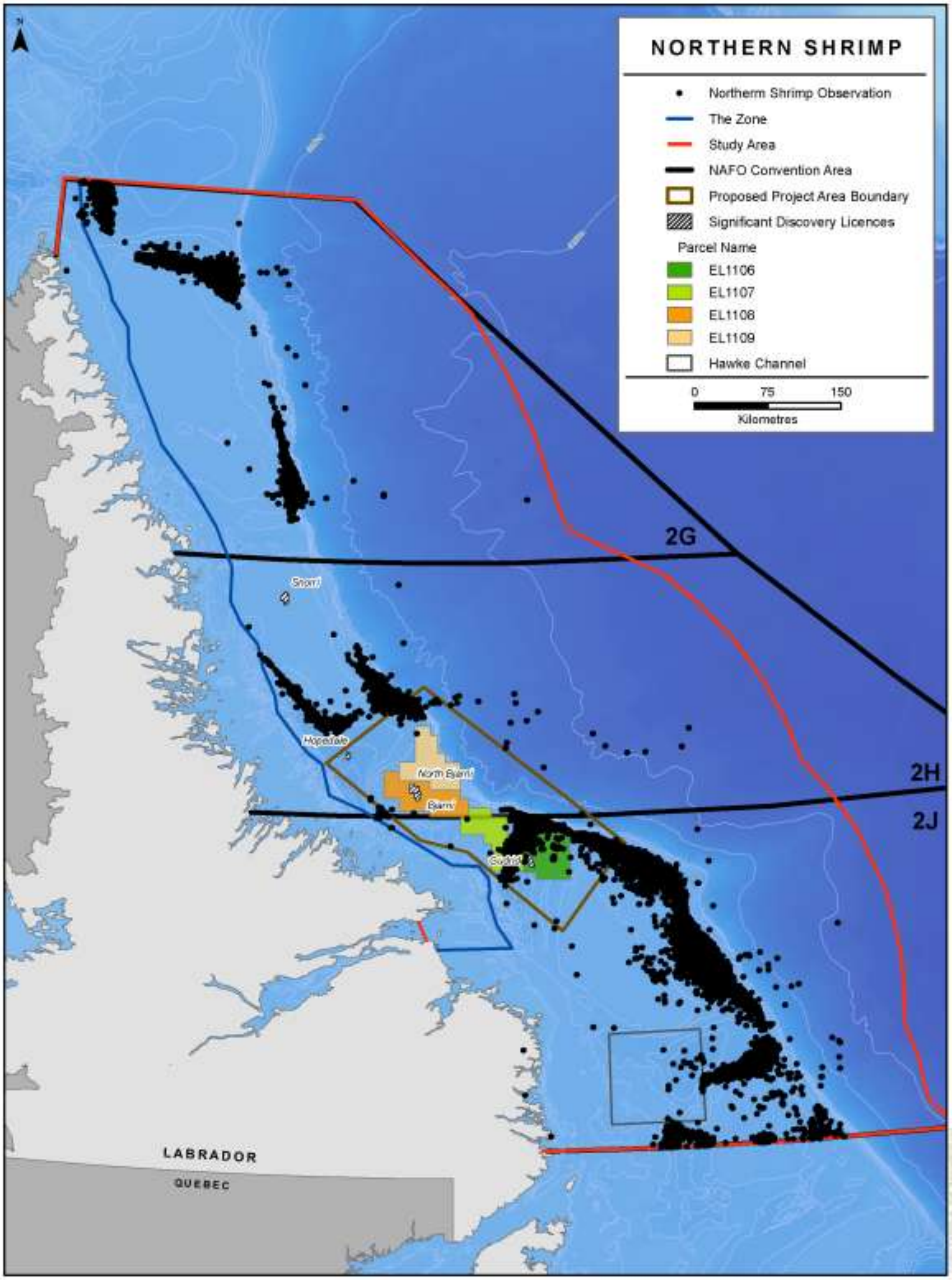


Figure 5-16 **Georeferenced Northern Shrimp Harvest Locations, 2006 to 2008**

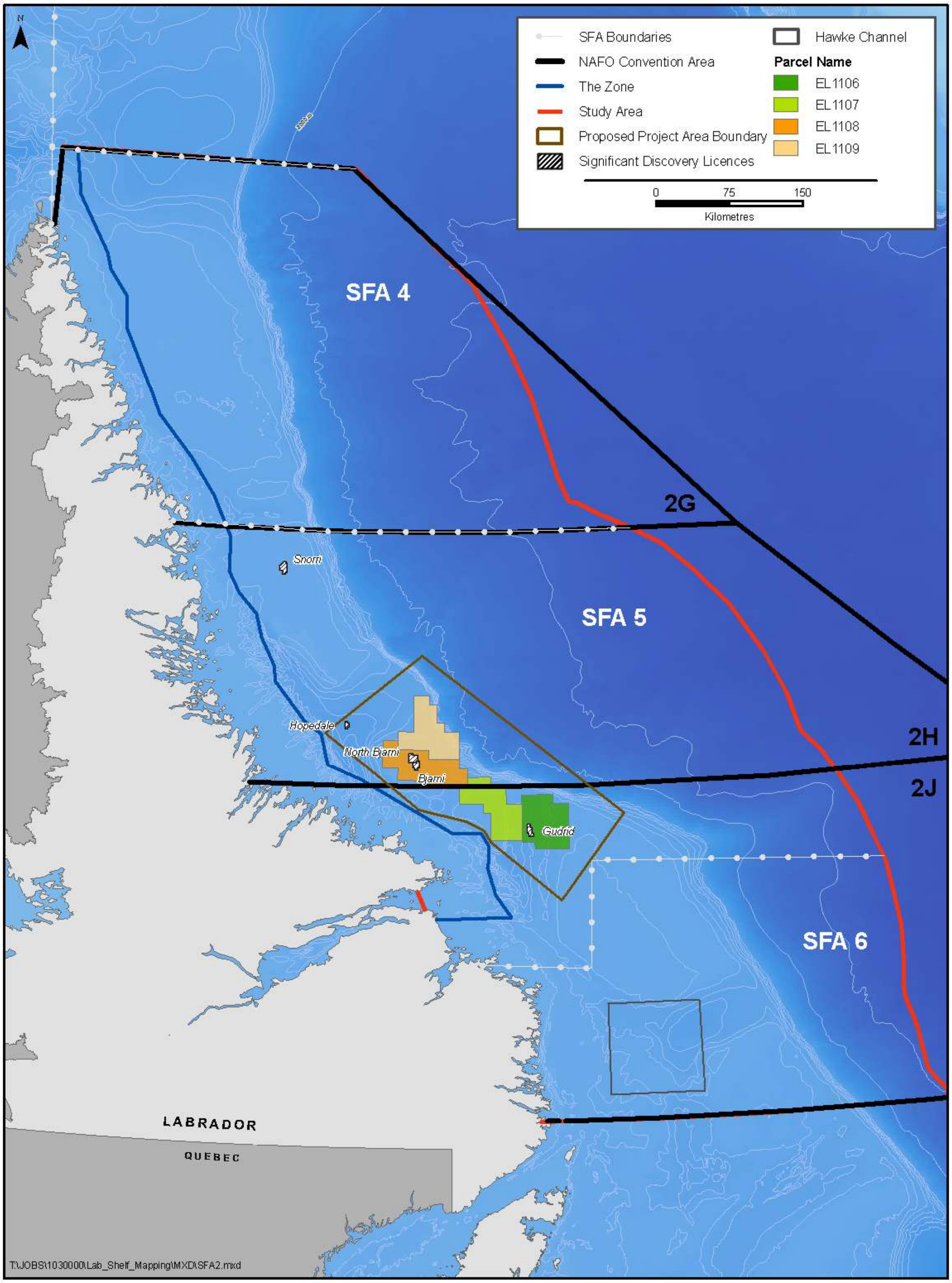
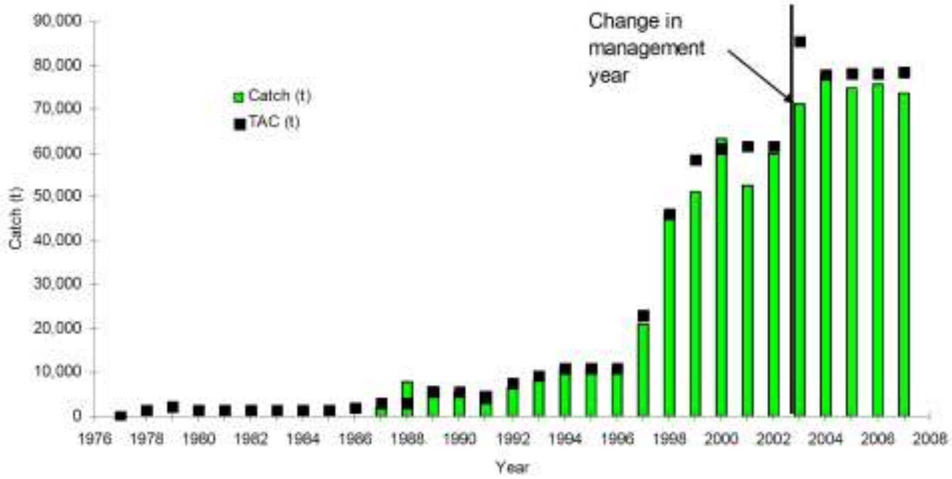


Figure 5-17 Shrimp Fishing Areas (SFA)

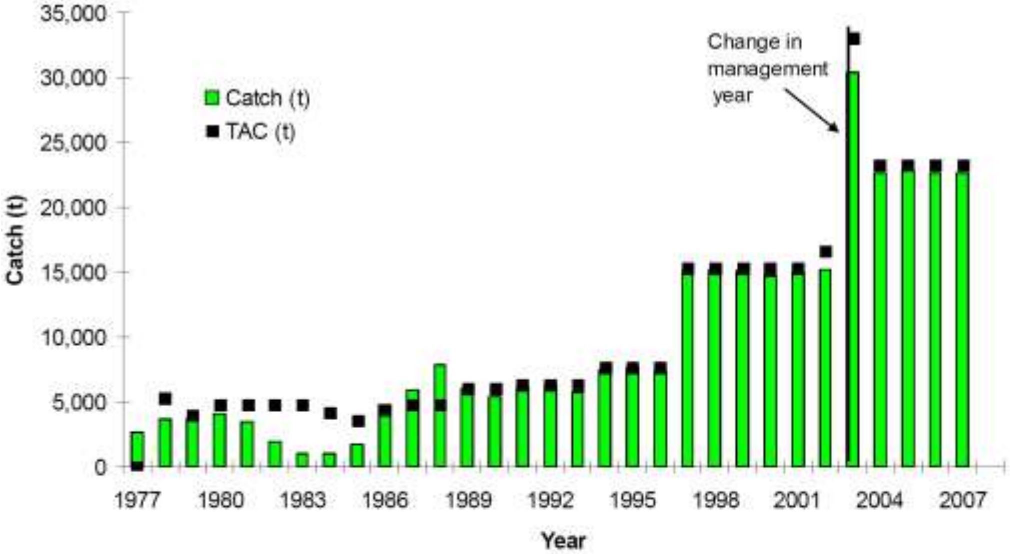


Source: DFO 2008b.

Figure 5-18 **Trends for Shrimp Fishing Area 6 Northern Shrimp for Catch (t) and Total Allowable Catch from 1976-2008**

Shrimp Fishing Area 5 (Hopedale and Cartwright Channels)

In SFA 5 (Figure 5-17), the TAC increased over the past two decades, peaking in 2003 at 33,084 t (note in 2003 the management year changed to April 1 to March 31 and a additional interim quota of 9,787 t was set for the period between January 1 to March 31, 2003) before decreasing to 23,300 t though 2008 (Figure 5-19) (DFO 2008b).

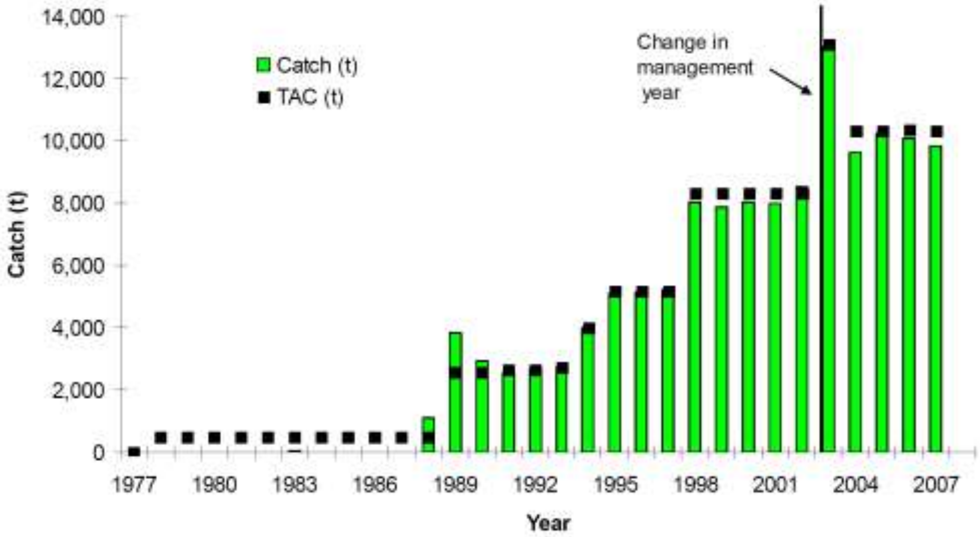


Source: DFO 2008b.

Figure 5-19 **Trends for Shrimp Fishing Area 5 Northern Shrimp for Catch (t) and Total Allowable Catch from 1976 to 2008**

Shrimp Fishing Area 4 (NAFO Division 2G)

In SFA 4 (Figure 5-17), the TAC increased from 2,580 t in 1989 to 8,320 t in 1998 (DFO 2008b). The TAC peaked in 2003 at 13,122 t (note in 2003 the management year changed to April 1 to March 31 and a additional interim quota of 9,787 t was set for the period between January 1 to March 31, 2003) before decreasing to 10,320 t though 2008 (Figure 5-20) (DFO 2008b).



Source: DFO 2008b.

Figure 5-20 **Trends for Shrimp Fishing Area 4 Northern Shrimp for Catch (t) and Total Allowable Catch from 1976 to 2008**

5.5.6.2 STRIPED SHRIMP

Striped shrimp (*Pandalus montagui*) makes up approximately 2.8 percent of the total harvest in the Study Area (Table 5-9). It is primarily caught as a by-catch during the northern shrimp fishery. Of the major landings (greater than 1 percent on the total harvest by weight) in the Study Area, 95.65 percent of the harvest was taken from 2G, while 3.88 and 0.47 percent was harvested from 2J and 2H, respectively. Landings of striped shrimp occur year round, but especially from August through December (Figure 5-21). Most landings occur in 2G.

Reported striped shrimp harvesting locations, from 2006 to 2008, based on the DFO georeferenced data in relation to the study area and the relevant Unit Areas, are shown in Figure 5-22.

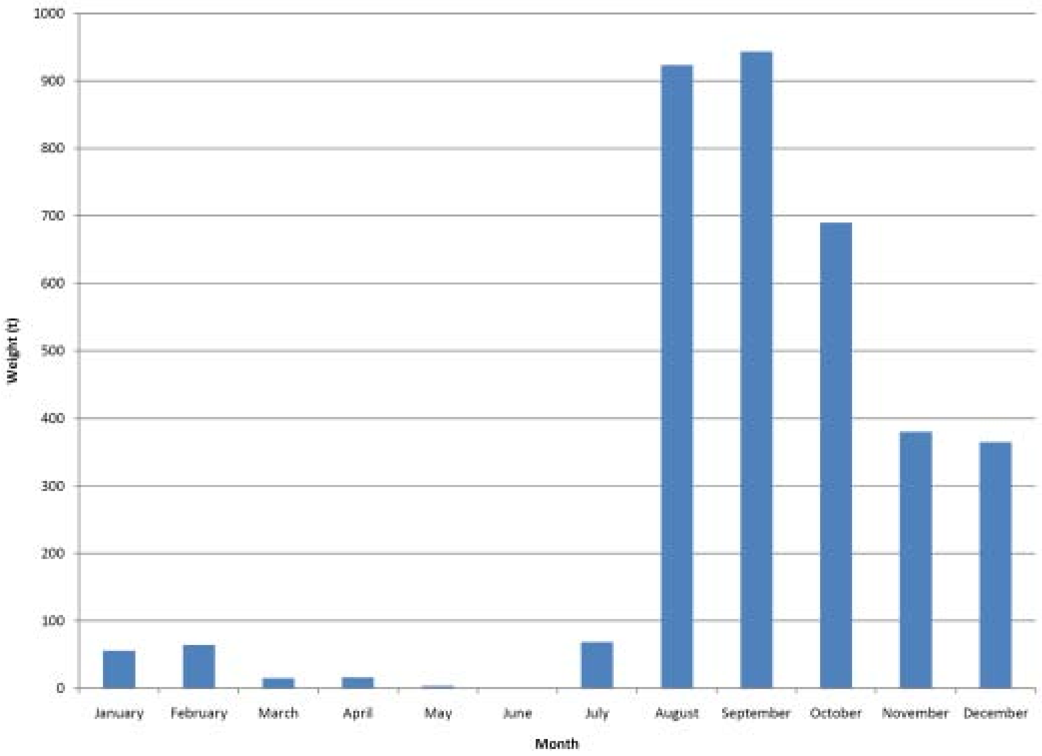


Figure 5-21 Study Area Striped Shrimp Harvest by Month, 2006 to 2008 Average

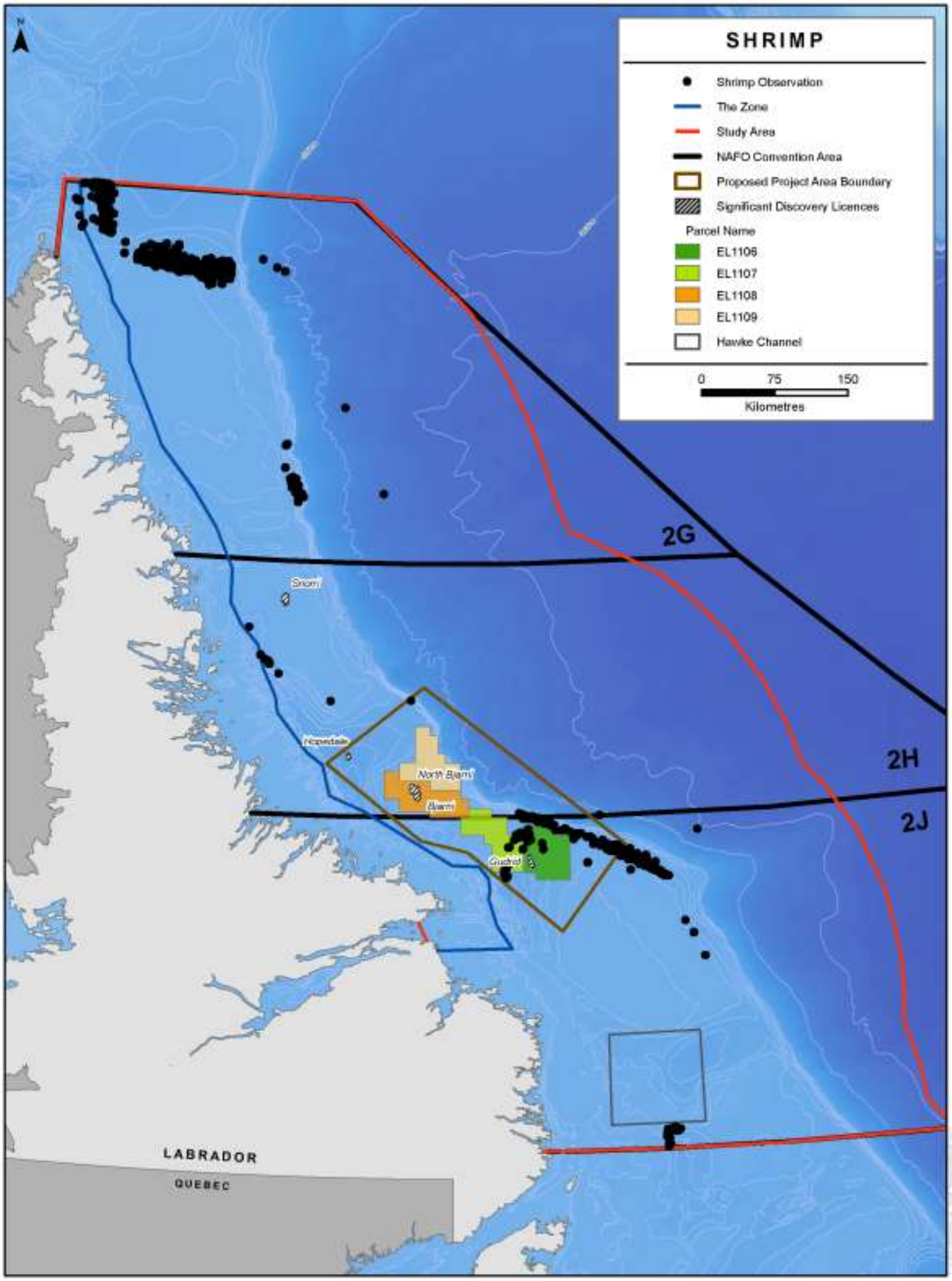


Figure 5-22 Georeferenced Striped Shrimp Harvesting Locations, 2006 to 2008

5.5.6.3 SNOW CRAB

In the Study Area, the snow crab fishery accounts for approximately 5.6 percent of the total harvest (Figure 5-14). Harvesting occurs between spring and summer with June having the highest landings while little is caught in September (Figure 5-23). Landings take place predominately in 2J, which accounts for approximately 93 percent of the total snow crab landings; the remaining 7 percent of landings occur in 2H.

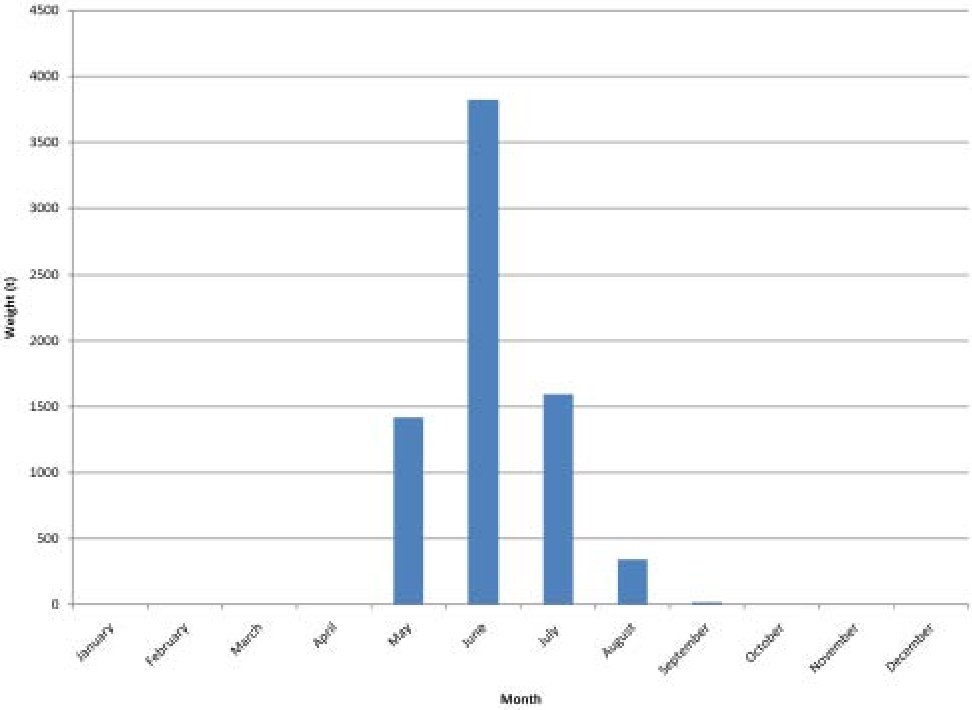


Figure 5-23 **Snow Crab Landings by Month in the Study Area**

Reported snow crab harvesting locations, from 2006 to 2008, based on the DFO georeferenced data in relation to the study area and the relevant Unit Areas, are shown in Figure 5-24.

In 2008, a quota of 2,366 t was set for snow crab in NAFO division 2J (DFO 2008c), of which 2,383 t was landed (108 percent of the quota) (DF0 2009c). In 2H, a quota of 100 t was set in 2008, of which 147 t (147 percent) was taken (DFO 2009c).

In Division 2J, commercial snow crab fishery landings peaked at 5,400 t in 1999, before decreasing to approximately 3,700 t from 2000 to 2002 (DFO 2008c, DFO 2009d). Landings continued to decline to 2003, then increased to 2,330 (53 percent) in 2007 (Figure 5-25) (DFO 2008c). Effort has also increased to its highest level in 2002 to 2004 before declining between 2004 to 2006; however, in 2007 it increased by 12 percent.

From 1998 to 2002, the exploitable biomass of snow crab in NAFO Division 2J decreased steadily by 94 percent (DFO 2008c). It has been increasing over the past five years; however, it remains below levels prior to 2002 (Figure 5-26; DFO 2008c).

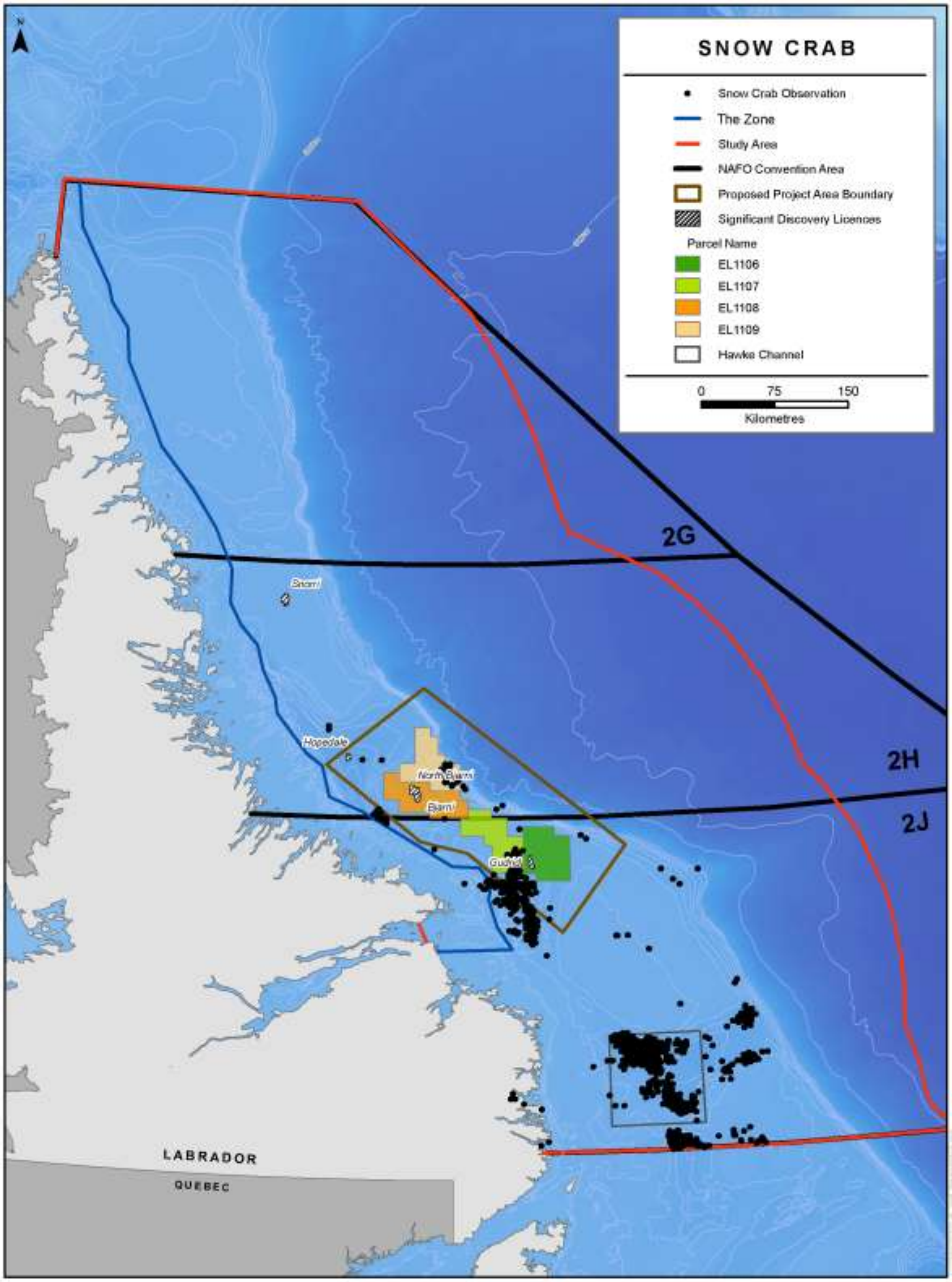
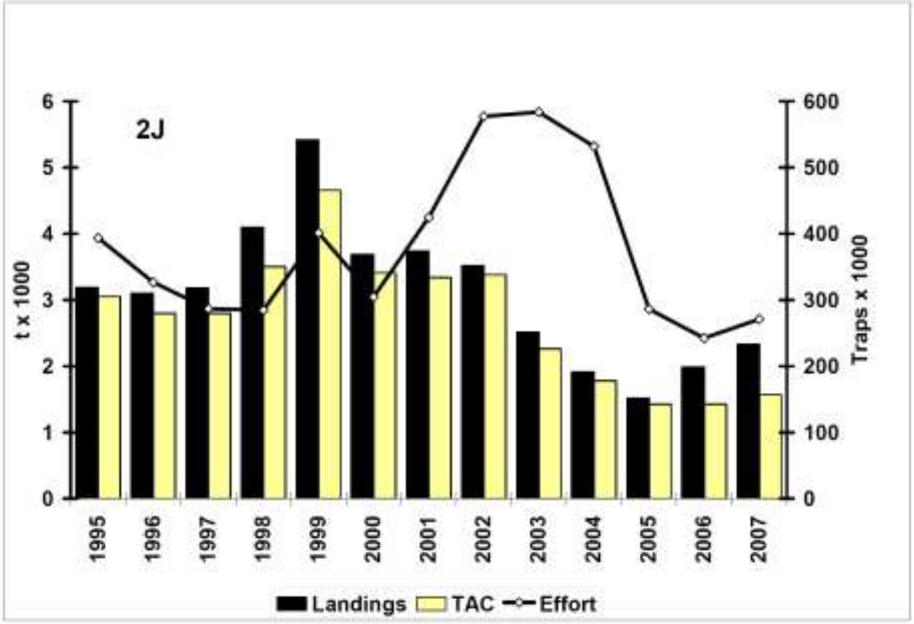
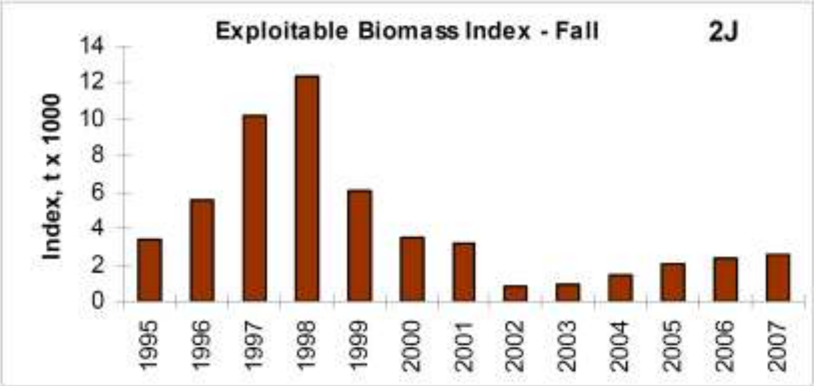


Figure 5-24 Georeferenced Snow Crab Harvesting Locations, 2006 to 2008



Source: DFO 2008c.

Figure 5-25 **Snow Crab Commercial Catch per Unit Area in NAFO Division 2J**



Source: DFO 2008c.

Figure 5-26 **Snow Crab Exploitable Biomass Index in NAFO Division 2J**

5.5.6.4 GREENLAND HALIBUT

Within the study area, Greenland halibut (turbot) accounted for approximately 4.7 percent of the total landings by weight (Table 5-9). Greenland halibut landings occur predominantly in NAFO Area 2J, which accounted for approximately 86 percent of the total Greenland halibut landings within the Study Area. NAFO area 2H and 2 G accounted for 12 and 2 percent, respectively, of the total Greenland halibut catch.

Landings occur year round but are primarily taken between January and March with a second smaller peak in August (Figure 5-27).

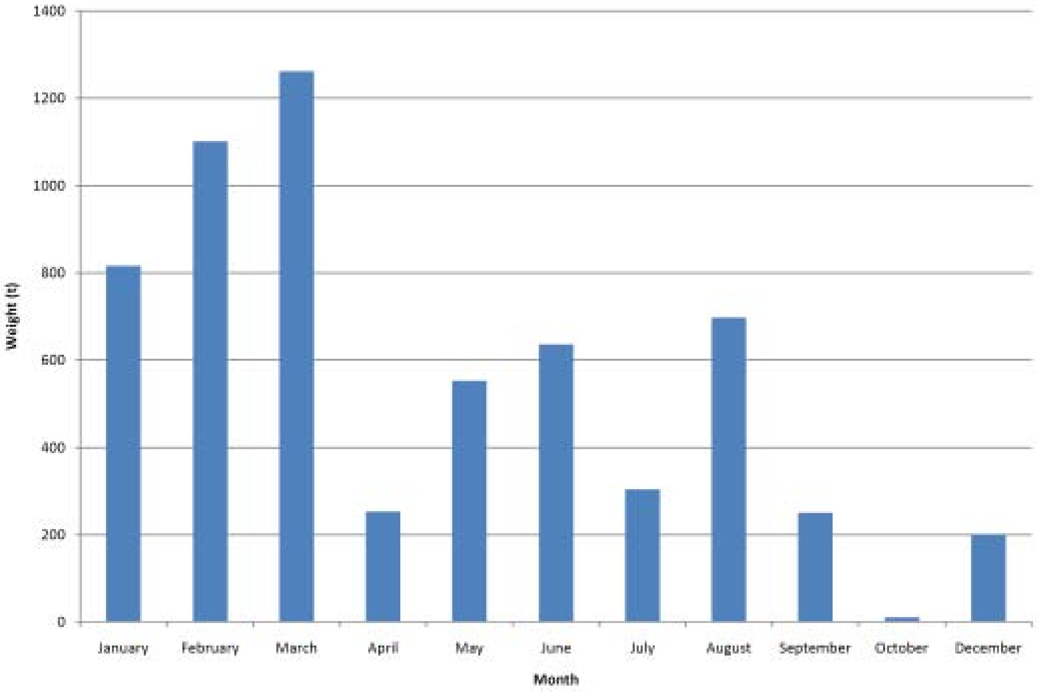


Figure 5-27 Study Area Greenland Halibut Harvest by Month, 2006 to 2008 Average

Greenland halibut harvesting locations, based on the DFO georeferenced data from 2006 to 2008 are shown in Figure 5-28. Greenland halibut were listed as one of the main commercial species harvested. Most Greenland halibut landed are on the south coast, with a little landed in Makkovik (Happy Valley-Goose Bay Public Consultation November 5, 2007).

In 2008, there was no quota set for NAFO Divisions 2GH, with 55 t being landed as by-catch in the northern shrimp fishery (DFO 2009e).

The most recent information with respect to the 2GH population indicates that biomass index of Greenland halibut is currently increasing with the 2004 to 2006 being at or near peak levels (Healey 2007). In NAFO 2J the biomass index for is also increasing and has substantially increased from 2006 to 2007.

5.5.6.5 ICELAND SCALLOP

Within the study area, Iceland scallop accounted for approximately 0.6 percent of the total landings by weight (Table 5-9). NAFO area 2J accounted the remaining 20 percent of Iceland Scallop landings. Landings occur from May thought September peaking in August (Figure 5-29).

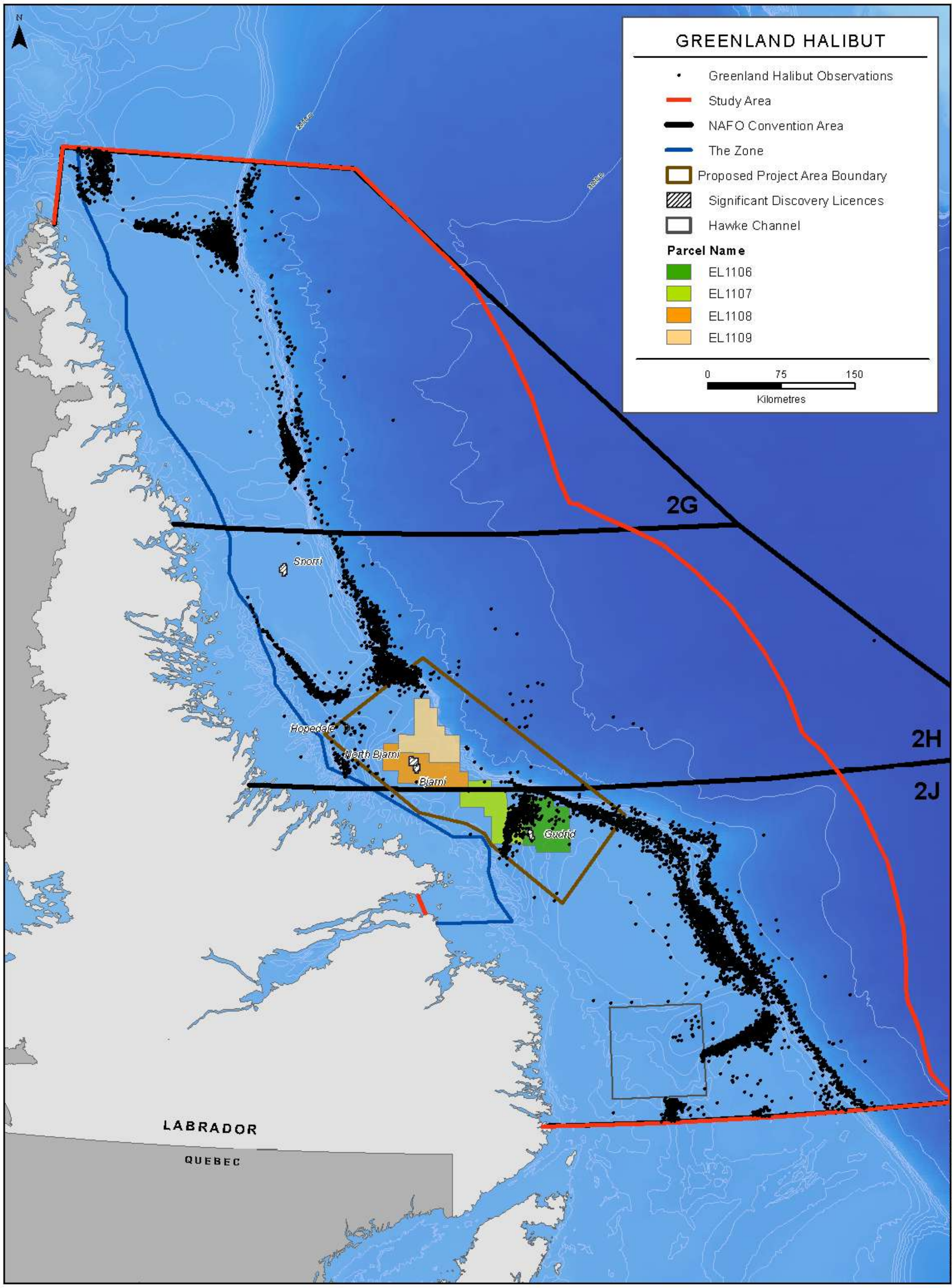


Figure 5-28 Georeferenced Greenland Halibut Harvesting Locations, 2006 to 2008

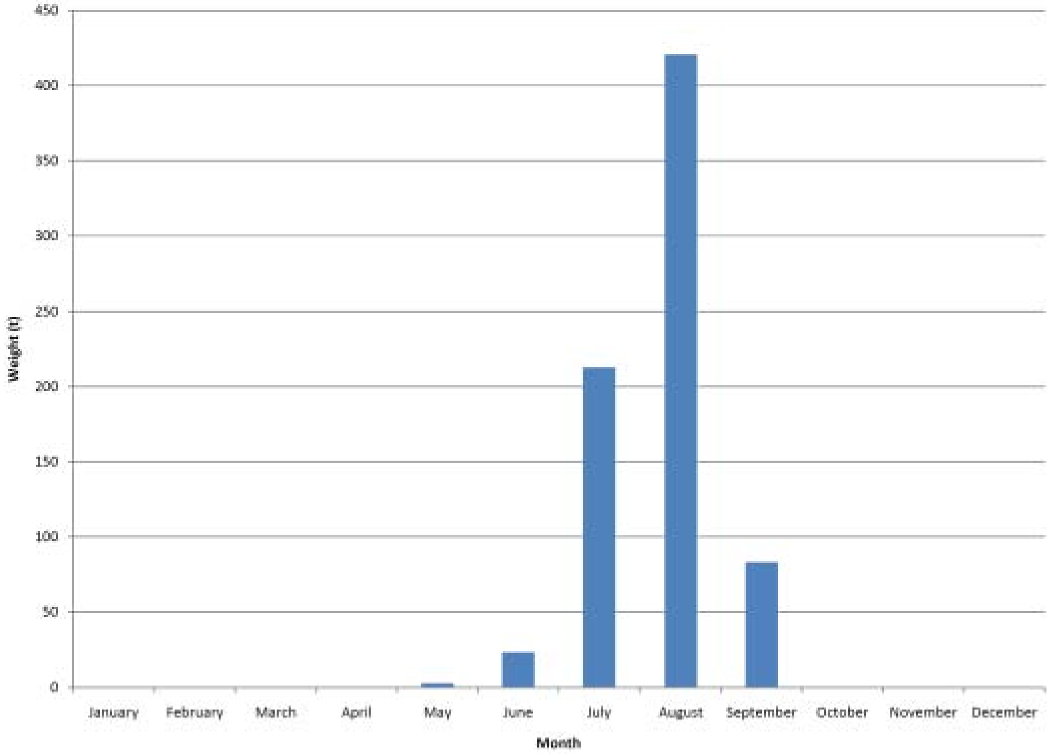


Figure 5-29 Study Area Iceland Harvest by Month, 2006 to 2008 Average

Iceland scallop harvesting locations, averaged for 2006 to 2008, and based on the DFO georeferenced data in relation to the study area are shown in Figure 5-30.

5.5.7 EXPERIMENTAL FISHERIES

An experimental fishery for toad crab for Newfoundland and Labrador was established in the mid-1990s and since 1998 it has been managed pursuant to the Emerging Fisheries Policy (DFO 2007e).

Catch and effort data have been collected since 1997 (via mandatory logbooks). In many areas, effort and landings stabilized around 2000 and over the past six years, annual landings have exceeded 1,000 t (DFO 2007e). Based on the catch and effort data, this level of harvest is expected to continue into the future.

In Newfoundland and Labrador waters, 170 toad crab licenses have been issued. The majority of these went to fishers in NAFO Divisions 3KL, southern 2J and 4R straights (DFO 2007e).

On August 30, 2007, the Honourable Loyola Hearn, then Minister of Fisheries and Oceans, announced the conversion of the exploratory toad crab fishery to a commercial fishery (DFO 200f). As part of this, the 170 fishers licensed to harvest toad crab during 2006 who met license renewal criteria were issued a commercial license in 2007 (DFO 2007f).

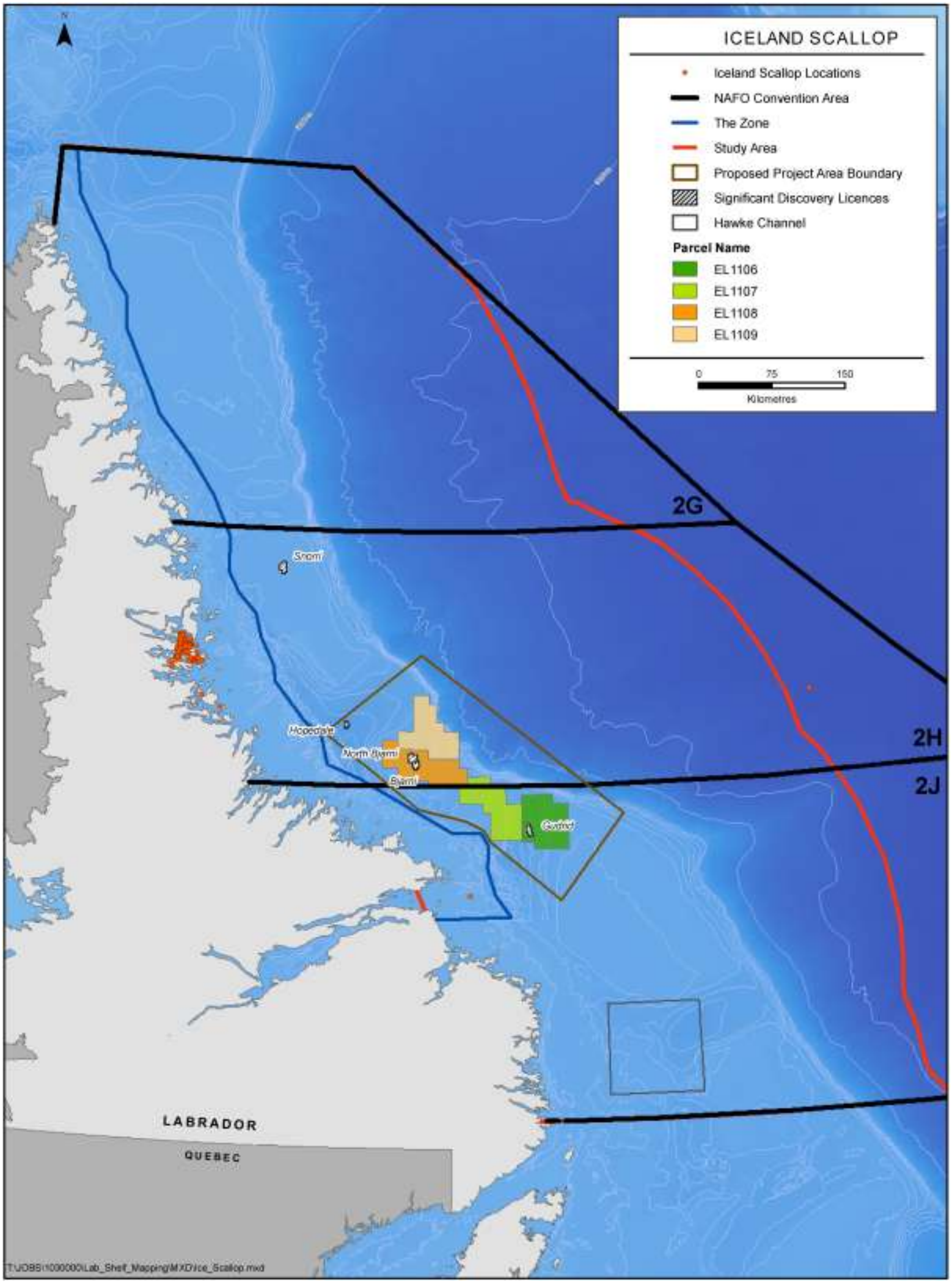


Figure 5-30 Georeferenced Iceland Scallop Harvesting Locations, 2006 to 2008

5.5.8 PROJECT AREA FISHERIES

The three key species (shrimp, crab and Greenland halibut) harvested in the Project Area are illustrated in Figure 5-31. There is a lot of overlap with the northern shrimp and Greenland halibut harvesting areas.

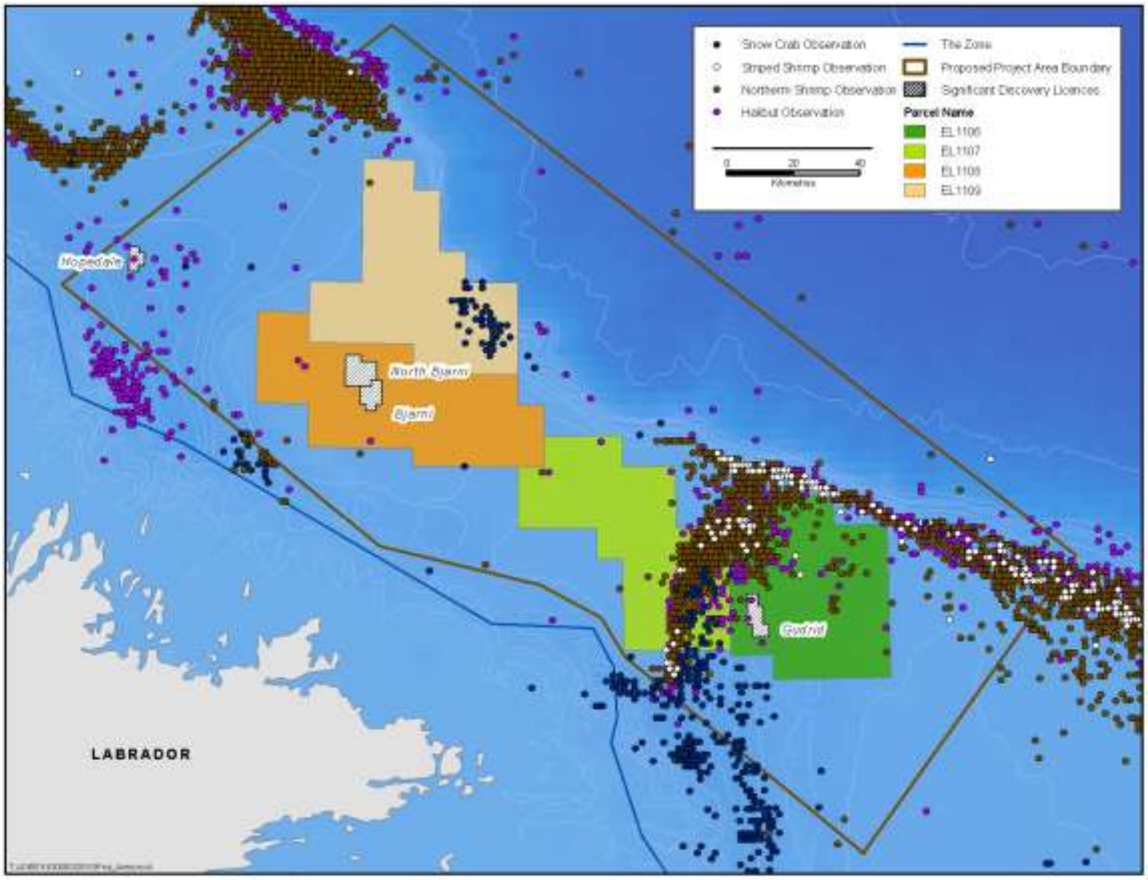


Figure 5-31 **Commercially-harvested Fish Species in the Project Area**

5.5.9 TRADITIONAL FISHERIES

Food that is used by traditional harvesting is referred to as country food (or wild food) and is important not only to the economy but also to the health and social well-being of families (Alton Mackey and Orr 1987). Alton Mackey and Orr (1987) conducted a study in 1980/1981 on the use of country food in Makkovik and found it accounted for 28,738 pounds, of which fish accounted for 30 percent (8,754 kg). The main traditional fish species were Atlantic cod (2,864 kg) and arctic char (2,830 kg). Other traditional fish species harvested included rock cod (1,530 kg), salmon (1,030 kg) and other fish species (equalling 320 kg combined) such as herring, capelin, smelt, flounder, turbot, halibut, whitefish, redfish and sculpin. A variety of nets, traps and jigs are used to harvest fish, including the use of motor boats; these require substantial investment in equipment, repairs and maintenance (Labrador Shelf SEA Section 4.10.6 (Sikumiut (2008)).

Postville residents only harvest smelt near the head of the bays during spawning, while capelin are harvested during spawning from sandy beaches within the bays and beaches along coast outside the bays (including Hopedale, Sandy Beach and the Rapid Point area). The importance of cod varied along the coast. Salmon are harvested along the coast using traps, nets, or jigged, in late June/early July (Brice-Bennett 1977) and char were traditionally speared as they migrated up the rivers. Char and salmon were also caught by n*et al.*ong the coast. Ice fishing camps can be found at the head of Anaktalak Bay in the spring (Labrador Shelf SEA Section 4.10.6 (Sikumiut (2008)).

"The Zone" encompasses 48,690 km^2 of ocean established under the Labrador Inuit Land Claims Agreement (2005). While overall responsibility for the conservation and management of the fishery in "The Zone" will be retained by the provincial and federal governments, The Torngat Joint Fisheries Board, a co-management board appointed by the Nunatsiavut Government, Government of Canada and Government of Newfoundland and Labrador, is the primary body for making recommendations to governments on the conservation and management of fish in "The Zone". Labrador Inuit will have the right to harvest fish and marine mammals for Inuit food, social and ceremonial purposes within "The Zone" (Labrador Shelf SEA Section 4.10.6.1 (Sikumiut 2008)).

5.5.10 FISHERIES AND OCEANS CANADA SCIENCE SURVEYS

Shrimp are surveyed from water depths between 100 to 750 m by the Canadian Association of Prawn Producers (in conjunction with DFO) in 2G (outside the Project Area). This survey has been run annually since 2005 from July 15 through the first week of September; it will continue for a minimum of five consecutive years (to 2010 as a minimum) (R. Anthony, pers. comm., in Labrador Shelf SEA Section 4.10.3.14 (Sikumiut 2008)). The only portion of the Labrador Shelf Study Area currently surveyed as part of the multispecies survey (conducted annually between October and December) is NAFO Area 2J (Exploration License 1106); no surveys have been conducted since 1999 (R. Anthony, pers. comm., in Labrador Shelf SEA Section 4.10.3.14 (Sikumiut 2008)).

5.6 SENSITIVE AREAS

A number of locations have been identified as "sensitive areas" within the Study Area (Figure 5-32) (Section 4.11 in the SEA (Sikumiut 2008)), based on:

- a level of protection provided by either federal (e.g., National Parks) or provincial (e.g., ecological reserves) legislation;
- the potential for protection provided by either federal or provincial legislation; or
- ecological or socio-cultural importance that do not have protection under federal or provincial legislation (e.g., IBAs or traditional harvesting areas).

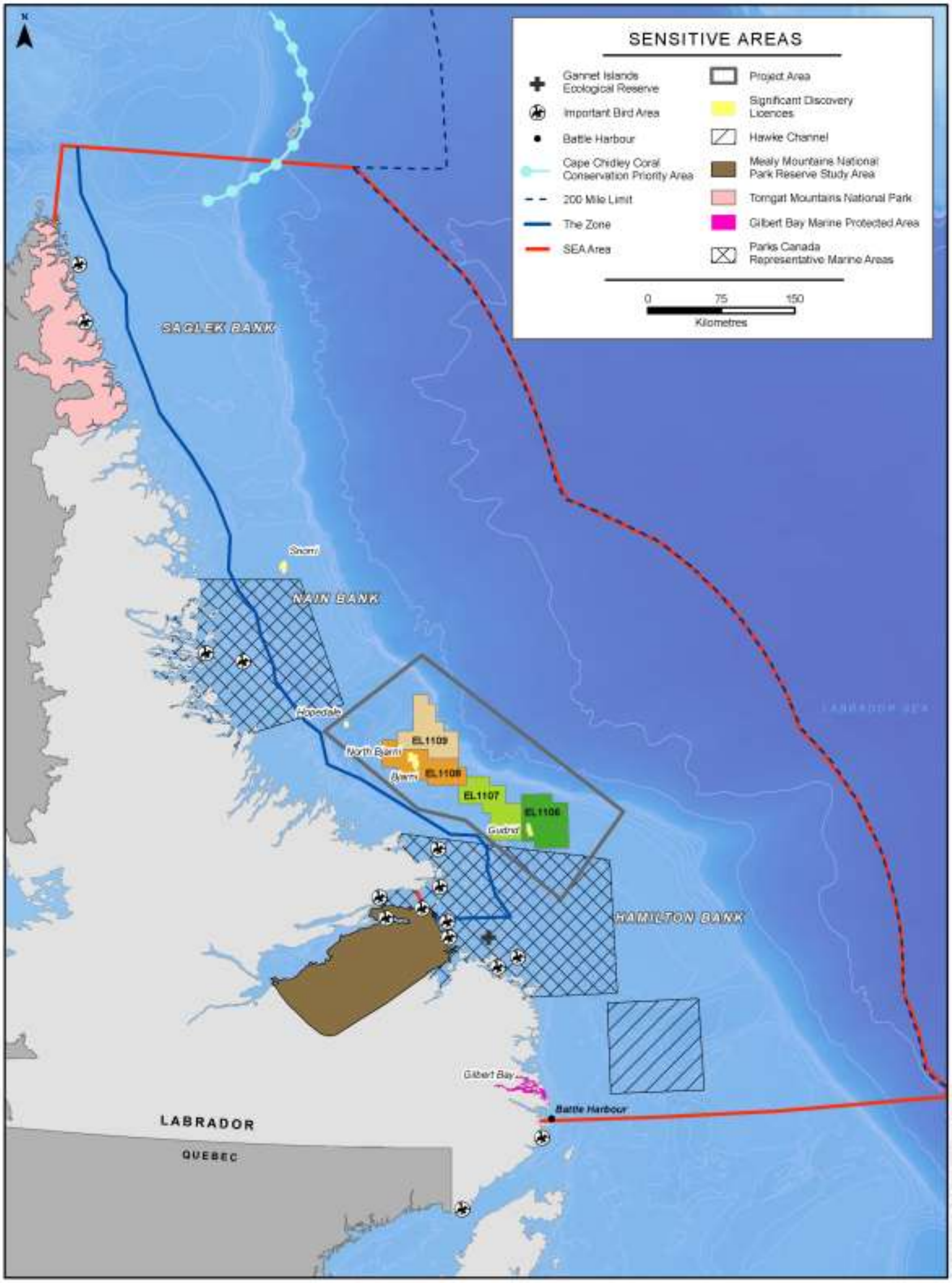


Figure 5-32 Sensitive Areas in the Vicinity of the Project

Sensitive areas identified within the Study Area are shown in Figure 5-32. These include:

- National Marine Conservation Areas (NMCAs): Nain Bight and Hamilton Inlet have been identified as representative marine areas (although there is no NMCA for the Labrador Shelf);

- Battle Harbour is managed under the *Parks Canada Agency Act*'s National Site Historic Program; designated as a National Historic District;

- Gilbert Bay (approximately 60 km^2) was classified as a Marine Protected Area (MPA) under the *Oceans Act* in 2005 due to its distinct population of Atlantic cod;

- Hawke Channel-Hamilton Bank is a highly productive area as a result of an areas of regional upwelling, with a number of important commercial fish species (i.e., shrimp, snow crab and capelin (Brown 1999)); it is also the location of the northern spawning grounds of Atlantic cod (Rose and O'Driscoll 2002);

- Gannett Islands Ecological Reserve includes the largest razorbill colony in North America and the largest seabird colony in Labrador and is situated on seven islands and their surrounding marine waters southwest of the Project Area, just south of the southern boundary of the Zone;

- fourteen IBAs (including the Gannet Islands Ecological Reserve) are located within the Study Area; none are located within the Project Area;

- Torngat Mountains National Park is 9,700 km^2, located at the northern tip of Labrador; no commercial, industrial or mineral development will be permitted, although traditional fishing and hunting can still occur within the park;

- Mealy Mountains National Park: while outside the Study Area, this 21,000 km^2 National extends to the coast and the adjacent waters are part of the proposed Hamilton Inlet MPA; and

- Coral Conservation Priority Area: Although there is one area within the Study Area at the northern tip of Labrador, there is no Coral Conservation Priority Area near the Project Area.

6.0 ENVIRONMENTAL EFFECTS ASSESSMENT METHODS

6.1 VALUED ENVIRONMENTAL COMPONENTS

As per the Scoping Document issued by the C-NLOPB (C-NLOPB 2009; Appendix A), the valued ecosystem components (VECs) include Species at Risk (both those listed under the *SARA* Schedule 1 and under consideration by COSEWIC), Marine Fish and Fish Habitat, Marine Mammals and Sea Turtles, Marine Birds, Commercial Fisheries and Sensitive Areas.

Accidental events (such as an unplanned hydrocarbon release) associated with Project activities are assessed in this environmental assessment. In addition, this environmental assessment includes an analysis of cumulative environmental effects.

6.2 ASSESSMENT BOUNDARIES

Boundaries help focus the scope of the environmental assessment and allow a meaningful analysis of potential environmental effects associated with the Project. The environmental assessment considers the potential effects of the proposed Project within spatial and temporal boundaries that encompass the periods and areas during and within which the Project may potentially interact with, and have an effect on, one or more VEC. These boundaries may vary with each VEC and the factors considered.

6.2.1 SPATIAL

The regional scale study area boundaries are addressed in this environmental assessment and will take into consideration the information compiled in the C-NLOPB's SEA for the Labrador Shelf Offshore Area (Sikumiut 2008). The SEA Study Area boundary encompasses the Project Study Area boundary. The Project Area is defined by the project leases plus a 30-km buffer around the exploration leases (shown in Figure 1-1).

6.2.2 TEMPORAL

Temporal boundaries describe the timing of Project activities. The temporal boundaries for the Project are 2009 to 2017 inclusive, with the timing of actual survey activities between July 1st and November 30th within any particular year.

6.2.3 ADMINISTRATIVE

Administrative boundaries refer to the spatial and temporal dimensions imposed on the environmental assessment for political, socio-cultural or economic reasons. Administrative boundaries are usually associated with resource management (e.g., NAFO Division and Unit Areas designating fishing areas along Newfoundland and Labrador's coast and offshore area).

6.3 POTENTIAL INTERACTIONS

The environmental assessment focuses on identifying and evaluating potential interactions between the Project components and activities and each of the VECs under consideration. As a first step in the environmental effects analysis, potential Project-VEC interactions are identified and discussed (Table 6-1).

Table 6-1 Potential Project-Valued Environmental Component Interactions

Project Activity	Species at Risk	Fish and Fish Habitat	Marine Mammals and Sea Turtles	Seabirds	Commercial and Traditional Fisheries	Sensitive Areas
Seismic Array Noise	✓	✓	✓	✓	✓	✓
Seismic Vessel Noise	✓	✓	✓	✓		
Supply Vessel Noise	✓	✓	✓	✓		
Picket Vessel Noise	✓	✓	✓	✓		
Geo-hazard Vessel Noise	✓	✓	✓	✓		
Presence of Seismic Vessel	✓		✓	✓	✓	
Presence of Supply Vessel	✓		✓	✓		
Presence of Picket Vessel	✓		✓	✓		
Presence of Geo-hazard Vessel	✓		✓	✓		
Vessel Lights	✓	✓		✓		
Air Emissions	✓	✓	✓	✓		
Domestic/Sanitary Wastes	✓	✓	✓	✓		
Helicopter	✓		✓	✓		
Accidental Spill from Streamer/EM Transmitter	✓	✓	✓	✓		✓
Accidental Diesel Spill from Boat (due to collision/sinking)	✓	✓	✓	✓		✓
Other Projects and Activities						
Chevron Seismic Surveys	✓	✓	✓	✓	✓	✓
Investcan Seismic Surveys	✓	✓	✓	✓	✓	✓
Fishing Activities	✓	✓	✓	✓	✓	
Marine Traffic	✓	✓	✓	✓	✓	
Tourism and Recreation	✓		✓	✓		✓

6.4 EXISTING KNOWLEDGE

Existing knowledge concerning these potential interactions is also reviewed and summarized. All identified VECs have the potential to interact with the Project (seismic surveys).

6.5 RESIDUAL ENVIRONMENTAL EFFECTS SIGNIFICANCE CRITERIA

Evaluating the significance of predicted residual environmental effects is one of the critical stages in an environmental assessment. Significant environmental effects are those adverse effects that will cause a change that will alter the status or integrity of a VEC beyond an acceptable level. In this environmental assessment, environmental effects are evaluated as significant or non significant based on definitions of significance that have been developed and used for each VEC.

The definitions for significant adverse environmental effects integrate key factors such as magnitude (i.e., the portion of the VEC population affected), potential changes in VEC distribution and abundance, effect duration (i.e., the time required for the VEC to return to pre-project levels), frequency, and geographic extent (refer to Section 6.7 for a more detailed definition of these criteria). They also include other important considerations such as interrelationships between populations and species, as well as any potential for changes in the overall integrity of affected populations. For each VEC, an adverse environmental effect that does not meet the criteria for a significant environmental effect is evaluated as not significant.

6.6 ENVIRONMENTAL EFFECTS MANAGEMENT

MMO(s) will be on board the vessel(s) to provide proper identification of marine mammals and species at risk for mitigation purposes and to collect opportunistic data on marine mammal behaviours and distribution with and without air guns operating. Seabird observations will also be collected. In addition, mitigation measures will be applied as set out in the "*Geophysical, Geological, Environmental and Geotechnical Program Guidelines*" (C-NLOPB 2008), which incorporates verbatim the *Statement of Canadian Practice on Mitigation of Seismic Noise in the Marine Environment* (DFO 2007a).

Plans will be developed to avoid or lessen any potential effects on the commercial fishery. These plans will include elements such as good communications (e.g., Fisheries Broadcast and Okalakatiget Society notifications and Notices to Shipping), a dedicated FLO on the vessel(s), a Single Point of Contact, use of a picket vessel, avoidance of areas during times of heavy fixed gear use, and a fishing gear damage compensation program.

6.7 RESIDUAL ENVIRONMENTAL EFFECTS ANALYSIS

This stage entails the assessment of the potential environmental effects associated with the Project's components/activities and potential accidental events for each of the VECs under consideration. Environmental effects are analyzed qualitatively and, where possible, quantitatively using existing knowledge, professional judgment and appropriate analytical tools.

The following includes some of the key factors that can be considered for determining adverse environmental effects, as per the Agency guidelines (CEA Agency 1994):

- loss of rare or endangered species;
- loss or avoidance of critical/productive habitat;
- negative environmental effects on the health of biota;
- reductions in biological diversity;
- interruption of movement corridors and migration routes; and
- discharge of persistent and/or toxic chemicals;

Potential environmental effects on each VEC are characterized using the following five descriptors:

- Magnitude: the nature and degree of the predicted environmental effect. Rating depends on the nature of the VEC and the potential environmental effect. For biophysical/ecological VECs the rating system is as follows:
    - Low: affects 0 to 10 percent of individuals (or critical habitat as defined by *SARA*) in an affected area due to exclusion due to disturbance, sublethal effects or mortality for one generation or less;
    - Medium: affects >10 to 25 percent of individuals in an affected area due to exclusion due to disturbance, sublethal effects or mortality for one or two generations;
    - High: affects more than 25 percent of individuals in an affected area (or due to the loss of an individual(s) in the case of a species at risk) due to exclusion due to disturbance, sublethal effects or mortality.
- Geographical Extent: describes the area within which an effect of a defined magnitude occurs;
- Frequency: the number of times during a project or a specific project phase that an effect may occur (i.e., one time, multiple);
- Duration: typically defined in terms of the period of time required until the VEC returns to its baseline condition or the environmental effect can no longer be measured or otherwise perceived (defined specifically for each VEC, may be a specific period of time):
    - 1 = <1 month
    - 2 = 1 to 12 months.

  - 3 = 13 to 36 months
  - 4 = 37 to 72 months
  - 5 = >72 months

- Reversibility: the likelihood that a measurable parameter will recover from an environmental effect, including through active management techniques such as habitat restoration works; and

- Ecological Context: the general characteristics of the area in which the Project is located; typically defined as limited or no anthropogenic disturbance (i.e., not substantially affected by human activity) or anthropogenically developed (i.e., the area has been substantially disturbed by human development or human development is still present).

Where possible, these characteristics are described quantitatively for each residual environmental effect. Where these characteristics cannot be expressed quantitatively, at minimum, they are described using qualitative terms that are defined specifically for the VEC or environmental effect. The environmental effects assessment is summarized in tabular form (see Table 6-2 for a sample matrix).

Table 6-2 Template for Environmental Effects Assessment

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Seismic Array Noise							
Seismic Vessel Noise							
Supply Vessel Noise							
Picket Vessel Noise							
Geo-hazard Vessel Noise							
Presence of Seismic Vessel							
Presence of Supply Vessel							
Presence of Picket Vessel							
Presence of Geo-hazard Vessel							
Vessel Lights							
Air Emissions							

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Domestic/Sanitary Wastes							
Helicopter							

KEY:

Magnitude:
1 = Low: <10 percent of Study Area population or habitat will be exposed to the effect.
2 = Medium: 11 to 25 percent of Study Area population or habitat will be exposed to the effect.
3 = High: >25 percent of Study Area population or habitat will be exposed to the effect.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 = <1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse effects.

A significant adverse environmental effect is defined as one with a medium or high magnitude for a duration greater than one year over a geographic extent greater than 100 km^2.

6.8 CUMULATIVE ENVIRONMENTAL EFFECTS

Individual environmental effects are not necessarily mutually exclusive of each other but can accumulate and interact to result in cumulative environmental effects. This environmental assessment includes consideration of cumulative environmental effects for each VEC. The cumulative environmental effects assessment is presented in a stand-alone section (Chapter 8).

Within-Project cumulative effects (i.e., those due to the accumulation and/or interaction of each Project’s own environmental effects) are considered as part of the Project-specific environmental effects analyses described above (i.e., the overall environmental effect of each project on a VEC). This section focuses on the cumulative environmental effects of a seismic survey in combination with other relevant projects and activities.

The region's natural and human environments have been affected by past and ongoing human activities. The description of the existing (baseline) environment reflects the effects of these other actions. The evaluation of cumulative environmental effects considers the nature and degree of change from these baseline environmental conditions as a result of the proposed program in combination with other ongoing and planned projects and activities.

An important step in undertaking a cumulative environmental effects assessment is the identification of other projects whose environmental effects will likely act in combination with those of the project under review to bring about cumulative effects. *CEAA* requires that only projects and activities that have been or will be conducted be considered. The degree of certainty that the project will proceed must therefore be considered (CEA Agency 1999). The other projects and activities considered in this assessment therefore include those that are ongoing or likely to proceed and have been issued permits, licenses, leases or other forms of approval (as specified by CEA Agency 1994). The cumulative environmental effects assessment considers the environmental effects of the seismic program in combination with the following activities:

- seismic survey program(s) by other operators;
- marine transportation;
- tourism/recreation; and
- commercial and traditional fishing activities.

Chevron is planning to conduct potential 3-D and/or 2-D seismic programs between 2011 and 2014 on or adjacent to Exploration License 1109 (directly adjacent to Husky's lease and within the Husky Energy Project Area), as indicated by their Project Description.

Vulcan Minerals Inc. is planning to conduct potential 3-D and/or 2-D seismic programs (as well as yet-to-be-determined area of geo-hazard survey and VSPs, address all petroleum exploration seismic-related activities) between 2010 and 2017 on or adjacent to Exploration License 1107 (directly between Husky's leases and within the Husky Energy Project Area), as indicated by their Project Description.

6.9 FOLLOW-UP AND MONITORING

Marine mammal monitoring (including species at risk) will be conducted during the seismic survey(s). MMO(s) will be on board the vessel(s) to provide proper identification of marine mammals and species at risk for mitigation purposes and to collect opportunistic data on marine mammal behaviours and distribution with and without air guns operating. Seabird observations will also be collected.

6.10 SUMMARY OF RESIDUAL ENVIRONMENTAL EFFECTS

Significance ratings for the predicted residual environmental effects of each Project component/activity and for the Project as a whole are provided in summary tables for each VEC (see Table 6-3 as an example).

Residual environmental effects are those remaining following application of Project mitigation. These predictions must:

- facilitate decision-making with respect to the proposed Project;
- clearly specify any degree of uncertainty inherent in the projections; and
- clearly identify positive and negative environmental effects (both biophysical and socio-economic) of the proposed Project.

Table 6-3 Template for Summary of Residual Environmental Effects

Project Activity	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Seismic Array Noise			
Seismic Vessel Noise			
Supply Vessel Noise			
Picket Vessel Noise			
Geo-hazard Vessel Noise			
Presence of Seismic Vessel			
Presence of Supply Vessel			
Presence of Picket Vessel			
Presence of Geo-hazard Vessel			
Vessel Lights			
Air Emissions			
Domestic/Sanitary Wastes			
Helicopter			

KEY:

Residual Environmental Effects Rating:	Levels of Confidence:	Probability of Occurrence:
S = Significant Adverse Environmental Effect	1 = Low level of Confidence	1 = Low Probability of Occurrence
NS = Not Significant Adverse Environmental Effect	2 = Medium Level of Confidence	2 = Medium Probability of Occurrence
P = Positive Environmental Effect	3 = High level of Confidence	3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria.

The evaluation of the significance of the predicted residual environmental effects is based on a review of relevant literature, available data (e.g., from DFO, CWS) and professional judgment. In some instances, assessing and evaluating potential environmental effects is difficult due to limitations of available information. Ratings are therefore provided to indicate the level of confidence in each prediction. The level of confidence ratings provide a general indication of the confidence within which each environmental effects prediction is made based on professional judgment and the environmental effects recorded from similar existing projects. The likelihood of the occurrence of any predicted significant adverse environmental effects is also indicated, based on previous scientific research and experience.

7.0 ENVIRONMENTAL EFFECTS ASSESSMENT ANALYSES

7.1 SPECIES AT RISK

The assessment of environmental effects on Species at Risk considers those species that are listed on Schedule 1 of the *SARA* (Section 5.1.1), or designated as Endangered, Threatened, or Special Concern by COSEWIC (Section 5.1.2), which are most likely to occur within the Study Area and thus will potentially interact with the Project. The effects of accidental events (except potential vessel strikes to marine mammal species at risk, considered herein) are assessed in Chapter 9. Cumulative environmental effects on Species at Risk are assessed in Chapter 8.

7.1.1 ASSESSMENT BOUNDARIES

7.1.1.1 SPATIAL BOUNDARIES

Spatial boundaries for the assessment of potential environmental effects on Species at Risk encompass the entire area within which interactions with the Project are likely to occur. These boundaries were established through consideration of the probable geographical extent of the environmental effects (i.e., the zone of influence) on the VEC and generally reflect the maximum area where Program-specific environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. Spatial boundaries may vary by species, but for Species at Risk boundaries are considered to be the spatial extent of either the 2-D or 3-D survey area (depending on the stage of the Project) plus an additional 30 km buffer (refer to Figure 1-1).

7.1.1.2 TEMPORAL BOUNDARIES

The temporal boundaries for the assessment of potential environmental effects on Species at Risk are 2010 to 2017 inclusive. Timing of potential interactions will occur during scheduled survey activities (between July 1st and November 30th of any particular year). The initial 2-D survey is estimated to take up to 40 days, and any well site survey approximately four to six days. Although the spatial extent of future 3-D program has not yet been determined, duration is expected to range from 30 to 75 days. A VSP survey takes less than 24 hours.

7.1.1.3 ADMINISTRATIVE BOUNDARIES

Administrative boundaries for Species at Risk include legal protection for wildlife species under *SARA*. *SARA* is a federal commitment to prevent Canadian indigenous wildlife species from becoming extirpated or extinct, to secure the necessary actions for their recovery, and to encourage wildlife management to prevent more species from becoming at-risk. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) ranks species according to conservation concern. Schedule 1 of *SARA*, which is the official list of wildlife species at risk in Canada, includes species that are extirpated (locally extinct), endangered, threatened, or of special concern (DFO 2009, Internet site). Once added to Schedule 1, species (and their critical habitats) are afforded legal protection and recovery measures are developed and implemented. Under *SARA*, it is an offence to:

- kill, harm, harass, capture or take an individual of a listed species that is extirpated, endangered or threatened;
- possess, collect, buy, sell or trade an individual of a listed species that is extirpated, endangered or threatened, or its part or derivative; and
- damage or destroy the residence of one or more individuals of a listed endangered or threatened species or of a listed extirpated species if a recovery strategy has recommended its reintroduction.

Currently, recovery strategies and/or management plans are in place for the three species of wolffish, leatherback turtle, Northwest Atlantic blue whale population (proposed), Northwest Atlantic walrus population (determined to be not feasible), Eskimo Curlew (determined to be not feasible), Harlequin Duck (eastern population in Atlantic Canada and Quebec).

Marine mammals and fish, including those species designated at risk, are further protected in Canada through federal legislation under the *Fisheries Act*. Amongst other things, the *Fisheries Act* mandates no harmful alteration, disruption or destruction of fish habitat (Section 35; administered by DFO). Marine mammals are included in the definition of fish under the Act. Furthermore, the *Marine Mammal Regulations* under the *Fisheries Act* stipulate, "*No person shall disturb a marine mammal except when fishing for marine mammals under the authority of these regulations*".

Marine birds are protected federally under the *Migratory Birds Convention Act*, which is administered by Environment Canada.

Technical boundaries relate to limitations of available data for Species at Risk within the Study Area as well as limits to scientific knowledge (including effects of seismic operations on marine species). Marine mammal and sea turtle distribution can be unpredictable, and the majority of available information on marine mammals and sea turtles relates to a very broad regional scale. Detailed data characterizing the existing environment for marine mammals and sea turtles on the Labrador Shelf are somewhat limited. Still, many of the species have similar limiting factors (e.g., vulnerability to ship strikes and anthropogenic noise), such that mitigation procedures for more well-known species may provide protection for species that are data deficient.

7.1.2 POTENTIAL INTERACTIONS

7.1.2.1 MARINE FISH

Seven marine fish Species at Risk occur within the Study Area and therefore have the potential to interact with routine Project activities. Potential interactions include:

- effects of noise from all routine activities (vessels, helicopters, seismic array, sounder, side-scan sonar, boomer, etc.).

Potential project interactions with marine fish Species at Risk are indicated in Table 7-1. Environmental effects of seismic acquisition on marine fish Species at Risk could potentially result in an environmental effect of concern, even with mitigation. Therefore, the potential environmental effects of seismic acquisition on the Marine Fish Species at Risk are the primary focus of this environmental assessment and are discussed in detail later in this section. Accidental spills are discussed in the section on Accidents and Malfunctions (Section 9.3.1.1).

Table 7-1 Potential Interactions between the Project and Marine Fish Species at Risk

Project Activities/ Physical Works	Wolffish (3 species)	Atlantic Cod	Porbeagle Shark	Roughhead Grenadier	American Plaice
Seismic Array Noise	✓	✓	✓	✓	✓
Seismic Vessel Noise	✓	✓	✓	✓	✓
Supply Vessel Noise	✓	✓	✓	✓	✓
Picket Vessel Noise	✓	✓	✓	✓	✓
Geo-hazard Vessel Noise	✓	✓	✓	✓	✓
Presence of Seismic Vessel	✓	✓	✓	✓	✓
Presence of Supply Vessel	✓	✓	✓	✓	✓
Presence of Picket Vessel	✓	✓	✓	✓	✓
Presence of Geo-hazard Vessel	✓	✓	✓	✓	✓
Vessel lights	✓	✓	✓	✓	✓
Air Emissions	✓	✓	✓	✓	✓
Sanitary/Domestic Waste	✓	✓	✓	✓	✓
Helicopter					

7.1.2.2 MARINE MAMMALS AND SEA TURTLES

Eleven marine mammal and sea turtle Species at Risk occur within the Study Area and therefore have the potential to interact with routine Project activities. Potential interactions include:

- effect from collisions with vessels;
- effects associated with the presence of vessel lights; and
- effects of noise from all routine activities (vessels, helicopters, seismic array, sounder, side-scan sonar, boomer, etc.).

A detailed list of the potential interactions between the Project and Marine Mammal and Sea Turtle Species at Risk is provided in Table 7-2. Accidental spills are discussed in the section on Accidents and Malfunctions (Section 9.3.1.2).

Table 7-2 Potential Interactions between the Project and Marine Mammal and Sea Turtle Species at Risk

Project Activities/ Physical Works	Odontocetes (4 species)	Mysticetes (4 species)	Pinnipeds (1 species)	Sea Turtles (1 species)	Polar Bear
Seismic Array Noise	✓	✓	✓	✓	✓
Seismic Vessel Noise	✓	✓	✓	✓	✓
Supply Vessel Noise	✓	✓	✓	✓	✓
Picket Vessel Noise	✓	✓	✓	✓	✓
Geo-hazard Vessel Noise	✓	✓	✓	✓	✓
Presence of Seismic Vessel	✓	✓	✓	✓	✓
Presence of Supply Vessel	✓	✓	✓	✓	✓
Presence of Picket Vessel	✓	✓	✓	✓	✓
Presence of Geo-hazard Vessel	✓	✓	✓	✓	✓
Vessel lights	✓	✓	✓	✓	✓
Air Emissions					
Sanitary/Domestic Waste					
Helicopter					

7.1.2.3 SEABIRDS

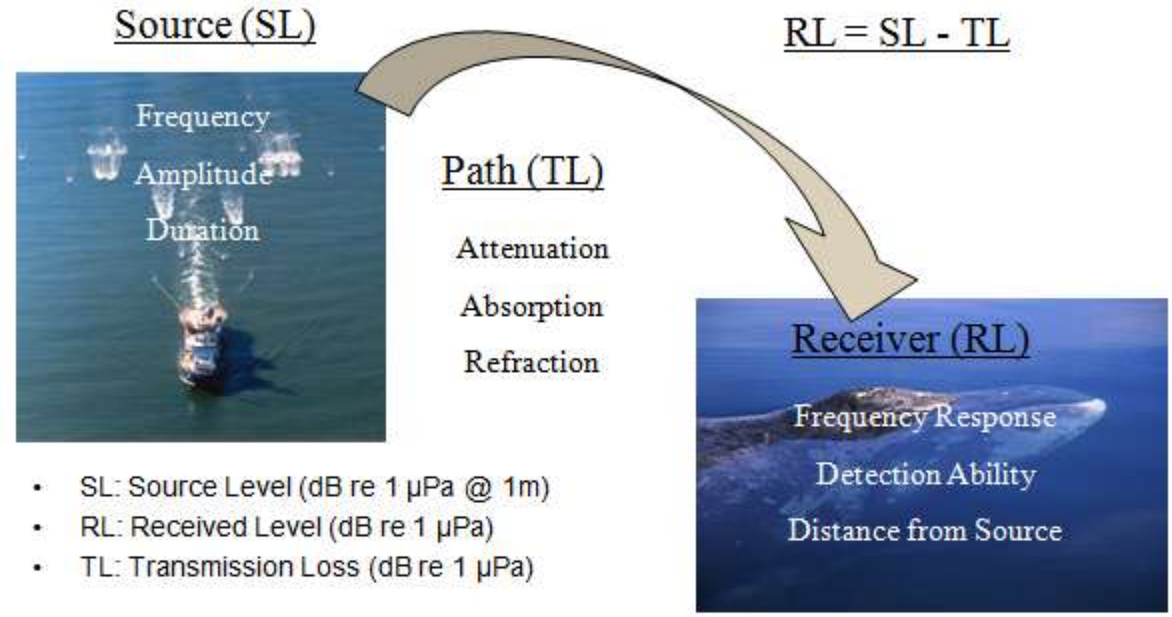
Six species of seabirds Species at Risk occur within the Study Area; however, with the exception of the Ivory Gull, it is unlikely that the seabird Species at Risk will interact with the Project, as the species are found either in rivers (Harlequin Duck), along shorelines (Peregrine Falcon, Red Knot, Barrows Goldeneye) or are believed to be extirpated (Eskimo Curlew). Ivory Gull has the potential to interact with routine Project activities. Potential interactions include:

- effects associated with the presence of vessel lights; and
- effects of noise from all routine activities (vessels, helicopters, seismic array, sounder, side-scan sonar, boomer, etc.).

Accidental spills are discussed in the section on Accidents and Malfunctions (Section 9.3.1.3)

7.1.3 EXISTING KNOWLEDGE

Anthropogenic sound sources have been grouped into six categories: shipping, seismic surveying, sonars, explosions, industrial activity and miscellaneous (NRC 2003). The effects of underwater sound are based on the Source - Path - Receiver concept shown in Figure 7-1. For the purposes of this assessment the source is an air gun array and the receivers considered are marine organisms.



Note: Acoustic terminology and units were explained in Section 3.3.2.

Figure 7-1 Source - Path - Receiver Model

The acoustic energy or sound originates with a source. The sound or acoustic energy from this source radiates outward and travels through the water as pressure waves. The sound level decreases with increasing distance from the source. The ability of a marine animal to hear sounds is dependent upon (LGL 2005b):

- the degree of propagation loss between the source and the receiver,
- the hearing abilities of the animal; and
- the amount of natural ambient or background sound in the surrounding sea.

Wind, waves, precipitation, vessel traffic and biological sources all contribute to ambient sound. Ambient sound is highly variable on oceanic continental shelves because of animal diversity and density, and proximity to shore (increased human presence, traffic and activities; breaking waves, etc.). This may result in considerable variability in the range at which marine animals can detect anthropogenic sounds, because of masking by ambient sound.

There are various potential effects of exposure to sound from seismic and other sources. The following section will provide an overview of the scientific information on the effects of sound on marine animals.

7.1.3.1 MARINE FISH

Sound-related Effects on Marine Fish

Fish with swim bladders and specialized auditory couplings to the inner ear (e.g., herring) are highly sensitive to sound pressure. Fish with a swim bladder but without a specialized auditory coupling (e.g., cod and redfish) are moderately sensitive, while fish with a reduced or absent swim bladder (e.g., mackerel and flounder) have low sensitivity (Fay 1988). Fay (1988) has developed an approximate threshold for each of these three classifications of hearing sensitivity. The highly sensitive group has a hearing threshold of less than 80 dB re 1µPa. The moderately sensitive threshold is between 80 and 100 dB re 1µPa and those fish with a low sensitivity have a threshold of greater than 100 dB re 1µPa. For example, cod, salmon, plaice and herring have hearing sensitivities between 80 and 200 Hz with a sensitivity threshold at 80 to 100 dB re1µPa (Mitson 1995). For a review of hearing sensitivities of fish see Popper and Carlson (1998) or Popper *et al.* (2003). There is much diversity in the structure of the auditory systems of different species. Ideally one would examine the effects of air guns on all types of hearing specializations. In addition, most studies to date have concentrated on short-term effects. Recent studies have been conducted on the effects of seismic noise on lobster and monkfish (*Lophius americanus*) eggs and larvae. Exposure of lobster to very high as well as low sound levels had no effects on delayed mortality or damage to animal equilibrium and posture, nor was there evidence for loss of legs or other appendages; however sub-lethal effects were observed (Payne *et al.* 2007). Laboratory testing and modelling indicated that monkfish eggs or near-hatch larvae that may float in veils on the sea surface are unlikely to be affected by seismic air gun discharges (capelin eggs were also tested during the same study with the same result, no effect) (Payne *et al*. 2009).

Behavioural Effects

The frequency of seismic pulses does fall within the general hearing range of fishes, indicating that fish will be able to detect seismic sound at some range. However, responses to these sounds vary according to species. Behavioural effects of seismic activity on marine fish may include avoidance behaviour, increased swimming speeds, disruption of reproductive behaviour and alteration of migration routes (McCauley *et al*. 2000a, 2000b). A comparison of moderately sensitive species such as cod, haddock, pollock and redfish determined a measurable behavioural response in the range of 160 to 188 dB re 1µPa (Turnpenny and Nedwell 1994). Gadoids have been shown to leave the area during seismic surveys (Skalski *et al*. 1992; Lokkeborg and Soldal 1993; Engås *et al*. 1996; Slotte *et al*. 2004; Parry and Gason 2006), and species such as cod, rockfish and whiting have been reported to change depth in response to seismic pulses (Pearson *et al.* 1992; Wardle *et al.* 2001). In contrast, Wardle *et al.* (2001) report that neither fish nor invertebrates showed signs of moving away from a reef on the west coast of Scotland after four days of seismic air gun firing.

Many finfish species display an alarm response of tightening schools, increased swimming speed and moving towards the sea floor at levels between 156 to 168 dB re 1µPa (McCauley *et al.* 2000b). McCauley *et al.* (2000a) studied the responses of fish contained within a 10 m x 6 m x 3 m cage to a nearby operating air gun. These studies indicated that the effects to fish from nearby air gun operations might include:

- a startle response (C-turn) to short range start up or high level air gun signals; a greater startle response was observed for smaller fish;
- evidence of alarm responses that were more noticeable for received air gun levels above approximately 156 to 161 dB re 1 μPa rms pressure;
- a lessening of severity of startle and alarm responses through time (habituation or loss of hearing sensitivity);
- the tendency in some trials for faster swimming and formation of tight groups correlating with periods of high air gun levels;
- a general behavioural response of fish to move to bottom, centre of cage in periods of high air gun exposure (for levels greater than 156 to 161 dB re 1 μPa (rms));
- no significant measured stress increases that could be directly attributed to air gun exposure; and
- evidence of damage to the hearing system of exposed fishes in the form of ablated or damaged haircells, although an exposure regime required to produce this damage was not established and it is believed such damage would require exposure to high-level air gun signals at short range from the source.

McCauley *et al.* (2000b) indicated that a received level of 156 dB re 1μPa can be detectable, corresponding to a range of between 3 and 5 km from a 3-D array (2,678 in^3). As a result, alarm responses could be expected to occur 3 to 5 km from a seismic vessel, with active avoidance behaviour beginning at distances of 1 to 2 km from a source of this level (McCauley *et al.* 2000b).

Pearson *et al.* (1992) studied the effect of sound on rockfish (*Sebastes* spp.) contained in a 4.6 m by 3.6 m cage deployed at the water surface. The fish were exposed to signals produced by a 100 in^3 (1,639 cm^3) air gun deployed at 6 m depth and operated at a 10 s rate. The fish began milling in increasingly tighter schools with increasing air gun levels, schools collapsed to the cage bottom when air gun operations commenced, and remained stationary near the bottom or rising in the water column on presentation of air gun signals. The sound level for which subtle changes in behaviour were observed was at 161 dB re 1 μPa and alarm responses were observed at 180 dB re 1 μPa. Dalen and Raknes (1985) have suggested that Atlantic cod may also respond to seismic signals by swimming towards the bottom.

The expected distance for fish to react to a typical peak source level of 250 to 255 dB re 1 μPa is from 3 to 10 km (Engås *et al.* 1996). A reaction may simply mean a change in swimming direction. The spatial range of response in fish will vary greatly with changes in the physical environment in which the sounds are emitted. In one environment, fish distribution has been shown to change in an area of 74 km x 74 km (40 x 40 nautical miles) and 250 to 280 m deep for more than five days after shooting ended, with fish larger than 60 cm being affected to a greater extent than smaller fish (Engås *et al.* 1996).

Turnpenny and Nedwell (1994) concluded that seismic activity has a reduced effect on fish behaviour inshore in shallow water because attenuation of the sound is more rapid. Two studies in shallow coastal areas found limited changes in fish behaviour in response to seismic noise. In one area with water depths less than 20 m, a seismic signal of 225 dB re 1 µPa at 1 m was emitted and the response of sea bass (*Dicentrarchus labrax*) observed. The study concluded that the bass were not displaced and that they continued to feed (Pickett *et al.* 1994). In another study, pollock (*Pollachius pollachius*) on a shallow coastal reef were observed during signal emission with a source level of 230 dB re 1 µPa (Wardle *et al.* 2001). Direct visual observations determined that only minor changes in fish behaviour patterns were detectable around the reef. This could be because reef fish have evolved to have a strong reef affinity and hence require higher levels to avoid their habitat. When smaller pollock passed within a few metres of the array and were exposed to approximately 229 dB, they showed a typical "c-start" response and moved away only a few metres. Furthermore, observed responses of schooled fish indicate that they are quite variable and depend on species, life history stage, current behaviour, time of day, whether the fish have fed and how the sound propagates in a particular setting (Davis *et al.* 1998).

If a seismic survey overlaps with the presence of migrating fish species (such as redfish and cod), startle responses and temporary changes in swimming direction and speed could be expected, but schooling behaviour is not expected to be affected (Blaxter *et al.* 1981). Any temporary change in behaviour is not expected to interrupt the natural migration instinct to a spawning or feeding area. Two proposed seismic surveys near Cape Breton were evaluated (Canada-Nova Scotia Offshore Petroleum Board 2002) and results seemed to indicate that displacement of marine fish is short-term. Most available literature (Blaxter *et al.* 1981; Dalen and Raknes 1985; Pearson *et al.* 1992; Davis *et al.* 1998; McCauley *et al.* 2000a; 2000b) seems to indicate that the effects of noise on fish are brief and if the effects are short-lived and outside a critical period, they are expected not to translate into biological or physical effects. It appears that behavioural effects on fish as a result of seismic shooting should result in negligible effects on individuals and populations in most cases. The potential for interactions during particularly sensitive periods, such as spawning or migration, are a concern.

Altogether, there are well-documented observations of fish exhibiting behaviours in response to exposure to seismic activity like a startle response, a change in swimming direction and speed, or a change in vertical distribution (Blaxter *et al.* 1981; Schwarz and Greer 1984; Pearson *et al.* 1992; McCauley *et al.* 2000b; Wardle *et al.* 2001; Hassel *et al.* 2003), although the significance of these behaviours is unclear. Some studies indicate that such behavioural changes are very temporary, while others imply that marine animals might not resume pre-seismic behaviours and/or distributions for a number of days (Løkkeborg 1991; Skalski *et al.* 1992; Engås *et al.* 1996).

Masking

Fish sounds are normally generated in the range of 50 to 3,000 Hz. Fish use sound for communication, navigation and sensing of prey and predators. Sound transmission is thought to play an important role in cod and haddock mating (Engen and Folstad 1999; Hawkins and Amorin 2000). Seismic signals are typically in the range of 10 to 200 Hz

(Turnpenny and Nedwell 1994) and will therefore overlap slightly with signals produced by fish, possibly causing a masking effect. Recent experiments on goldfish indicate that fish are capable of "auditory scene analysis", meaning that a sound stream of interest can be "heard out" and analyzed for its informational content independently of simultaneous, potentially interfering sounds (Fay 1988). These studies were carried out using repetitive pulses or clicks as signals and as potentially interfering sounds. These results suggest that the presence of intermittent, audible air gun shots would not necessarily impair fish in receiving and appropriately interpreting other biologically relevant sounds from the environment (UN Minerals Management Service 2004).The degree of masking and the biological significance of masking are unknown.

Hearing Impairment

Several studies have shown that exposure to noise such as that produced by seismic air guns can result in temporary hearing loss and physical damage to the ear (Enger 1981; Hastings *et al.* 1996; Amoser and Ladich 2003; McCauley *et al.* 2003; Smith *et al.* 2004; Popper *et al.* 2005). However, studies on temporary threshold shift used captive fish and temporary threshold shift may seldom (or never) occur in the wild unless fish are prevented from fleeing the irritant (LGL 2005a). Turnpenny and Nedwell (1994) estimated that hearing damage might occur out to several hundred metres. However, there are substantial differences in the effects of air guns on the hearing thresholds of different species. Popper *et al.* (2005) showed that fish with poorer hearing, such as pike, showed little hearing loss in response to seismic air gun activity, while fish with good hearing, such as lake chub, showed the most hearing loss. Unlike mammals, fish can regrow hair cells after damage from noise exposure, recovering their hearing (Smith *et al.* 2006). Periods of hearing loss may affect survival due to the compromised ability to hear biologically relevant sounds.

Injury

No mass fish kills associated with the operation of air guns have been recorded (Payne 2004). Since fish (with the exception of perhaps reef fish) are likely to be driven away by approaching seismic shots, mortality of adult fish is unlikely (Turnpenny and Nedwell 1994). Depending on source noise level, water depth and distance of the fish relative to the source, injuries (such as to eyes and internal organs) would only occur within a few tens of metres.

The mortality rate of plankton during seismic surveys has been estimated from several studies. Up to 1 percent of the plankton in the top 50 m of the water column could be killed during a 3-D seismic survey off Nova Scotia (Davis *et al.* 1998). An estimated 0.45 percent of planktonic organisms in the top 10 m of water in a survey area off Norway could be killed (Saetre and Ona 1996). Kenchington *et al.* (2001) estimated a plankton mortality rate of 6 percent if they were concentrated in the upper 10 m. Given that seismic-related mortality in fish has not been reported beyond 5 m during field and laboratory studies, these estimates are considered conservative and may apply more to phytoplankton and zooplankton than to planktonic life stages of fish and shellfish. Kostyuchenko (1973) reported more than 75 percent survival of fish eggs at 0.5 m from the source (233 dB re 1 µPa @ 1 m) and more than 90 percent survival at 10 m from the source.

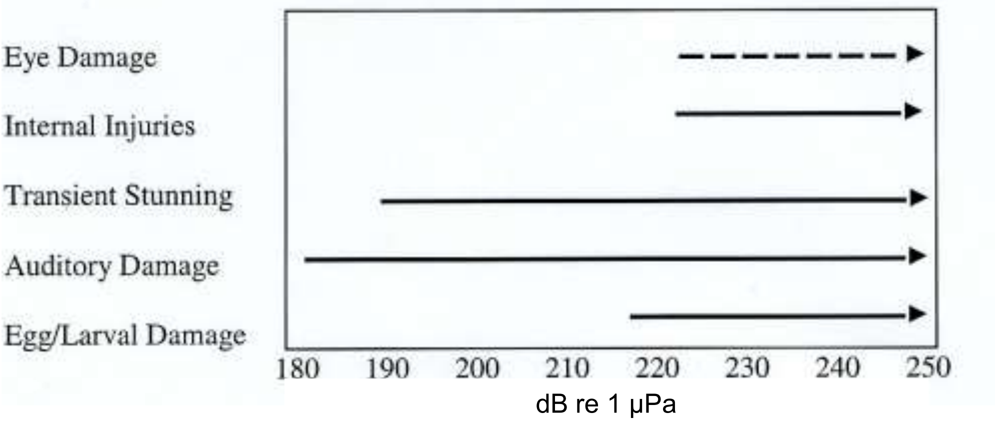
It is assumed that a peak sound pressure level of 220 dB re 1 µPa is required for egg/ larval damage (Table 7-3). A 'worst-case scenario' mathematical model was applied to investigate the effects of seismic energy on fish eggs and larvae and concluded that mortality rates caused by exposure to seismic were so low compared to natural mortality, the effect of seismic activity on recruitment to a fish stock would be not significant (Saetre and Ona 1996). In addition, mortality of phytoplankton and zooplankton near the seismic vessel should be sufficiently localized as to negligibly affect food availability for fish, shellfish, birds and mammals.

Table 7-3 Observations from Exposures of Fish and Shellfish Planktonic Life Stages to Seismic Air guns at Close Range

Organism	Life Stage	Exposure Distance from Air Sleeve (m)	Estimated Exposure Level (dB re 1 µ pA)	Observed Response	Reference
Pollock (*Pollachus virens*)	Egg	0.75	242	Some delayed mortality	Booman *et al.* 1996
Cod (*Gadus morhua*)	Larvae	5	220	Immediate mortality	Booman *et al.* 1996
	Fry	1.3	234	Immediate mortality	
	5-day-old larvae	1	250	Delamination of retina	Matishov 1992
	Eggs	1 to 10	202 to 220	No signs of injury	Dalen and Knutsen 1987
Plaice (*Pleuronectes platessa*)	Eggs & larvae	1	220	High mortality (unspecified0	Kosheleva 1992
		2	214	No effect	
Anchovy (*Engraulis mordax*)	Eggs	unknown	223	8.2% mortality	Holiday *et al.*, in Turnpenny and Nedwell 1994
	2-day-old larvae	3	238	Swimbladder rupture	
Red Mullet (*Mullus surmuletus*)	Eggs	1	230	7.8% of eggs injured	Kostyuchenko 1973
		10	210	No injuries	
Fish (various spp.)	Eggs	0.5	236	17% dead in 24 hr	Kostyuchenko 1973
		10	210	2.1% dead in 24 hr	
Dungeness Crab (*Cancer magister*)	Larvae	1	231	No observed effect on time to molt or long-term survival	Pearson *et al.* 1994

A review of the current scientific literature indicates that egg and larval mortality is limited to within a few metres of the seismic array, and physical injury to fish is limited to tens of metres (Kostyuchenko 1973; Dalen and Knutsen 1987; Turnpenny and Nedwell 1994; Saetre and Ona 1996; Kenchington *et al.* 2001; Parry and Gason 2006).

Kosheleva (1992) reports no obvious physiological effects beyond 1 m from a source of 220 to 240 dB re 1 µPa. Hastings (1990) reports the lethal threshold for fish at 229 dB and a stunning effect in the 192 to 198 dB range. Turnpenny and Nedwell (1994) deduce that blindness can be caused in fish exposed to air sleeve blasts on the order of 214 dB re 1 µPa. A summary of fish injuries caused by exposure to sound pressure is given in Turnpenny and Nedwell (1994) (Figure 7-2).



Note: Dashed line indicates an assumed sound level rather than an estimated one.

Figure 7-2 **Sound Pressure Threshold for the Onset of Fish Injuries**

Seismic activity inshore can have its greatest effect if the program overlaps spatially and temporally with the occurrence of concentrations of fish eggs or larvae. Temporal overlap will occur because there are eggs or larvae in the water column year-round and all of the fish and shellfish assessed can have pelagic eggs and larvae in the water column during August and September. July, August and September are when most species are expected to have eggs or larvae present in the water column. In order for an interaction to occur between fish eggs and larvae and seismic activity, there must be spatial as well as temporal overlap with the Project Area.

Hastings and Popper (2005) reviewed the available scientific information on bioacoustic impact on fish up to 2005. Popper *et al.* (2006) derived interim criteria for injury of fish exposed to pile driving, another impulsive sound source. For any single strike, a received sound exposure level of SEL > 187 dB re 1µPa^{2}s and a received peak sound pressure level of SPL0p > 208 dB re 1µPa might cause injury.

7.1.3.2 MARINE MAMMALS AND SEA TURTLES

Sound-related Effects on Marine Mammals

Underwater sounds produced during exploration can be classified into three broad categories (Southall *et al.* 2007). Impulsive sound associated with single events (e.g., an explosion), is thought of as “single pulses”. Sounds of short duration that are produced at regular intervals, such as those produced by air guns, are classified as "multiple pulses". Sounds produced for extended periods, such as sounds from generators or drilling, are classified as "continuous" or “nonpulses”. Sounds from moving sources, such as ships, can be continuous, but for an animal at a given location, these sounds are "transient" (i.e., increasing in level as the ship approaches and then diminishing as it moves away). Studies indicate that marine animals respond differently to the three categories of noise.

Ocean water conducts light very poorly but sound very well. Marine mammals therefore rely primarily on their acoustic sense for communication, social interaction, navigation and foraging. It is evident that certain sounds (both natural and anthropogenic) have the potential to interfere with these functions.

The marine environment contains many natural sources of noise (e.g., surf, wind, earthquakes, biological activity) that may impede acoustic communication and other vital functions, but to which marine animals have likely evolved to accommodate. Anthropogenic sounds are a recent advent to the marine environment, having essentially begun with the introduction of industrialization.

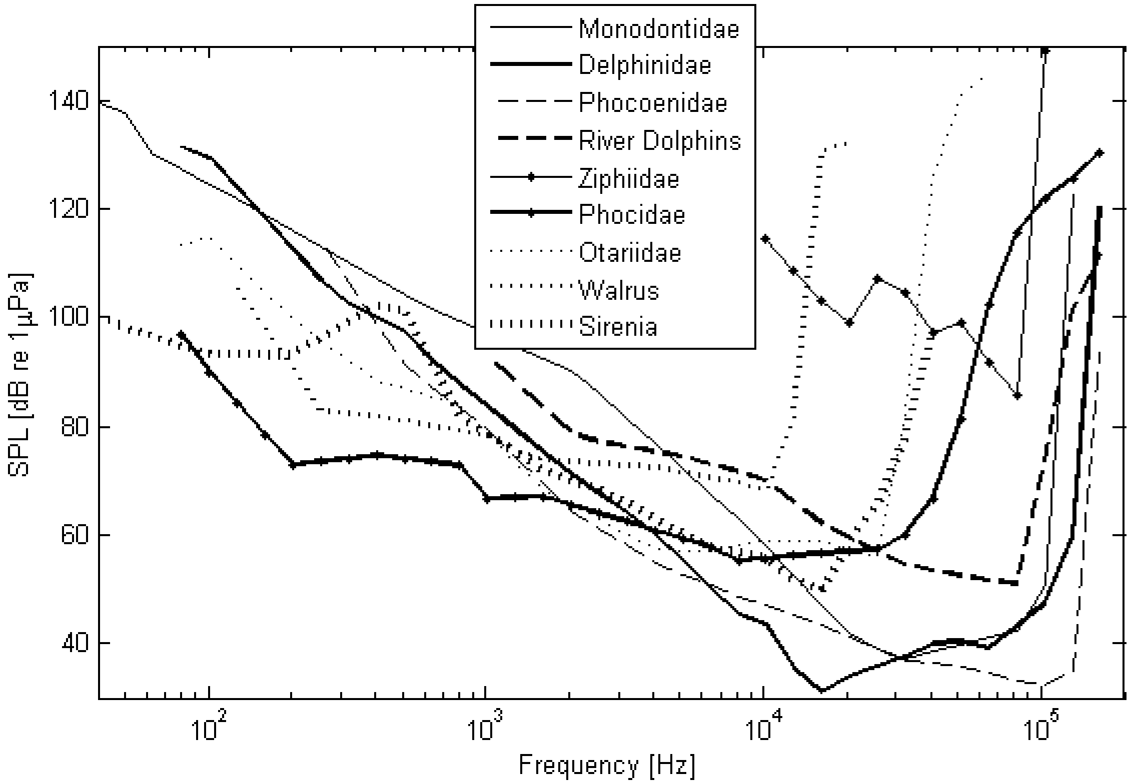
Close to the sound source, levels might be high enough to cause physiological injury to auditory and non-auditory organs and tissues. Over somewhat larger ranges, the sound might cause auditory fatigue (i.e., a temporary decrease in hearing sensitivity, termed temporary threshold shift). Over longer ranges yet, the sound has the potential to mask signals (e.g., communication sounds, predator or prey sounds, environmental sounds) to the point of incomprehensibility. A behavioural response might be seen over rather long ranges, shorter than the range over which parts of the sound are just audible.

Audibility

Sound levels decrease with range due to propagation losses. Audibility is limited by the sound dropping either below the animal's hearing curve (audiogram) or below ambient noise levels.

An audiogram is a graph showing hearing thresholds of pure tones as a function of frequency. Audiograms have been measured from only approximately 20 marine mammal species, and from only a few individuals. Audiogram variability on an individual (l*et al.*one species or genus) level is barely understood. The reported threshold is a statistical quantity (e.g., depending on the method used, the level at which the tone was heard 50 percent of the time).

Marine mammal audiograms, grouped into families, are shown in Figure 7-3. Published audiograms were assembled and interpolated for the centre frequencies of 1/3 octave bands between 40 Hz and 200 kHz. Within each family, the lowest threshold of all species and individuals was plotted at each frequency. The computation of 1/3 octave band levels (commonly used for marine mammal impact assessment) was explained in Section 3.3.2; they provide a convenient way of averaging individual audiograms and smoothing audiograms for different species (Figure 7-3).



Note: Shows the minimum thresholds over all species belonging to the same family.

Figure 7-3 Underwater Audiograms of Marine Mammals

There are no direct measurements of underwater audiograms of polar bears, sea otters, sperm whales and baleen whales. It is expected that their frequencies of best sensitivity overlap to some degree with the frequencies of their calls. Other indicators for what these animals can hear come from controlled exposure experiments looking for responses of animals to sound. Anatomical studies of baleen ears have suggested good hearing sensitivity between 10 Hz and 30 kHz (Ketten 2000). At the low-frequency end, sound detection by baleen whales might often be ambient noise-limited rather than audiogram-limited.

Marine mammal audiograms exhibit a similar U-shape. At low frequencies, sensitivity improves as approximately 10 dB/octave; best sensitivity is between 30 dB re 1µPa (odontocetes) and 70 dB re 1µPa (pinnipeds), with the exception of the Gervais' beaked whale audiogram, the current estimate of which has a much higher threshold. At high frequencies, sensitivity drops fast at >100 dB/octave.

Ranges of audibility can be quite large (e.g., many tens of kilometres (Erbe and Farmer 2000)) from large vessels, in particular for low-frequency sounds in deep water and animals capable of detecting low frequencies.

Behavioural Responses

Anthropogenic sounds have the potential to disturb behavior and/or interfere with important functions (Richardson *et al.* 1995; NRC 2003). The zone of behavioural response is mostly going to be smaller than the zone of audibility. Richardson *et al.* (1995) reported that marine mammals tend not to respond overtly to barely audible man-made sounds. Indicators of 'disturbance' include changes in swim direction, swim speed, dive duration, surfacing duration, respiration (blow rate), movement towards or away from the noise, changes in acoustic behaviour, etc.

Behavioural responses of marine mammals to noise are highly variable and dependent on a suite of internal and external factors (NRC 2003). Internal factors include:

- individual hearing sensitivity, activity pattern and motivational and behavioural state at time of exposure;
- past exposure of the animal to the noise, which may have led to habituation or sensitization;
- individual noise tolerance; and
- demographic factors such as age, sex and presence of dependent offspring.

External factors include:

- non-acoustic characteristics of the sound source, such as whether it is stationary or moving;
- environmental factors that influence sound transmission;
- habitat characteristics, such as being in a confined location; and
- location, such as proximity to a shoreline.

Summaries and reviews of behavioural responses can be found in Richardson *et al.* (1995), Nowacek *et al.* (2007) and Southall *et al.* (2007).

Observers on seismic vessels off the U.K. from 1997 to 2000 reported that in good sighting conditions, the number of baleen whales seen when air guns were shooting was similar to the number seen when air guns were not shooting. However, baleen whales remained considerably farther from the air guns and exhibited more frequent alterations in course (usually away from the vessel) when air guns were shooting (Stone 2003). Humpback whales, gray whales and bowhead whales reacted to seismic noise pulses by deviating from their normal migration route and/or interrupting feeding and moving away from the sound source (e.g., Richardson *et al.* 1986, 1995, 1999; Ljungblad *et al.* 1988; Richardson and Malme 1993; LGL 2005b). Fin and blue whales also showed some behavioural reactions to air gun noise (McDonald *et al.* 1995; Stone 2003). Fin whales and sei whales were less likely to remain submerged during periods of shooting (LGL 2005b). Bowhead whales migrating off the Alaskan coast have been shown to avoid seismic survey vessels to a distance of more than 24 km (15 miles) (Jasny *et al.* 2005). Baleen whales may strand after exposure to seismic sounds; Jasny *et al.* (2005)

reported that the stranding of eight humpback whales was correlated with the opening of the area to oil exploration.

McCauley *et al.* (2000b) examined data from whale observations made from a seismic survey vessel north east of North West Cape, off Exmouth. They found that there were no discernible differences in the number of whales sighted per observation block (40-minute period) between observation blocks with the guns on and guns off. In-depth examination of the data for ranges <3 km found that the guns-off sighting rates were considerably higher than the guns-on sightings. This suggests localized avoidance of the operating air gun vessel during periods with the air guns on and is consistent with published findings.

These findings indicate that at most, whales will avoid an operating seismic vessel. Richardson *et al.* (1995) noted that most research indicated that gray and bowhead whales generally avoided seismic vessels where the received sound level was between 150 to 180 dB re 1 µPa (rms). The level at 3 km from the seismic vessel from which the humpback observations were made was in the range 157 to 164 dB re 1 µPa (rms) for a receiver at 32 m depth, which was in agreement with the standoff level provided for gray and bowhead whales (McCauley *et al.* 2000a).

McCauley *et al.* (2000b) noted that pod sighting rates observed when the air guns were switched on/off or off/on were higher than the sighting rates during which air guns were continually on or continually off for distances between 0.75 to 3 km. These higher pod sightings may be explained by a startle response bringing animals to the surface for air guns turned on after being off for a protracted period. An investigative response might bring whales to the surface when air guns are turned off after being on for a protracted period. Startle responses by humpback whales to seismic survey sounds have been reported at levels between 150 to 169 dB re 1 µPa (effective pulse pressure, believed equivalent to rms measure) by Malme *et al*. (1985).

McCauley *et al*. (2000b) conducted approach trials in Exmouth Gulf that found humpback whale pods with females consistently avoided an approaching single operating air gun (Bolt 600B, 20-in^3 chamber) at a mean range of 1.3 km. Avoidance maneuvers were evident before standoff at ranges from 1.22 to 4.4 km.

During the approach trials single, large mature humpbacks approached the operating air gun, coming to within 100 to 400 m, investigated it, then swam off (McCauley 2000b). These approaches were deliberate, direct and at considerable speed. These whales would have been exposed to air gun signals at 100 m of 179 dB re 1 µPa (rms) (or 195 dB re 1 µPa peak-peak). This level is equivalent to the highest peak-peak source level (level at 1 m) of song components measured from humpback whales in Hervey Bay by McCauley *et al*. (1996). Thompson *et al*. (1986) measured humpback whale source levels in Alaska, of 192 dB re 1µPa peak-peak @ 1 m.

McCauley *et al*. (2000b) concluded that it is probable that humpback whales are not at physiological risk unless at short range from a large air gun array. McCauley *et al.* (2000b) further concluded that displacements to migratory humpback whales were comparatively short in time, involved limited range changes and a low probability for physiological effects; therefore, there appears to be a low risk for migratory humpback whales exposed to seismic activity.

Reactions of baleen whales to vessels have been studied directly for species such as gray whales, humpback whales, and bowhead whales. Reactions have been found to vary from approach to avoidance. In general, baleen whales tend to change their behaviour in response to strong or rapidly changing vessel noise (Watkins 1986; Beach and Weinrich 1989). Behavioural changes include course changes, changes in surfacing and respiration patterns, and displays such as breaching, flipper slapping, and tail slapping (Wyrick 1954; Edds and Macfarlane 1987; Stone *et al.* 1992).

The sounds produced by seismic air guns are in the frequency range of low hearing sensitivity for toothed whales. However, they are high intensity sounds and their received levels can sometimes remain above the hearing thresholds of toothed whales for distances out to several tens of kilometres (Richardson and Würsig 1997).

Dolphins and porpoises are often seen by observers on seismic vessels (Stone 2003); however, dramatic avoidance responses at considerable distances from the array have been exhibited by species such as harbour porpoises (Jasny *et al*. 2005). In addition, Stone (2003) noted localized avoidance of seismic vessels by dolphins off the UK. While the distribution of sperm whales in the northern Gulf of Mexico has been observed to change in response to seismic operations (Mate *et al.* 1994), other studies report little evidence of reactions by sperm whales to seismic pulses (Madsen *et al.* 2002; Jochens and Biggs 2003; Stone 2003).

There is increasing evidence that beaked whales may strand after exposure to intense sound from sonars. Sonar surveying is a separate activity from seismic surveying and may be used during geo-hazard surveys. Several Cuvier's beaked whale (*Ziphius cavirostris*) strandings have been reported coincident with seismic operations (Gentry 2002; Jasny *et al.* 2005).

Responses of toothed whales to vessels vary within and among species and range from avoidance to approach and bowriding (Baird and Stacey 1991a, 1991b; Stacey and Baird 1991; Mullin *et al.* 1994a, 1994b). For example, Risso's dolphins have been reported to bow-ride, but have also been described as shy of vessels (Baird and Stacey 1991a). For many species, reactions to vessels appear to be related to the dolphins' activity state and their history of harassment. Dolphins that are resting tend to avoid vessels, those that are foraging tend to ignore vessels, and those that are socializing may approach vessels (Richardson *et al.* 1995). Dolphins that have been sensitized by previous harassment tend to avoid vessels (Au and Perryman 1982). Larger toothed whales such as beaked whales generally seem to avoid survey vessels (Sorensen *et al.* 1984).

Ringed seals (*Phoca hispida*) near an artificial-island drilling site were monitored before and during development of the site. Although air and underwater sound was audible to the seals for up to 5 km, there was no change in their density in that area between breeding seasons before and breeding seasons after development began (Moulton *et al.* 2003).

Very little information exists on the reactions of pinnipeds to sounds from seismic exploration in open water (Richardson *et al.* 1995). Visual monitoring from seismic vessels has shown that pinnipeds frequently do not avoid the area within a few hundred metres of an operating air gun array (Harris *et al.* 2001). However, the telemetry research of Thompson *et al.* (1998) suggests that reactions may be stronger than has been evident from visual studies. Based on anecdotal evidence, pinnipeds appear to show little reaction to vessels in open water (Richardson *et al.* 1995). However, there are few studies that describe the responses of pinnipeds in the water to vessel traffic.

Masking

Underwater ambient sound may prevent an animal from detecting another sound through a process known as masking. Masking is the process by which the threshold of hearing for one sound is raised by the presence of another (masking) sound. Masking is also the amount by which the threshold of hearing for one sound is raised by the presence of another (masking) sound. Masking can occur as a result of either natural sounds (e.g., periods of strong winds or heavy rainfall) or anthropogenic sounds (e.g., ship propeller sound). The sea is a naturally noisy environment and even in the absence of anthropogenic sounds, this natural sound can “drown out” or mask weak signals from distant sources. Signals that might be masked include social sounds, communication sounds, predator sounds, prey sounds, echolocation sounds and environmental sounds (e.g., the sound of surf) that animals might listen to for navigation.

All marine mammals emit sound that is produced internally. Other sounds, that may also take a social or communicative role, are generated when an animal strikes an object or the water surface.

Odontocete (toothed whale) sounds are generated within the nasal system, not the larynx. They can be classified into three categories: tonal whistles, burst-pulse sounds and echolocation clicks. Whistles and burst-pulse sounds have a social function. Some odontocetes do not whistle (e.g., Phocoenidae, *Cephalorhynchus* sp., *Kogia* sp., *Physeter macrocephalus*). Whistles have a fundamental frequency below 20 to 30 kHz plus higher harmonics. Whistles may be categorized according to the shape of the fundamental frequency with time: constant frequency, upsweep, downsweep, concave (hill), convex (valley), sinusoidal. Burst-pulse sounds are series of broadband pulses with substantial ultrasonic energy. Echolocation clicks are broadband and mostly in the ultrasonic range. Burst-pulse sounds have lower source levels and lower interclick intervals than echolocation click trains. Both have highly directional beam-patterns.

The sound production mechanism of Mysticete (baleen whale) sounds is unclear. Sounds can be classified into calls and songs. Calls have been categorized further into simple calls (low frequency <1 kHz, narrow band, frequency and amplitude modulated), complex calls (broadband, 500 to 5,000 Hz, frequency and amplitude modulated), grunts and knocks (<0.1 s duration, 100 to 1,000 Hz), and clicks and pulses (short duration <2 milliseconds, 3 to 30 kHz) (Clark 1990). Songs have been recorded from humpback, bowhead, blue and fin whales. Humpback song can be broken down into themes, which consist of repetitions of phrases, which are made up of patterns of units (with energy up to 30 kHz).

Pinniped sounds occur in air and under water, and are often described by onomatopoeic words: grunts, snorts, buzzes, barks, yelps, roars, groans, creaks, growls, whinnies, clicks etc. (Richardson *et al.* 1995; Au and Hastings 2008).

The frequency bands of sounds emitted by marine mammals (including echolocation) are illustrated in Figure 7-4.

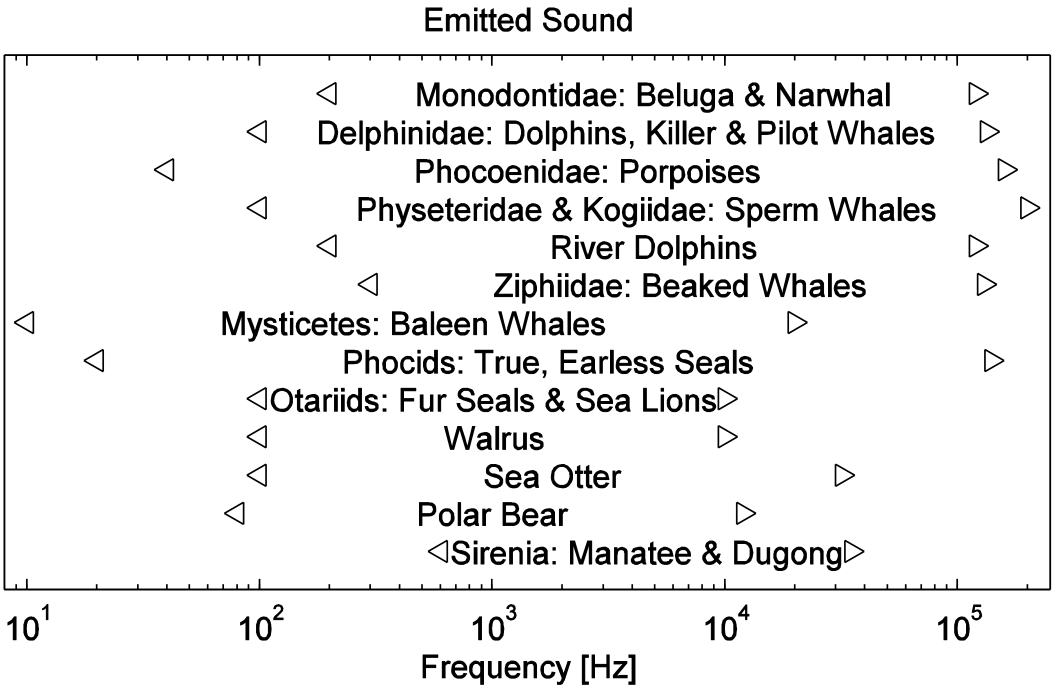


Figure 7-4 Frequency Bands of Marine Mammal Sounds

Marine animals themselves also contribute to the level of natural ambient noise. The calls of a blue whale have been recorded for 600 km (Stafford *et al.* 1998). A sperm whale call can be as loud as 232 dB re 1µPa at 1 m (rms) (Møhl *et al.* 2003) and a species of shrimp has been recorded at 185 to 188 dB re 1µPa at 1 m (Au and Banks 1998). In areas where natural background noise is relatively high, such as near a shelf break or high surf, anthropogenic noise itself can be masked and reduce the area in which it is detectable. The anthropogenic noise is undetectable for marine mammals once it falls below ambient noise level or the hearing threshold of the animal. Given this, and the fact that mammal response will vary by species and between individuals, the zone of potential influence of noise on marine mammals is highly variable.

Marine mammals have evolved in an environment that contains a variety of natural sounds and as such, some degree of masking occurs; thus, marine mammals have evolved systems and behaviour to reduce the impacts of masking (NRC 2003). Since little is known about the importance of how a temporary interruption in sound detection affects mammals (Richardson *et al.* 1995), it is very difficult to assess the environmental effect. In general, the environmental effect of both natural and anthropogenic noise is less severe when it is intermittent than continuous (NRC 2003). The level of masking may be significantly reduced if the anthropogenic noise originates from a different direction than the mammal vocalization (NRC 2003). While marine mammals may adapt behaviour changes to reduce masking, the physiological costs associated with the behavioural changes cannot be estimated at this time (NRC 2003).

Acoustic energy in the sound pulses produced by seismic air guns and sub-bottom profilers overlaps with frequencies used by baleen whales, but the discontinuous, short duration nature of these pulses is expected to result in limited masking of baleen whale calls. Side-scan sonar and echosounder signals do not overlap with the predominant frequencies of baleen whale calls, which avoids significant masking. Several species of baleen whales have been observed to continue calling in the presence of seismic pulses, including bowhead whales (Richardson *et al.* 1986), blue whales and fin whales (McDonald *et al.* 1995).

The low frequency spectrum of industrial noise will not overlap with the high frequency echolocation of belugas, dolphins, or pilot whales, for example. Because seismic and sub-bottom profiler pulses are intermittent and predominantly low frequency, masking effects are expected to be negligible for toothed whales. However, while Madsen *et al.* (2002) reported that sperm whales off northern Norway continued calling in the presence of seismic pulses, Bowles *et al.* (1994) reported that sperm whales ceased calling when exposed to pulses from a distant seismic ship. Some pulses emitted by side-scan sonars and echo-sounders are likely audible to toothed whales, but significant masking of communication signals is improbable due to the fact that the pulses are short and have narrow beam widths.

The frequencies contained in seismic and sub-bottom profiler pulses do overlap with some frequencies used by pinnipeds, but the discontinuous, short duration nature of the pulses is expected to result in limited masking of pinniped calls. Side-scan sonar and echo-sounder signals do not overlap with the predominant frequencies of pinniped calls, which avoids significant masking.

Overall, the masking effect from the seismic survey is expected to be limited. LGL (2005b) reports that some marine mammals continue calling in the presence of seismic operations, which typically emit an impulse every 11 seconds. It has been postulated that an increase in interval time will enable mammals to receive communications that persist through the survey operation, as reported during other surveys (Richardson *et al.* 1986; McDonald *et al.* 1995; Greene and McLennan 2000; Madsen *et al.* 2002; Jochens and Briggs 2003). However, prolonging a survey by increasing the interval time might have other negative effects.

Hearing Impairment

M-weighting (Southall *et al.* 2007) emphasizes the frequency band where acoustic exposures to high-amplitude noise can have auditory effects. Low and high frequencies are de-emphasized compared to the central frequencies at which acoustic impact is considered more likely. M-weighting curves are wider than the bandwidth of best sensitivity as indicated in audiograms. To compute M-weighted SEL (SEL-M), the noise spectrum needs to be filtered with the appropriate M-weighting curve before integrating energy over all frequencies.

For M-weighting, marine mammals are grouped into the four functional hearing groups listed in Table 7-4, plus pinnipeds in air (all species).

Table 7-4 Marine Mammal Functional Hearing Groups

Functional Hearing Group	f_{low}	f_{high}
Low-frequency (LF) Cetaceans (Balaena, Caperea, Eschrichtius, Megaptera, Balaenoptera)	7 Hz	22 kHz
Mid-frequency (MF) Cetaceans (Steno, Sousa, Sotalia, Tursiops, Stenella, Delphinus, Lagenodelphis, Lagenorhynchus, Lissodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Orcaella, Physeter, Delphinapterus, Monodon, Ziphius, Berardius, Tasmacetus, Hyperoodon, Mesoplodon)	150 Hz	160 kHz
High-frequency (HF) Cetaceans (Phocoena, Neophocaena, Phocoenoides, Platanista, Inia, Kogia, Lipotes, Pontoporia, Cephalorhynchus)	200 Hz	180 kHz
Pinnipeds in water	75 Hz	75 kHz

The formula for the M-weighting curves is:

$$M(f) = 20\log_{10}\frac{f_{high}^2 f^2}{(f_{high}^2 + f^2)(f_{low}^2 + f^2)}$$

The M-weighting curve for the marine mammal functional hearing groups is illustrated in Figure 7-5.

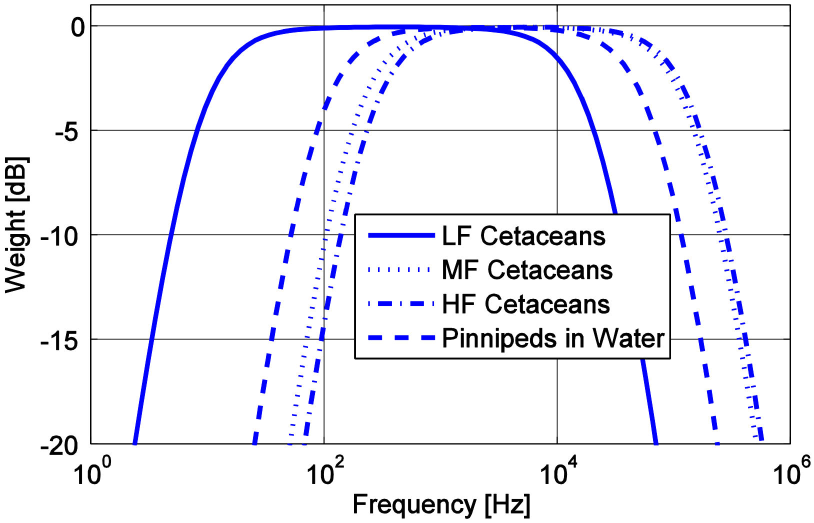


Figure 7-5 M-weighting curves M(f)

At some level and duration, sound can cause hair cells of the inner ear to fatigue, yielding an increase in auditory threshold by the temporary threshold shift. The amount of temporary threshold shift depends on the noise level, rise time, duration, duty cycle, spectral characteristics, etc. After some quiet time (minutes – days), hearing returns to normal. Temporary threshold shift has been measured in a few individual cetaceans and pinnipeds. There are no data for baleen whales.

Southall *et al.* (2007) reviewed data on temporary threshold shift in marine mammals up to 2007. Their conclusion for cetaceans indicated that temporary threshold shift might occur at 224 dB re 1µPa SPLpk or 183 dB re 1µPa^{2}s SEL M-weighted. For pinnipeds in water, temporary threshold shift onset was expected at 212 dB re 1µPa SPLpk or 171 dB re 1µPa^{2}s SEL M-weighted. If hearing does not fully return to normal after noise exposure, the remaining threshold shift is called a permanent threshold shift. Permanent threshold shift is considered auditory injury. Noise-induced permanent threshold shift has not been measured in marine mammals. To estimate at what level permanent threshold shift might occur, Southall *et al.* (2007) used marine mammal temporary threshold shift data in combination with temporary threshold shift growth rates (how the amount of temporary threshold shift changes as a function of noise level) from terrestrial mammals. Peak-SPL and M-weighted SEL values were given; the one that is reached first should be used for impact assessment. For cetaceans, a permanent threshold shift was considered possible for SPLpk in excess of 230 dB re 1 µPa and SEL M-weighted in excess of 198 dB re 1 µPa2s. For pinnipeds under water, a permanent threshold shift was considered possible for SPLpk in excess of 218 dB re 1 µPa and SEL M-weighted in excess of 186 dB re 1 µPa2s.

Exposure to high-intensity pulsed sound can cause other, non-auditory physical effects such as: stress, neurological effects, bubble formation, resonance effects or other types of organ or tissue damage (LGL 2005b). Little is known about the potential for the sounds produced during geo-hazard surveys to cause auditory threshold shifts or other effects in marine mammals and turtles. Data suggest that if these effects do occur, they would only occur in close proximity to the sound sources. Thus, species that show behavioral avoidance of seismic vessels, including most baleen whales, some toothed whales and some pinnipeds would not likely experience threshold shifts or other physical effects (LGL 2005b).

Sound-related Effects on Sea Turtles

The frequency of hearing sensitivity for sea turtles has been reported as 250 to 300 Hz to 500 to 700 Hz (Ridgway *et al.* 1969; Bartol *et al.* 1999). These frequencies overlap with those prominent in air gun pulses. It is therefore likely that air guns are audible to sea turtles. The distance over which an air gun array might be audible to a sea turtle is impossible to estimate due to an absence of absolute hearing threshold data. It has been suggested that sound may play a role in navigation, but recent studies suggest that visual, wave and magnetic cues are the main navigational cues used by hatchling and juvenile sea turtles (Lohmann and Lohmann 1998; Lohmann *et al.* 2001). Thus, masking is unlikely to be an important issue for sea turtles exposed to pulsed sounds.

Behavioural observations carried out by Lenhardt (1994) showed that sea turtles increase their movements after air gun shots and do not return to the depth where they usually rest. McCauley *et al.* (2000b) conducted two trials with caged sea turtles and an approaching-departing single air gun (Bolt 600B, 20-in^3 chamber) to gauge behavioural responses by the green (*Chelonia mydas*) and loggerhead (*Cartetta caretta*) turtle. The first trial involved 2:04 hours of air gun exposure and the second 1:01 hours. Each trial used a 10 s repetition rate. The two trials showed that above an air gun level of approximately 166 dB re 1 µPa (rms), the turtles noticeably increased their swimming activity compared to non-air gun operation periods. At air gun levels above 175 dB re 1 µPa (rms), the turtles' behaviour became more erratic, possibly indicating the turtles were in an agitated state (McCauley *et al.* 2000b). The increase in swimming behaviour tracked the received air gun level, in that the turtles spent increasingly more time swimming as the air gun level increased. The point at which the turtles showed more erratic behaviour was expected to approximately equal the point at which avoidance would occur for unrestrained turtles.

O'Hara and Wilcox (1990) conducted studies on loggerhead turtles in a 300 x 45 m enclosure in a 10 m deep canal. The sound source was a Bolt 600B air gun with a 10-in^3 chamber and two Bolt 'poppers', all operating at 2,000 psi (14 MPa), suspended at 2 m depth and operated at a 15 s interval. The turtles maintained a stand-off range of approximately 30 m. The received air gun levels were not measured and, as such, data for study comparability are missing. McCauley *et al.* (2000a) estimated that the level at which O'Hara and Wilcox (1990) observed avoidance behaviour was approximately 175 to 176 dB re 1 µPa (rms).

Moein *et al.* (1994) studied loggerhead turtles' avoidance behaviour, physiological response and electroencephalogram measurements of hearing capability, in response to an operating air gun. The turtles were held in an 18 m x 61 m x 3.6 m netted enclosure in a river. The air guns were deployed and operated from the net ends at 5 to 6 s intervals for five-minute periods. Details of the air gun, its operational pressure, deployment depth and sound levels experienced by the turtles throughout the cage were not given. Avoidance behaviour was observed during the first presentation of the air gun exposure at a mean range of 24 m. Further trials several days afterwards did not elicit statistically significant avoidance behaviour. The physiological measures did show evidence of increased stress; however, the effects of handling turtles were not taken into account and therefore, the increased stress could not be attributed to the air gun operations. A temporary reduction in hearing capability was evident from the neurophysiological measurements, but this effect was temporary and the turtles' hearing returned to pre-test levels at the end of two weeks. Moein *et al.* (1994) concluded that this might have been due to either habituation or a temporary shift in the turtles' hearing capability.

The available evidence from the scientific literature suggests that sea turtles may show behavioural responses to an approaching air gun array at a received level approximately 166 dB re 1 µPa (rms) and avoidance at approximately 175 dB re 1 µPa (rms). McCauley *et al.* (2000b) estimated that this corresponds to behavioural changes occurring at approximately 2 km and avoidance at approximately 1 km for seismic vessels operating 3-D air gun arrays in 100 to 120 m water depth. It is necessary to note that important sea turtle habitats mostly occur in shallower water, often less than 20 m deep. The propagation of an air gun array in such water depths may be vastly different than that for the array measured in 120 m water depth.

Other Effects

Marine mammal and sea turtle Species at Risk may be attracted to, or deterred from, vessel lighting. While it is possible that certain marine mammals or sea turtles may be influenced by vessel lights, this effect is expected to be minimal (due to transient nature of vessel) and will unlikely lead to collision (discussed below) or increased interaction.

The mechanisms of effects for noise on marine mammals and sea turtles are well documented in Labrador Shelf SEA Section 5.1.3.7 (Sikumiut 2008). For the purposes of this assessment, the primary sound sources of concern are considered to be the seismic array, seismic and geo-hazard vessels. Given that the supply and picket vessels will mostly be operating within a relatively short distance of the aforementioned vessels, their contribution to underwater sound in the area is considered relatively negligible.

Project-related vessels (seismic, geo-hazard, supply, and picket) have the potential to interact with Species at Risk through direct contact (i.e., collision). A study of green sea turtles by Hazel *et al.* (2007) suggested that 60 percent of observed turtles (n=1,819) actively avoided vessels travelling at 2 knots, but only 22 percent avoided vessels travelling at speeds of 6 knots. Such a study has not been done for leatherback turtles; however, this species is recognized as being the fastest reptile (19 knots when frightened; McFarlan 1992) and might be expected to better able to avoid a strike.

Toothed whales and pinnipeds are rarely struck by vessels (Laist *et al.* 2001; Jensen and Silber 2003). These marine mammals are fast swimming and agile, enabling them to avoid approaching vessels. In contrast, the most commonly struck of all marine mammals are the baleen whales (Laist *et al.* 2001; Jensen and Silber 2003). It is thought that these large, slow-moving animals are often unable to react fast enough to avoid approaching vessels (Laist *et al.* 2001; Jensen and Silber 2003). However, evidence suggests that serious (or lethal) vessel strikes to whales are infrequent at vessel speeds less than 14 knots and are rare at vessel speeds less than 10 knots (Laist *et al.* 2001). Seismic vessel and geo-hazard vessel strikes with marine mammals are therefore considered unlikely given the predictable direction and slow speed of advance (4 to 5 knots) of the vessels. Supply vessels and picket vessels will generally be travelling alongside the seismic or geo-hazard vessels and are therefore expected to operate at similar speeds. However, as a precautionary mitigation measure, all Project-related vessels will be restricted to a maximum speed of 10 knots within the Project Area (i.e., not in transit to/from the Project Area). With this mitigation in place, on the rare chance that a few encounters occur, any environmental effect would be slight (given the vessel speed upon collision). The potential environmental effect of vessel strikes to marine mammal and sea turtle Species at Risk is therefore considered minimal and is not assessed further.

Helicopters are often used for larger vessel crew changes and light re-supplying. Baleen whales, toothed whales, and pinnipeds have been known to react to the sounds produced by aircraft and a summary of marine mammals responses (reported pre-1995) are presented in Richardson (1995; pages 243-252). It is unknown how sea turtles respond, if at all. They are expected to hear helicopters but it is likely that single or occasional overflights would only elicit a brief behavioural response if any. Mitigative measures will require that helicopters maintain a high altitude (minimum cruising altitude of 500 m) and not circle above marine mammals or sea turtles, thus reducing potential sound exposure time and intensity. With these measures in place, the effects of helicopters on marine mammal and sea turtle Species at Risk are expected to be minimal.

7.1.3.3 SEABIRDS

Seabird Species at Risk may be attracted to lighting on the vessel during darkness periods, which may result in a bird strike on a vessel, leading to injury or strandings. There are no seabird species at risk that spend considerable amounts of time below the surface of the water and in close proximity to air gun pulses; therefore, it is unlikely that seabird Species at Risk will experience hearing impairment.

There is little information available on the effects of seismic surveys on seabirds, which may be a reflection of the fact that there is little evidence that problems occur (Davis *et al.* 1998). Sound from an air gun is focused downward below the surface of the water and the generated sound levels at and immediately below the surface are likely greatly reduced (LGL 2002). As Ivory Gull do not spend measurable time under water (unlike the Alcidae) (see Section 7.4.3 for more detail on the potential environmental effects of sound on seabirds).

7.1.4 ENVIRONMENTAL EFFECTS MANAGEMENT

7.1.4.1 MARINE FISH

Mitigation procedures, consistent with the C-NLOPB's guidelines (C-NLOPB 2008) for this activity will include an FLO to facilitate information flow between the survey and vessels and fishing vessels in the vicinity of the seismic survey. Fisheries damage compensation (for damaged gear and market losses, directly associated with damage to fishing gear attributable to the seismic survey) will also be provided.

7.1.4.2 MARINE MAMMALS AND SEA TURTLES

The seismic vessel will me*et al.*l mitigation measures outlined in the C-NLOPB *Geophysical, Geological, Environmental and Geotechnical Program Guidelines*, in particular with respect to Appendix 2: Environmental Planning, Mitigation and Reporting (C-NLOPB 2008). Appendix 2 contains verbatim the *Statement of Canadian Practice with Respect to the Mitigation of Sound in the Marine Environment* (DFO 2007a) (Statement), as well as a set of requirements with respect to marine mammal monitoring and reporting. Mitigation requirements under the Statement include:

- use of a 500 m safety zone for marine mammals and sea turtles;
- a qualified MMO who will continuously observe the safety zone for a minimum of 30 minutes prior to the start up of the air source to make sure there are no marine mammals or sea turtles;
- a qualified MMO who will maintain a regular watch of the safety zone at all other times;
- shut-downs when a Schedule 1 *SARA* species is observed (as specified in the Statement);

- ramp-up of the air source over a minimum of a 20-minute period;
- ramp up before shutdown; and
- operations in low visibility including use of Passive Acoustic Monitoring when the full extent of the safety zone is not visible and the survey occurs in "critical habitats"[2] as defined under *SARA* for a cetacean on Schedule 1 of *SARA* or, identified in the context of this environmental assessment.

The mitigation measures outlined above and detailed in both the C-NLOPB Guidelines (C-NLOPB 2008) and the Statement are widely used internationally, in the Canadian Atlantic and elsewhere in Canada.

7.1.4.3 SEABIRDS

Based on the potential interactions identified in Section 7.1.3.3 and existing knowledge regarding these interactions, the following mitigation measures to reduce or eliminate potential adverse effects of the Project on Marine Birds have been identified:

- routine checks for stranded birds and implementation of appropriate procedures for release that will minimize the effects of vessel lighting on birds; and
- avoidance of seabird colonies by the seismic vessels and any support helicopter.

7.1.5 ENVIRONMENTAL EFFECTS ANALYSIS

A significant adverse environmental effect is defined as one with a medium or high magnitude for a duration greater than one year over a geographic extent greater than 100 km^2.

An adverse environmental effects that is not significant is defined as one that does not meet the above criteria.

A positive environmental effect is defined as one that results in a measurable population increase and/or enhances the quality of habitat for Species at Risk.

7.1.5.1 MARINE FISH

Seismic activity may results in behavioural effects such as avoidance behaviour, increased swimming speeds, disruption of migration patterns and disruption of reproductive behaviour. Some species may avoid the noise zone of influence around the source vessel. Seismic activity should have negligible behavioural effects on individuals and populations unless it occurs during sensitive periods.

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[2] No critical habitat has been defined as of yet, therefore, the Passive Acoustic Monitoring is not needed.

The approaching noise from a seismic array is likely to drive fish away; therefore, mortality of adult fish is not expected (Turnpenny and Nedwell 1994), unless fish that are within a few metres of a seismic array as it is discharged (Turnpenny and Nedwell 1994). There are no records of mass fish kills associated with the operation of seismic air gun arrays (Payne 2004). The survival and recovery of the northern and spotted wolffish populations in the Gulf of St. Lawrence will be negligibly affected by oil exploration (DFO 2004b).

Mathematical modelling of a 'worst-case scenario' of the effects of seismic energy on fish eggs and larvae indicated that mortality rates caused by exposure to seismic activity are so low as to be comparable to natural mortality (Saetre and Ona 1996). Potential environmental effects of seismic activity from this Project on larvae and eggs will not affect the distribution or abundance of a species at risk population for more than one generation. Critical habitats of species listed under SARA and COSEWIC legislation are not expected to be affected. Egg and larval mortality, physical injury of adult fish and auditory damage is possible only within a few metres, a few tens of metres and a few hundreds of metres from a seismic array, respectively. The environmental effects assessment is summarized in Table 7-5.

Table 7-5 Environmental Effects Assessment: Marine Fish Species at Risk

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Seismic Array Noise	Disturbance (A): Physical Effects (A)	Ramp up; delay start	1	3	2/6	R	1
Seismic Vessel Noise	Disturbance (A)		1	1	2/6	R	1
Seismic Array Noise	Disturbance (A)		1	1	2/6	R	1
Supply Vessel Noise	Disturbance (A)		1	1	2/6	R	1
Picket Vessel Noise	Disturbance (A)		1	1	2/6	R	1
Geo-hazard Vessel Noise	Disturbance (A)		1	1	2/6	R	1
Presence of Seismic Vessel	Disturbance (A)		1	1	2/6	R	1
Presence of Supply Vessel	Disturbance (A)		1	1	2/6	R	1
Presence of Picket Vessel	Disturbance (A)		1	1	2/6	R	1
Presence of Geo-hazard Vessel	Disturbance (A)		1	1	2/6	R	1
Vessel Lights	Disturbance (A)		1	1	2/6	R	1
Air Emissions	Disturbance (A)		1	1	2/6	R	1
Domestic/Sanitary Waste	Disturbance (A)		1	1	2/6	R	1

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Helicopters							

KEY:

Magnitude:
1 = Low: <10 percent of Study Area population or habitat will be exposed to the effect.
2 = Medium: 11 to 25 percent of Study Area population or habitat will be exposed to the effect.
3 = High: >25 percent of Study Area population or habitat will be exposed to the effect.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 =< 1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse effects.

Based on existing knowledge of the effects of seismic activity on marine fish species at risk and the mitigations that will be implemented, the Project is predicted to have a *not significant* residual environmental effect on marine fish and fish habitat species at risk.

7.1.5.2 MARINE MAMMALS AND SEA TURTLES

For marine mammal and sea turtle Species at Risk, the primary potential effect of concern is that noise from the survey may cause changes in behaviour or physiological harm. Potential sources of noise associated with seismic exploration activities can be roughly grouped into three categories:

- 2-D and 3-D seismic surveys (seismic vessel and seismic array);
- vertical seismic profiling and geo-hazards survey (geo-hazard vessel, echo sounder, side scan sonar, boomer); and
- support vessels and aircraft (supply vessel, picket vessel, helicopter).

Sound is integral to marine mammal species at risk, to both their ability to communicate and to gather information about their surroundings. Most environmental effects of sound on marine mammals can be divided into the following three categories:

- hearing impairment and other physical effects;
- behavioural disturbance; and
- masking.

The air gun arrays used in seismic surveys typically produce high amplitude sound (source levels of 220 to 248 dB re 1 µPa at 1 m) (Weir and Dolman 2007). The highest energy output is at relatively low frequencies of 10 to 200 Hz, which overlap with sound produced by baleen whales (12 to 500 Hz). In addition, air gun arrays also produce high frequency sound energy (up to 22 kHz), which overlap with sound used by small toothed whale species (0.5 to 20 kHz range) (Weir and Dolman 2007). Therefore, both baleen and toothed whales may potentially be adversely affected by air gun noise.

Potential environmental effects to marine mammals the sound generated by a seismic array include direct physical injury (e.g., temporary and permanent hearing loss), indirect physical damage, physiological effects (e.g., stress), behavioural effects (including displacement from important habitat), masking of echolocation signals, and indirect effects resulting from food species avoiding the sound source (Weir and Dolman 2007).

There is some overlap between the sound generated by seismic arrays and seals, as most seals produce sounds with dominant frequencies between 0.1 and 3 kHz (Richardson and Malme 1993). However, the nature of the array pulses (short and discontinuous) is expected to result in limited masking of seal calls. Ramp-up of seismic systems would allow time for marine mammals to avoid the sound source.

While sea turtle hearing sensitivity (250 to 700 Hz (Ridgeway *et al.* 1969; Bartol *et al.* 1999)) is higher than the frequencies of most seismic sounds; they do overlap with those produced by air gun pulses, so air guns are likely audible to sea turtles.

Sea turtles may show behavioural responses to an approaching air gun array at a received level of approximately 166 dB re 1 µPa (rms) (approximately 2 km from the sound source in 100 to 120 m water) and avoid sound generated at approximately 175 dB re 1 µPa (rms) (1 km from the sound source in 100 to 120 m water) (McCauley *et al.* 2000b).

Other effects from seismic activities include vessel and aircraft traffic (both the noise generated by them and the physical presence of the vessel). Strong or rapidly changing vessel noise can result in a change in the behaviour of baleen whales (Watkins 1986; Beach and Weinrich 1989). The response of toothed whales to vessels varies within and among species and ranges from avoidance to approach and bowriding (Baird and Stacey 1991a, 1991b; Stacey and Baird 1991; Mullin *et al.* 1994a, 1994b).

Noise from aircraft has resulted in some bowhead whales performing shorter and abrupt dives, away from the noise made by helicopters (Patenaude *et al.* 2002); the aircraft altitudes above the water were usually 150 m or lower.

Further details on the environmental effects of seismic noise on marine mammal and sea turtles, including species at risk, are provided in Sections 5.1.3.8 to 5.1.3.11 in the Labrador Shelf SEA (Sikumiut 2008).

The environmental effects assessment is summarized in Table 7-6.

Table 7-6 Environmental Effects Assessment: Marine Mammals and Sea Turtles Species at Risk

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	**Geographic Extent**	**Duration/ Frequency**	**Reversibility**	**Ecological/Socio-economic Context**
Seismic Array Noise	Disturbance (A); Physical Effects (A)	Ramp up; Delay start; Shut down	1	4	2/6	R	1
Seismic Vessel Noise	Disturbance (A)		1	2	2/6	R	1
Supply Vessel Noise	Disturbance (A)		1	2	2/6	R	1
Picket Vessel Noise	Disturbance (A)		1	2	2/6	R	1
Geo-hazard Vessel Noise	Disturbance (A)		1	2	2/6	R	1
Presence of Seismic Vessel	Disturbance (A)		1	2	2/6	R	1
Presence of Supply Vessel	Disturbance (A)		1	2	2/6	R	1
Presence of Picket Vessel	Disturbance (A)		1	2	2/6	R	1
Presence of Geo-hazard Vessel	Disturbance (A)		1	2	2/6	R	1
Vessel Lights	Attraction (A)		1	2	2/6	R	1
Air Emissions							
Domestic/Sanitary Waste							
Helicopter							

KEY:

Magnitude:
1 = Low: <10 percent of Study Area population or habitat will be exposed to the effect.
2 = Medium: 11 to 25 percent of Study Area population or habitat will be exposed to the effect.
3 = High: >25 percent of Study Area population or habitat will be exposed to the effect.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 =< 1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse effects.

While large cetaceans travel through the Study Area, there are no specific identified whale migration routes within the Study Area (J. Lawson, pers. comm.). Harp seals tagging studies have shown that both harp and hooded seals move along the Labrador Shelf during their annual breeding and moulting periods, and as they disperse afterwards to feed the rest of the year. They appear to use both the nearshore and offshore margins of the shelf (G. Stenson, pers. comm.). There was much variability in seasonal movement between years and among tagged individuals. Harp seals generally migrate southward along the Labrador coast in the fall, reaching the mouth of the St. Lawrence Gulf in early winter; the migration is reversed in late spring/early summer (Stenson and Sjare 1997). There have been no satellite-tagged cetacean surveys to follow their movements in this area (J. Lawson, pers. comm.). Kellog (1928) suggested that fin whales did not arrive on the Labrador coast until mid-July and were most numerous in August. Fins, humpbacks and perhaps other larger whales seem to move up the Strait in the late summer and early fall to feed on the fall herring and mackerel in southern Labrador (J. Lawson, pers. comm.). Whitehead *et al.* (1982) speaks of identified humpback whales moving along the Newfoundland northeast coast and on to southern Labrador. How far they travel north of that is unknown, although recently, very large aggregations of humpbacks and fin whales have been sighted during aerial surveys off the southwest of Greenland, so these might be "Canadian" whales (J. Lawson, pers. comm.).

With the implementation of all mitigation measures outlined in the C-NLOPB Guidelines (C-NLOPB 2008) and the Statement, in particular the use of MMOs, the transient and temporary environmental effects of noise on marine mammal and sea turtle Species at Risk are deemed *not significant*. This determination is made with moderate confidence given the lack of current and site-specific (Study Area) information pertaining to marine mammals (e.g., relative abundances, important biological [feeding, migratory, and social] habitat, etc.).

7.1.5.3 SEABIRDS

Air guns create sound that is focused downward below the surface of the water. Any above-water sound is non-existent and should have no effect on birds that have their heads above water or are in flight. Most species of seabirds spend only a few seconds underwater foraging for food, so there would be minimal opportunity for exposure to noise associated with seismic shooting. The seismic survey will occur in ice-free waters and the Ivory Gull generally avoids ice-free waters. Therefore, the environmental effects of noise on seabird Species at Risk are deemed *not significant*.

7.1.6 SUMMARY OF RESIDUAL ENVIRONMENTAL EFFECTS ON SPECIES AT RISK

Potential adverse environmental effects from seismic activities on species at risk will be unlikely because of planned monitoring and mitigation measures and species at risk are expected to show some avoidance of the area of highest received levels of seismic sounds. Therefore, the residual adverse environment effect of the Project on species at risk is not significant. The Project is therefore not expected to contravene the prohibitions of *SARA* (Sections 32(1), 33 and 58(1)). A summary of residual environmental effects is provided in Table 7-7.

Table 7-7 Summary of Residual Environmental Effects on Species at Risk

Project Activity	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Seismic Array Noise	NS	3	na
Seismic Vessel Noise	NS	3	na
Supply Vessel Noise	NS	3	na
Picket Vessel Noise	NS	3	na
Geo-hazard Vessel Noise	NS	3	na
Presence of Seismic Vessel	NS	3	na
Presence of Supply Vessel	NS	3	na
Presence of Picket Vessel	NS	3	na
Presence of Geo-hazard Vessel	NS	3	na
Vessel Lights	NS	3	na
Air Emissions	NS	3	na
Domestic/Sanitary Wastes	NS	3	na
Helicopter	NS	3	na

KEY:

Residual Environmental Effects Rating:	Levels of Confidence:	Probability of Occurrence:
S = Significant Adverse Environmental Effect	1 = Low level of Confidence	1 = Low Probability of Occurrence
NS = Not Significant Adverse Environmental Effect	2 = Medium Level of Confidence	2 = Medium Probability of Occurrence
P = Positive Environmental Effect	3 = High level of Confidence	3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria.

na = likelihood is only indicated for those VECs that have a significant residual adverse environmental effect rating.

7.2 MARINE FISH AND FISH HABITAT

Twenty-eight species of fish (shellfish, finfish, skates and sharks) have been reported in the Study Area. Of these, species that are listed under *SARA* or considered at-risk by COSEWIC are assessed separately as Species at Risk (Section 7.1). This VEC considers environmental effects of the Project resulting from vessel mobilization, seismic operations, and vessel demobilization for those 21 species (and their habitat) that are not considered at risk but that may interact with the Project. The effects of accidental events are assessed in Chapter 9. Cumulative environmental effects on marine fish are assessed in Chapter 8. Commercial and traditional fisheries are considered a separate VEC (Section 7.5).

7.2.1 ASSESSMENT BOUNDARIES

The spatial and temporal distribution of the fish and shellfish species (five of which are commercial species) within the Project Area are not precisely known, so it is assumed that species known to occur regularly on the Labrador Shelf (includes migratory species (e.g., capelin) as well as sessile invertebrates) may occur in the affected area and be potentially affected by Project activities. Ecological boundaries for fish vary among species due to differences in home ranges, migration patterns and life histories.

The spatial, temporal and administrative boundaries outlined in Section 7.1.1 (Species at Risk) also apply to Marine Fish.

7.2.2 POTENTIAL INTERACTIONS

The potential interactions described for marine fish Species at Risk (Section 7.1.2.1) are also applicable to non-listed species.

7.2.3 EXISTING KNOWLEDGE

The literature covering the effects of seismic sound in particular and noise in general on invertebrates is limited. Some of the existing scientific literature is difficult to compare and draw concrete conclusions as a result of inadequate documentation on measurement methods and units.

In general, marine animals with gas-filled organs are more vulnerable to acoustic impact because of the impedance difference between air and water. An acoustic wave travelling under water and approaching an animal will travel straight through the animal's tissues because of the similarities of acoustic characteristics (impedance, speed of sound) of water and tissues. If the acoustic wave hits a gas-filled cavity, the acoustic impedance drops significantly (as a result of reduced density and sound speed). The boundary between the medium of water and the medium of air acts as a pressure-release surface potentially causing damage (rupture, hemorrhaging) to the organ's tissues (the tissues enveloping the gas-filled cavity). Most invertebrates do not have gas-filled organs and are therefore usually considered less vulnerable than fish (Parry and Gason 2006).

Decapods, such as crabs, have an array of hair-like receptors in and on their body surface, which could potentially respond to water or substrate displacements. Rather than being sensitive to pressure changes, invertebrates appear to be more sensitive to particle displacement (Popper *et al.* 2001). The total energy of an acoustic pulse is the integral of the intensity over the duration of the pulse and over the (spherical) surface that it passes through. Acoustic energy consists of kinetic energy and potential energy. The former is contained in particle movement; the latter is equal to the work done by elastic pressure forces. Intensity is the product of pressure and particle velocity. The pressure gradient (∇P) is proportional to the particle acceleration:

$$\nabla P = -\rho \frac{\partial u}{\partial t}$$, where u is the particle velocity and ρ is the water density.

Far away from the source, particle velocity is proportional to pressure ($P = \rho c u$) and energy is proportional to the time integral of squared pressure. Near the source, however, particle velocity has a "quadrature" component that is out-of-phase with acoustic pressure. Therefore, when relating acoustic impact to acoustic energy, particle velocity and pressure components should be considered separately in the near-field.

The following summarizes studies that showed some effect of seismic sound on invertebrates.

Scallop shells were damaged by air guns 2 m away (Pearson *et al.* 1994). Iceland scallop shells split in 1 of 3 tested during exposure to sleeve guns at 2 m range and received levels of 217 dB re 1µPa (Matishov 1992). Snow crab eggs showed delayed embryonic development after exposure to seismic energy (Payne 2004). Snow crab eggs were exposed to 221 dB at 2m in a study and showed possible signs of retarded development (Christian *et al.* 2004). Sea urchins (*Strongylocentrotus droebachiensis*) had 15 percent of spines falling off after exposure to sleeve guns at 2m and received levels of 217 dB re 1 µPa (Matishov 1992). Crustaceans appear to be most sensitive to low frequency sounds, less than 1,000 Hz (Budelmann 1992; Popper *et al.* 2001). A number of physiological studies of statocysts of marine crabs suggest that some of these species are potentially capable of sound detection (Popper *et al.* 2001).

Behavioural effects of exposure of caged cephalopods (50 squid and two cuttlefish) to sound from a single 20-inch air gun have been reported (McCauley *et al.* 2000). The behavioural responses included squid firing their ink sacs and moving away from the air gun, startle responses and increased swimming speeds. No squid or cuttlefish mortalities were reported as a result of these exposures to the air gun sources.

Guerra *et al.* (2004) indicated that two incidents of multiple stranding of the giant squid (*Architeuthis dux*) along the north coast of Spain appeared to be linked to geophysical seismic surveys in the Bay of Biscay. Evidence of acute tissue damage was presented and the authors speculated that one female with extensive tissue damage was affected by the impact of acoustic waves. No detail with respect to the seismic sources, locations and durations of seismic exposure were provided, so this study has to be considered anecdotal, merely pointing out that some damage to squid from seismic pulses might be possible; however, levels are unknown.

The following paragraphs summarize studies that failed to show any effect of seismic sound on invertebrates.

Mussels and periwinkles showed no effects within 0.5m of an air gun (Perry and Gason 2006). Kosheleva (1992) found no effect on mussels (*Mytilus edulis*), periwinkles (*Littorina* spp.) and crustaceans (*Gammarus locusta*) within 30 days after exposure to sleeve guns at 0.5m and 229 dB re 1µPa. Mortality and development rates of Stage II Dungeness crab larvae exposed to single discharges from a seismic array were compared with those of unexposed larvae. No statistically significant differences between the exposed and unexposed larvae were observed with respect to immediate and long-term survival and time to molt, even for those exposed larvae within approximately 1 m of the seismic source receiving peak levels of 230 dB re 1 µPa (Pearson *et al.* 1994).

Parry and Gason (2006) examined catch rates of rock lobster in western Victoria, Australia, in relation to seismic surveys and found no evidence that catch rates were affected in the weeks or years following the surveys. Brown shrimp (*Cragnon cragnon*) in the Wadden Sea were exposed by Webb and Kempf (1998) to a 15 gun array (volume 480 cubic inches with source levels of 190 dB re 1µPa at 1 m depth). There was no evidence of mortality or reduced catch rates for the shrimp. The authors hypothesized that the lack of effects was due to the absence of gas-filled organs and a rigid exoskeleton.

There are no indications of acute or mid-term mortality in adult snow crab due to seismic activity, nor does there appear to be any effect on the survival of embryos carried on the female or on the locomotion of the larvae after hatch (DFO 2004c).

Egg-bearing female snow crabs were caught, caged and subsequently exposed to seismic energy released during a commercial seismic survey off Cape Breton, Nova Scotia. Both acute and chronic effects on the adult female crabs, embryos and larvae hatched from the eggs were studied (DFO 2004c). Three observations resulted from this study:

- the seismic survey did not cause any acute or chronic (five months) mortality of the crab, or any changes to the feeding activity of the treated crabs being held in the laboratory;
- neither the survival of embryos being carried by the female crabs during exposure nor the locomotion of the larvae after hatch appeared to be affected; and
- there was acute soiling of gills, antennules and statocysts of the crabs at the exposure site but after five months, all structures had returned to their clean state (theorized to be due to dragging on the bottom in their cages during retrievals, etc.).

Christian *et al.* (2004) conducted a behavioural investigation during which caged snow crabs were positioned 50 m below a seven-gun array. Observations on the crabs' responses to seismic shooting were recorded by remote underwater camera. No obvious startle behaviours were observed.

In conclusion, invertebrates without gas-filled organs appear less vulnerable to the effects of air guns than animals with gas-filled organs. Benthic invertebrates in water deeper than about 20 m are likely far enough away from the seismic source near the surface so that particle velocity effects become negligible.

Existing knowledge concerning potential environmental effects of Project activities on Marine Fish are adequately represented by the consideration of effects to marine fish Species at Risk in Section 7.1.3.1.

Two commercially-important species harvested in the Project Area are shrimp and snow crab. Christian *et al.* (2004) exposed snow crab eggs to 221 dB at 2 m. There were possible signs of retarded development; however, eggs in nature are unlikely to be exposed to noise levels of range or intensity in nature as they are carried by the female on the seafloor (the same is true for shrimp). Results from a DFO (2004c) study on the effects of seismic activity on adult snow crab indicated no acute or mid-term mortality; nor were embryo survival or mobility of hatched larvae affected.

7.2.4 ENVIRONMENTAL EFFECTS MANAGEMENT

Mitigation procedures, consistent with the C-NLOPB's guidelines (C-NLOPB 2008) for this activity will include an FLO to facilitate information flow between the survey and vessels and fishing vessels in the vicinity of the seismic survey. In addition, Husky Energy will use a picket (or guide vessel) and will provide Notices to Shipping and advertize their activities on the CBC Radio program Fisheries Broadcast and the Okalakatiget Society radio.

7.2.5 ENVIRONMENTAL EFFECTS ANALYSIS

A significant adverse environmental effect is defined as one with a medium or high magnitude for a duration greater than one year over a geographic extent greater than 100 km^2. The environmental effects analysis for marine fish and fish habitat is the same as for marine fish Species at Risk (see Table 7-5).

An adverse environmental effects that is not significant is defined as one that does not meet the above criteria.

A positive environmental effect is defined as one that results in a measurable population increase and/or enhances the quality of habitat for Marine Fish.

With the implementation of all mitigation measures outlined in the C-NLOPB Guidelines, the transient and temporary effects of noise on Marine Fish are deemed *not significant*.

A summary of residual environmental effects is provided in Table 7-8.

Table 7-8 Summary of Residual Environmental Effects on Marine Fish and Fish Habitat

Project Activity	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Seismic Array Noise	NS	3	na
Seismic Vessel Noise	NS	3	na
Supply Vessel Noise	NS	3	na
Picket Vessel Noise	NS	3	na
Geo-hazard Vessel Noise	NS	3	na
Presence of Seismic Vessel	NS	3	na
Presence of Supply Vessel	NS	3	na
Presence of Picket Vessel	NS	3	na
Presence of Geo-hazard Vessel	NS	3	na
Vessel Lights	NS	3	na
Air Emissions	NS	3	na
Domestic/Sanitary Wastes	NS	3	na
Helicopter			

<table>
<tr><th>Project Activity</th><th>Residual Adverse Environmental Effect Rating[A]</th><th>Level of Confidence</th><th>Probability of Occurrence (Likelihood)</th></tr>
<tr><td colspan="4">KEY:
Residual Environmental Effects Rating:
S = Significant Adverse Environmental Effect
NS = Not Significant Adverse Environmental Effect
P = Positive Environmental Effect
Levels of Confidence:
1 = Low level of Confidence
2 = Medium Level of Confidence
3 = High level of Confidence
Probability of Occurrence:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence
[A] As determined in consideration of established residual environmental effects rating criteria.
na = likelihood is only indicated for those VECs that have a significant residual adverse environmental effect rating.
Blank rows indicate no Project interaction with VEC.</td></tr>
</table>

7.3 MARINE MAMMALS AND SEA TURTLES

The ensuing chapter assesses the following taxa: baleen whales (Mysticetes), toothed whales (Odontocetes), dolphins (Delphinids), porpoises (Phocoenids), seals and walrus (Pinnipeds), polar bears (Ursids), and sea turtles (Chelonioids). Of these, species that are listed under *SARA* or considered at-risk by COSEWIC are assessed separately as Species at Risk (Section 7.1). This VEC considers environmental effects of the Project resulting from vessel mobilization, seismic operations, and vessel demobilization for those 12 species that are not considered at risk but that may interact with the Project. The effects of accidental events (except potential vessel strikes, considered herein) are assessed in Chapter 9. Cumulative environmental effects on marine mammals and sea turtles are assessed in Chapter 8. Although marine fish habitat, marine fish and shellfish are fundamentally linked to the health of marine mammals, these are considered a separate VEC (Section 7.2), as are commercial and traditional fisheries (Section 7.5).

7.3.1 ASSESSMENT BOUNDARIES

The spatial, temporal and administrative boundaries outlined in Section 7.1.1 (Species at Risk) also apply to non-listed Marine Mammals and Turtles.

7.3.2 POTENTIAL INTERACTIONS

The potential interactions and described for marine mammal and sea turtle Species at Risk (Section 7.1.2.2) are also applicable to non-listed Marine Mammals and Sea Turtles.

7.3.3 EXISTING KNOWLEDGE

Existing knowledge concerning potential environmental effects of Project activities on marine mammals and sea turtles are adequately represented by the consideration of effects to marine mammal and sea turtle Species at Risk in Section 7.1.3.2.

7.3.4 ENVIRONMENTAL EFFECTS MANAGEMENT

Mitigation measures that are effective for at-risk marine mammal and sea turtle species (Section 7.1.3.2) will also be applicable for other marine mammals and sea turtles.

7.3.5 ENVIRONMENTAL EFFECTS ANALYSIS

A significant adverse environmental effect is defined as one with a medium or high magnitude for a duration greater than one year over a geographic extent greater than 100 km^2. The environmental effects analysis for Marine Mammals and Sea Turtles is the same as for marine mammals and sea turtles Species at Risk (see Table 7-6).

An adverse environmental effect that is not significant is one that does not meet the above criteria.

A positive effect is defined as one that results in a measurable population increase and/or enhances the quality of habitat for Marine Mammals and Sea Turtles.

With the implementation of all mitigation measures outlined in the C-NLOPB Guidelines and the Statement, in particular the use of MMOs, the transient and temporary effects of noise on Marine Mammal and Sea Turtles are deemed *not significant*.

A summary of residual environmental effects is provided in Table 7-9.

Table 7-9 Summary of Residual Environmental Effects on Marine Mammals and Sea Turtles

Project Activity	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Seismic Array Noise	NS	3	na
Seismic Vessel Noise	NS	3	na
Supply Vessel Noise	NS	3	na
Picket Vessel Noise	NS	3	na
Geo-hazard Vessel Noise	NS	3	na
Presence of Seismic Vessel	NS	3	na
Presence of Supply Vessel	NS	3	na
Presence of Picket Vessel	NS	3	na
Presence of Geo-hazard Vessel	NS	3	na
Vessel Lights	NS	3	na
Air Emissions			
Domestic/Sanitary Wastes			
Helicopter			

KEY:

Residual Environmental Effects Rating:	Levels of Confidence:	Probability of Occurrence:
S = Significant Adverse Environmental Effect	1 = Low level of Confidence	1 = Low Probability of Occurrence
NS = Not Significant Adverse Environmental Effect	2 = Medium Level of Confidence	2 = Medium Probability of Occurrence
P = Positive Environmental Effect	3 = High level of Confidence	3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria.

na = likelihood is only indicated for those VECs that have a significant residual adverse environmental effect rating.

Blank rows indicate no Project interaction with VEC.

7.4 SEABIRDS

The Labrador coast is used by numerous species of seaducks, shorebirds and seabirds use for breeding (many of the breeding marine species nest on the 4,000+ islands off the coast), overwintering, or as a migratory or moulting stopover. Of these, species that are listed under SARA or considered at-risk by COSEWIC are assessed separately as Species at Risk (Section 7.1). This VEC considers environmental effects of the Project resulting from vessel mobilization, seismic operations, and vessel demobilization for those the not-listed species (and their habitat) that are not considered at risk but that may interact with the Project. The effects of accidental events are assessed in Chapter 9. Cumulative environmental effects on marine fish are assessed in Chapter 8.

7.4.1 ASSESSMENT BOUNDARIES

The spatial, temporal and administrative boundaries outlined in Section 7.1.1 (Species at Risk) also apply to un-listed Seabirds.

7.4.2 POTENTIAL INTERACTIONS

The potential interactions and described for seabird Species at Risk (Section 7.1.2.3) are also applicable to non-listed Seabirds.

7.4.3 EXISTING KNOWLEDGE

There are limited data available with respect to the effects of underwater sound on birds. The sound created by air guns is focused toward the substrate, below the surface of the water. Above the water, sound is reduced to a muffled noise that should have little or no effect on birds that have their heads above water or are in flight. Most species of seabirds that may be present in the Study Area spend only a few seconds underwater during a foraging dive; therefore, there would be minimal opportunity for exposure to noise associated with seismic shooting.

Only the Alcidae (Dovekie, Common Murre, Thick-billed Murre, Razorbill, Black Guillemot and Atlantic Puffin) spend measureable time underwater during forage dives. They typically spend 25 to 40 seconds underwater during each dive (Gaston and Jones 1998), reaching depths of 20 to 60 m, and have the potential to be exposed to the sounds produced by seismic shooting. The effects of seismic noise on Alcids are not well known. Some bird species are attracted to ships, while others avoid interactions with vessels, so it is possible that traffic could affect foraging birds at sea. It is not anticipated that vessels travelling to and from the Study Area/Project Area will cause disturbance to seabird colonies.

No effects on movement or diving behaviour were observed during a study in the Beaufort Sea on the effects of seismic surveys on moulting long-tailed ducks (although the authors indicated that their ability to detect subtle disturbance effects was limited) (Lacroix *et al.* 2003). No evidence of mortality or distributional effects on marine birds was observed during a seismic survey in the Davis Strait area (Stemp 1985). Shearwaters with their heads below the surface 30 m from a seismic source showed no response (Parsons, in Stemp 1985). There was no evidence that seismic testing in the Irish Sea either attracted or repelled seabirds (Evans *et al.* 1993); nor were there any reported ill effects on guillemot, fulmar and kittiwake species that were monitored during air gun seismic surveys in the North Sea (Turnpenny and Nedwell 1994).

Aircraft activity in the vicinity of seabird colonies can result in mortality of chicks due to panic responses of adult birds. Helicopters servicing projects in the area will be required to avoid major colonies along the Labrador coast. Disturbance to marine birds on the water surface will be negligible when aircraft are 600 m above the sea surface. Marine birds in the vicinity of helicopters taking off and landing on platforms may be disturbed.

7.4.4 ENVIRONMENTAL EFFECTS MANAGEMENT

Based on the potential interactions identified in Section 7.4.2 and existing knowledge regarding these interactions, the following mitigation measures to reduce or eliminate potential adverse effects of the Project on Marine Birds have been identified:

- routine checks for stranded birds and implementation of appropriate procedures for release that will minimize the effects of vessel lighting on birds;

- avoidance of seabird colonies by the seismic vessels and any support helicopter; and

- ship operations will adhere to Annex I of the *International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78).

7.4.5 ENVIRONMENTAL EFFECTS ANALYSIS

A significant adverse environmental effect is defined as one with a medium or high magnitude for a duration greater than one year over a geographic extent greater than 100 km^2.

A not significant adverse environmental effect is defined as an adverse effect that does not meet the above criteria.

A positive environmental effect is defined as one that results in a measurable population increase and/or enhances the quality of habitat for Seabirds.

Air gun sound is focused downward below the surface of the water, so there would be minimal opportunity for exposure to noise from an array, as most species of seabirds that may be present in the Project Area spend only a few seconds underwater during a foraging dive. Therefore, it is unlikely that non-diving birds would be affected by air guns. The Alcidae (which includes Dovekie, Common Murre, Thick-billed Murre, Razorbill, Black Guillemot, and Puffin) have longer underwater foraging dives; therefore, they could potentially be exposed to the noise from an array. However, the incremental increases in ambient noise and disturbance from a vessel will be temporary in any one area. Diving birds within close range of a sound source could possibly be startled by the sound; however, the birds would likely have already reacted to the presence of the ship and its associated seismic equipment (LGL 2005a).

Seabirds may also be attracted to vessel lighting; they may become disoriented and fly into vessel lights or infrastructure, or continuously fly around the light, consuming energy and delaying foraging or migration. During conditions of drizzle and fog, moisture droplets in the air refract the light and greatly increase the illuminated area; disorientation appears to occur most frequently during these periods (Wiese *et al.* 2001). Since the Project operates on a 24-hour basis, lighting is required at night for safety purposes; therefore, mitigative measures will need to be applied (i.e., routine checks for stranded seabirds and implementation of appropriate release procedures).

Normal deck drainage from the vessels may result in limited amounts of hydrocarbons entering the marine environment; however, these discharges are not generally associated with formation of a surface slick. Therefore, it is unlikely they will have a measurable environmental effect on seabirds.

The seismic vessel is usually supported by another vessel. However, support is sometimes required by helicopters. A low-flying helicopter could create a startle response in a seabird colony. Fourteen IBAs (including the Gannet Islands Ecological Reserve) are located within the Study Area; none are located within the Project Area (Section 5.6). Husky Energy will ensure that any requirement to support the seismic vessel by helicopter will follow a flight path that avoids the IBAs (refer to Figure 5-32). The seismic vessel itself (and the picket vessel) will also avoid any seabird colonies.

The environmental effects assessment is summarized in Table 7-10.

Table 7-10 Environmental Effects Assessment: Seabirds

Project Activity	**Potential Positive (P) or Adverse (A) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Residual Adverse Environmental Effects**				
			Magnitude	**Geographic Extent**	**Duration/ Frequency**	**Reversibility**	**Ecological/Socio-economic Context**
Seismic Array Noise			1	1	2/6	R	1
Seismic Vessel Noise	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Supply Vessel Noise	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1
Picket Vessel Noise	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1
Geo-hazard Vessel Noise	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1
Presence of Seismic Vessel	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1
Presence of Supply Vessel	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1
Presence of Picket Vessel	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1
Presence of Geo-hazard Vessel	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1
Vessel Lights	Attraction to vessel (A); Stranding on vessel (A)	Routine checks for stranded birds Release of stranded birds	1	2	2/6	R	1
Air Emissions			1	1	2/6	R	1
Domestic/Sanitary Waste	Attraction to vessel (A)		1	1	2/6	R	1
Helicopter	Disturbance (A)	Avoidance of seabird colonies	1	1	2/6	R	1

KEY:

Magnitude:
1 = Low: <10 percent of Study Area population or habitat will be exposed to the effect.
2 = Medium: 11 to 25 percent of Study Area population or habitat will be exposed to the effect.
3 = High: >25 percent of Study Area population or habitat will be exposed to the effect.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 =< 1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/ Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse effects.

The Project is predicted to have a *not significant* residual environmental effect on Seabirds in the Project Area. A summary of residual environmental effects is provided in Table 7-11.

Table 7-11 Summary of Residual Environmental Effects on Seabirds

Project Activity	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Seismic Array Noise	NS	3	na
Seismic Vessel Noise	NS	3	na
Supply Vessel Noise	NS	3	na
Picket Vessel Noise	NS	3	na
Geo-hazard Vessel Noise	NS	3	na
Presence of Seismic Vessel	NS	3	na
Presence of Supply Vessel	NS	3	na
Presence of Picket Vessel	NS	3	na
Presence of Geo-hazard Vessel	NS	3	na
Vessel Lights	NS	3	na
Air Emissions	NS	3	na
Domestic/Sanitary Wastes	NS	3	na
Helicopter	NS	3	na

KEY:

Residual Environmental Effects Rating:	Levels of Confidence:	Probability of Occurrence:
S = Significant Adverse Environmental Effect	1 = Low level of Confidence	1 = Low Probability of Occurrence
NS = Not Significant Adverse Environmental Effect	2 = Medium Level of Confidence	2 = Medium Probability of Occurrence
P = Positive Environmental Effect	3 = High level of Confidence	3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria.

na = likelihood is only indicated for those VECs that have a significant residual adverse environmental effect rating.

7.5 COMMERCIAL AND TRADITIONAL FISHERIES

While there is little fishing that occurs within the exploration licenses, species are harvested around the exploration licenses, especially immediately adjacent around EL 1106 (see Figure 5-12; Section 5.5.2); the predominant harvested species is shrimp (see Figure 5-16; Section 5.5.6.1), which are harvested using a trawl and accounts for approximately 85 percent of the commercial catch in the Study Area. Snow crab are harvested (using fixed gear) adjacent to the southwest corner of Exploration License 1106 (see Figure 5-24; Section 5.5.6.3). Of the remaining principal commercial species, turbot is not harvested in the vicinity of the exploration licenses (and only sporadically in the Project Area) and Iceland scallop are not collected in the Project Area.

7.5.1 ASSESSMENT BOUNDARIES

The spatial boundary is the seismic survey Project Area. The temporal boundary is July to November, 2010 to 2017.

7.5.2 POTENTIAL INTERACTIONS

Potential effects on Commercial and Traditional Fisheries include direct interference in fishing activities (either through interfering with fixed gear of fishing vessels), the possibility of reduced catch rates (due to avoidance of an area by fish species), or interfering with DFO stock assessment and/or research surveys.

7.5.3 EXISTING KNOWLEDGE

Potential effects of seismic surveys on fisheries catches are a concern to fishers. Collins *et al.* (2002) looked at potential effects on fish catches during and after two independent inshore and near shore seismic surveys undertaken in the Bay St. George and Port au Port areas of western Newfoundland. While not statistically conclusive, their analyses suggested no observable effects on overall fish catches, including snow crab, during or in the years following the seismic surveys.

Engås *et al.* (1996) found that cod and haddock moved away from a 3 x 10 nautical mile region (5.6 x 18 km) in which seismic operations were carried out over a five-day period. Reductions in fish catches were observed out to their sampling limit of 33 km. Other studies showed an increase in catch rate at 30 to 50 km range (Slotte *et al.* 2004). They postulated that the fish may have been responding to continuously discharging air guns by swimming through a gradient of exponentially decreasing sound levels and, as such, habituation may have occurred. Therefore, the fish may have terminated their avoidance reaction at different distances depending on their size and swimming speed. Alternatively, the fish may have responded to the air gun discharges by increasing their swimming speed leading to exhaustion. Avoiding the sound source by prolonged swimming speeds (He 1993) may have produced a response pattern of alternating intervals of swimming and resting until habituation terminated the response at different distances for fish of different sizes. Engås *et al.* (1996) reported that the effects of seismic had lasted for at least five days.

Løkkeborg (1991) analyzed longline catches of cod in the presence of seismic surveys and concluded a reduction in catch rate had occurred. Løkkeborg and Soldal (1993) examined catch data obtained from commercial vessels operating on fishing grounds where seismic explorations were being conducted. They found a 56 percent reduction in longline catches of cod and 81 percent reduction in the by-catch of cod in shrimp trawling. Skalski *et al.* (1992) reported that catches of various redfish species (using vertical lines) declined by 50 percent during discharges of a single air gun. These observations suggested that the fish had responded by either avoiding the sound field of operating seismic vessels or their behavioural state was changed and as such they were no longer available to the fishing techniques tested. Løkkeborg and Soldal (1993) suggested that behavioural changes that forced fish to the bottom acted to temporarily increase catch rates of cod in the trawls during seismic activities.

7.5.4 ENVIRONMENTAL EFFECTS MANAGEMENT

An FLO will be on board the vessel to provide and maintain communications with fishers before and during the Project. This communication will be critical to plan to avoid areas that could raise concerns with respect to gear conflicts. Other mitigative measures include:

- following C-NLOPB (2008) Guidelines to minimize any effects of petroleum industry surveys on commercial fish harvesting;
- compensating for fishing gear losses directly attributable to seismic survey activity;
- to the greatest extent possible scheduling surveys to avoid heavily fished areas when fisheries are active and avoidance of fishing activity and any potential reduction in fish catch rates;
- scheduling surveys to avoid gear conflicts and fish disruptions during the execution of DFO surveys;
- establishing a safety zone of at least 500 m radius from the centre of the air source array;
- publishing a Canadian Coast Guard "Notice to Shipping" and a "Notice to Fishers" via the Okalakatiget Society Radio and the CBC Radio program Fisheries Broadcast;
- use of FLO and picket vessel in front of the seismic vessel.

7.5.5 ENVIRONMENTAL EFFECTS ANALYSIS

A significant adverse environmental effect on Commercial and Traditional Fisheries is defined as one that affects fishers in such a way that they are excluded for fishing in more than 10 percent of their traditional area for the entire fishing season and/or causes attributable damage to fixed gear and/or vessels and/or results in a measurable loss of income due to avoidance by commercial species.

An adverse environmental that is not significant adverse environmental effect is one that does not meet the above criteria.

The environmental effects assessment is summarized in Table 7-12.

7.5.5.1 CONFLICT WITH USE OF AREA

The primary commercial fish users in the vicinity of the Project Area are shrimp harvesters (using trawlers). There are snow crab harvesters that use a specific portion of the Project Area, but as these use fixed gear, they are assessed under Conflict with Fishing Gear.

A seismic vessel's maneuverability is restricted due to the streamer array towed behind the vessel. As a result, other fishing vessels must yield the right of way to the seismic vessel. While the majority of the fishing effort for shrimp is outside the Project Area, shrimp are harvested immediately adjacent to Exploration License 1106, especially around its northwest corner. The seismic vessel (through the FLO) will have to maintain good communication with other fishing vessels in the area and supply Notices to Shipping. As well, the picket vessel should provide an avenue for communication with vessels in the immediate area during the survey.

Table 7-12 Environmental Effects Assessment: Commercial Fisheries

Project Activity	Potential Positive (P) or Adverse (A) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Residual Adverse Environmental Effects				
			Magnitude	Geographic Extent	Duration/ Frequency	Reversibility	Ecological/Socio-economic Context
Seismic Array Noise	Use of Area (behavioural response) (A)	Avoidance; Communication; FLO	1	3	2/6	R	1
Presence of Seismic Vessel	Gear Conflicts (A); Gear Damage (A)	Avoidance; FLO; Compensation	1	2	2/6	R	1

KEY:

Magnitude:
1 = Low: <10 percent of Study Area population or habitat will be exposed to the effect.
2 = Medium: 11 to 25 percent of Study Area population or habitat will be exposed to the effect.
3 = High: >25 percent of Study Area population or habitat will be exposed to the effect.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 11-100 km^2
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Duration:
1 =< 1 month
2 = 1 to 12 months.
3 = 13 to 36 months
4 = 37 to 72 months
5 = >72 months

Frequency:
1 = <10 events/year
2 = 11 to 50 events/year
3 = 51 to 100 events/year
4 = 101 to 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/ Socio-economic Context:
1 = Area is relatively pristine or not adversely affected by human activity.
2 = Evidence of adverse effects.

Stock assessments are conducted in NAFO Area 2G (outside of the Project Area) and as such, should not conflict with the Project. While there have been no DFO research surveys (which are conducted in NAFO Area 2J) since 1999, there is no guarantee that they will not occur again during the life of the Project (to 2017). These surveys are conducted by "fishing" for species and DFO requires a spatial (30 km) and temporal (seven days) "quiet time" if surveys are being conducted in an area that overlaps with a seismic program. In any survey year, Husky Energy will need to obtain specific, detailed information from DFO on DFO research survey timing and locations and coordinate with DFO to establish a temporal and spatial separation plan (this has been implemented with DFO Newfoundland and Labrador in past seasons). Such planning will allow the seismic program to avoid overlap and interference with a DFO research survey (should it be resumed in NAFO Area 2J) and if implemented, the residual environmental effect is predicted to be *not significant*.

7.5.5.2 CONFLICT WITH FISHING GEAR

A picket vessel accompanies the seismic vessel to identify fixed gear locations to avoid (or minimize) entanglement of streamers with fixed gear. In addition, planning of the seismic program will include provision of fixed gear coordinates by fishers and plotting the coordinates on the seismic vessel. There have been (fixed) fishing gear-seismic streamer conflicts within Atlantic Canada (typically three to four times per year) (CRA 2008; LGL 2008). The gear damage from these events was assessed and if the loss/ damage was attributable to the seismic survey, then compensation was paid for loss/ damage. Such compensation assessment will be consistent with the C-NLOPB *Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity* (C-NOPB 2002). Fisheries damage compensation (for damaged gear and market losses, directly associated with damage to fishing gear attributable to the seismic survey) will be provided. These guidelines are familiar to seismic companies operating in Newfoundland and Labrador.

With the application of the mitigative measures (including FLO, picket vessel and compensation plan (if there is a conflict with gear)), the residual environmental effects of the Project on conflict with fishing gear and vessels will be *not significant*.

7.5.5.3 LOSS OF INCOME

Sound from a seismic array can result in fishing avoiding the sound by temporarily moving out of the vicinity of the source (e.g., Chapman and Hawkins 1969; Skalski *et al.* 1992; Turnpenny and Nedwell 1994; Engås *et al.* 1996), reducing the amount of fish caught in a trawl or longliner. There is no agreement on the duration (or distance of effect (localized to 15 to 20 km away)) of the avoidance behaviour (or its resultant effect on the catchability of a species). Observations ranged from an extended reduction in catch of at least one week Engås *et al.* (1996) to one day later, the catch rate appeared to have returned to pre-recording levels (Thompson *et al.* 2000), to no affect (CEF 2002). Observations of caged finfish indicated that normal behaviour was resumed within 14 to 30 minutes after the cessation of a seismic array (McCauley *et al.* 2003). Such range on observations could be dependent upon species, receiving environment or methodologies. Of the two principal commercial species in the Project Area, neither shrimp nor snow crab catch rates are likely to be affected (LGL 2008), nor is Greenland halibut, the only groundfish harvested in the Project Area. The residual environmental effect of the Project on loss of income is predicted to be *not significant*.

The overall residual environmental effect of the Project on Commercial and Traditional Fisheries is predicted to *not significant*. A summary of residual environmental effects is provided in Table 7-13.

Table 7-13 Summary of Residual Environmental Effects on Commercial and Traditional Fisheries

Project Activity	Residual Adverse Environmental Effect Rating[A]	Level of Confidence	Probability of Occurrence (Likelihood)
Seismic Array Noise	NS	3	na
Seismic Vessel Noise			
Supply Vessel Noise			
Picket Vessel Noise			
Geo-hazard Vessel Noise			
Presence of Seismic Vessel	NS	3	na
Presence of Supply Vessel			
Presence of Picket Vessel			
Presence of Geo-hazard Vessel			
Vessel Lights			
Air Emissions			
Domestic/Sanitary Wastes			
Helicopter			

KEY:

Residual Environmental Effects Rating:	Levels of Confidence:	Probability of Occurrence:
S = Significant Adverse Environmental Effect	1 = Low level of Confidence	1 = Low Probability of Occurrence
NS = Not Significant Adverse Environmental Effect	2 = Medium Level of Confidence	2 = Medium Probability of Occurrence
P = Positive Environmental Effect	3 = High level of Confidence	3 = High Probability of Occurrence

[A] As determined in consideration of established residual environmental effects rating criteria.

na = likelihood is only indicated for those VECs that have a significant residual adverse environmental effect rating.

Blank rows indicate no Project interaction with VEC.

7.6 SENSITIVE AREAS

There are IBAs along the shoreline within The Zone and any potential environmental effects of helicopter support on the IBAs are addressed in the assessment of environmental effects on Seabirds (Section 7.4).

The only Sensitive Area within the Project Area is a Parks Canada representative Marine Area, located in the south corner of the Project Area boundary in the Hamilton Bank Area, immediately adjacent to the southern boundary of Exploration License 1106 (see Figure 5-32; Section 5.6). Hamilton Bank, in conjunction with Hawke Channel is an area of high productivity and species diversity, including several major commercial fish species (e.g., redfish, Atlantic cod, and capelin, shrimp and snow crab) and is also important to marine mammals and seabirds (Brown 1999).

The activities associated with seismic surveys would be expected to have little or no environmental effect on sensitive areas; rather, the effect of sound from activities associated with a seismic survey would be more likely to affect the marine fish, marine mammals and sea turtles and seabirds that use the sensitive areas as critical habitat and is addressed in the sections specific to each group.

Given the minimal overlap with Sensitive Areas and the Project Area, and the anticipated lack of environmental effect from seismic surveys, the residual environmental effects of the Project on Sensitive Areas is predicted to be *not significant*.

7.7 FOLLOW-UP AND MONITORING

As noted previously MMO(s) will be on board the vessel(s) to provide identification of marine mammals and sea turtles (including species at risk) for mitigation purposes and to collect opportunistic data on marine mammal behaviours and distribution with and without air guns operating. Seabird observations will also be conducted. The observer will report any dead birds on board the vessel. As well, routine checks will be done for stranded birds that may have been attracted to vessel lighting. Any dead birds will be handled and documented as per a required Seabird Handling Permit and Husky's procedures on this topic that are on file with the C-NLOPB.

7.8 SUMMARY OF RESIDUAL ENVIRONMENTAL EFFECTS

The residual environmental effects on those VECs that interact with the Project are summarized in Table 7-14.

Table 7-14 Residual Environmental Effects Summary Table

VEC	Residual Adverse Environmental Effect Rating	Level of Confidence	Probability of Occurrence (Likelihood)
Species at Risk	Not Significant	Moderate	na
Marine Fish	Not Significant	High	na
Marine Mammals and Sea Turtles	Not Significant	High	na
Marine Birds	Not Significant	High	na
Commercial Fisheries	Not Significant	High	na
Sensitive Areas	Not Significant	High	na
na = likelihood is only indicated for those VECs that have a significant residual adverse environmental effect rating.			

8.0 CUMULATIVE ENVIRONMENTAL EFFECTS

The cumulative environmental effects assessment considers the environmental effects of the seismic program in combination with the following activities (see Section 6.8):

- seismic survey program(s) by other operators;
- commercial and traditional fishing activities.
- marine transportation; and
- tourism/recreation.

8.1 SEISMIC SURVEY PROGRAM(S) BY OTHER OPERATORS

Although operators of the other two exploration leases will likely conduct seismic surveys in the near future, the activities will not overlap spatially, as they could interfere with data collection (i.e., there will need to be at least 50 km between ends of streamers). It is possible that geophysical activities could occur concurrently, with appropriate distances between geophysical locations (although it is more likely that they would occur sequentially). Therefore, the worst case (three concurrent seismic programs) scenario would result in a temporal overlap.

Even sequential surveys could result in a potential environmental effect to marine fish and marine mammal species (including species at risk) that may be sensitive to noise generated during a seismic survey. However, given on the current demand and related availability of seismic vessels, it is unlikely that more than one seismic vessel would be available to conduct more than one program at any given time.

8.2 COMMERCIAL AND TRADITIONAL FISHERIES

There is little fishing that occurs within the exploration licenses; however, shrimp (predominantly) and snow crab are harvested around the exploration licenses, especially immediately adjacent around Exploration License 1106 and in other parts of the Project Area. Traditional activities are well dispersed throughout the Study Area.

8.3 MARINE TRANSPORTATION

Marine transportation in the Study Area involves vessels travelling to and from Labrador ports and to other ports in the province, and vessels that are travelling to and from ports in the Canadian High Arctic. Most marine transportation (including the coastal ferry service and fuel transportation) is dependent on the ice-free season (June to November), with the exceptions of offshore fishing activities, freighter traffic between Greenland and eastern North American ports and concentrated ore shipments from Voisey's Bay. (For more detailed information on marine transportation, refer to Labrador Shelf SEA Section 5.8.1 (Sikumiut 2008).

8.4 TOURISM/RECREATION

Tourism and recreation activities within the Study Area include cruise ships, tour boats, local and visitor personal boating, ecotourism and prehistoric and historic resources. None of these activities take place within the Project Area (for example, the prehistoric and historic resources are all land-based). Cruise ships would transit the Project Area between 10 ports of call along the Labrador Coast (Saglek Fjord, Nain, Hebron, Hopedale, Rigolet, Northwest River, Happy Valley-Goose Bay, Cartwright, Battle Harbour and Red Bay (CANAL 2007 in Labrador Shelf SEA Section 5.8.4.4 (Sikumiut 2008)). For more detailed information on tourism and recreation activities, refer to Labrador Shelf SEA Section 5.8.4 (Sikumiut 2008).

8.5 CUMULATIVE ENVIRONMENTAL EFFECTS ASSESSMENT

Certain Project activities may act in a cumulative fashion with other projects/activities operating in the area at the same time.

8.5.1 SPECIES AT RISK

8.5.1.1 MARINE FISH

Potential cumulative environmental effects on marine fish Species at Risk may result from seismic survey program(s) from other operators being conducted and commercial and traditional fisheries.

While commercial fishing by its nature results in mortality of fish, there is no directed commercial fishery for wolffish. Nor is there a directed fishery for any of the other marine fish Species at Risk in the Study Area. Seismic activities do not cause direct mortalities of juvenile and adult fish (although they may temporarily displace them). The noise generated during a seismic program could act cumulatively with noise generated by commercial fishery vessels; however, there will be no spatial overlap with fishing vessels in the immediate vicinity during a survey. Therefore, the cumulative environmental effects of the Project in combination with other projects and activities are predicted to be *not significant*.

8.5.1.2 MARINE MAMMALS AND SEA TURTLES

Potential cumulative environmental effects on marine mammal and sea turtle Species at Risk may result from seismic program(s) from other operators, marine transportation and tourism/recreation (specifically, whale watching tours and cruise ships).

Seismic survey program(s) by other operators may act cumulatively with the Project, which may result in significant cumulative environmental effects. Due to the limited availability of seismic vessels, it is unlikely that multiple seismic programs will occur simultaneously on the Labrador Shelf. If they do, seismic vessels will be required to observe a minimum separation distance of 50 km during seismic operations to minimize noise interference between the respective programs. Received levels in the ocean will vary with range, depth and bearing. Sound propagation characteristics (paths, patterns and attenuation) depend on the local environment at the time (water temperature, salinity, bathymetry, seafloor geology, etc.). If seismic programs are run concurrently, it is recommended that information from the marine mammal observation programs be shared between respective programs.

The incremental amount of vessel traffic as a result of this Project will be negligible compared to existing vessel traffic in the area (for example, the ferry service along the coastal communities and fishing vessels, all which occur within the open water season (June to November). They will be acclimated to the presence of the seismic vessel.

The residual cumulative environmental effects of other seismic program(s) are expected to be *not significant*. This determination is made with moderate confidence based on the current knowledge of marine mammal and sea turtle Species at Risk in the Study Area (there is a lack of Study Area information pertaining to marine mammals (e.g., important biological (feeding, migratory, and social) habitat, etc.)).

8.5.1.3 SEABIRDS

Marine bird distribution and abundance can be influenced by both natural (e.g., weather, availability of food) and anthropogenic (e.g., pollution, marine transportation, commercial fishing) processes (Wiese and Montevecchi 2000). Changes in prey that seabirds feed on and the predators that feed on birds may also affect seabird populations. Projects and activities that occur within the migratory range of seabirds (but outside the Project Area) could also affect seabird populations.

Potential cumulative environmental effects on seabird Species at Risk may result from seismic survey program(s) from other operators, marine transportation, commercial and traditional fisheries and tourism/recreation (specifically bird watching tours and cruise ships). The only seabird Species at Risk that could likely occur in the Study Area is the Ivory Gull; this species does not spend a lot of time under water. The seismic program will not cause any significant residual environmental effects on seabird Species at Risk due to the sound generation; however, they could attract birds to the vessel due to lights on the vessel during the night (it is a 24-hour operation). Birds can be an accidental casualty of commercial fishing activities; however, the scarcity of Ivory Gull in the Project Area makes this effect highly unlikely. While ecotourism is a growing movement and cruise ships are a developing industry within Labrador, it is unlikely that they interact with Ivory Gull.

Therefore, the cumulative environmental effects of the Project in combination with other projects and activities are predicted to be *not significant*.

8.5.2 MARINE FISH AND FISH HABITAT

Cumulative Project environmental effects on Marine Fish and Fish Habitat will be the same as those listed for marine fish Species at Risk in Section 8.5.1.1. In addition, seismic activities do not cause direct mortalities of juvenile and adult fish (although they may temporarily displace them), nor did they cause and acute or chronic mortality of caged egg-bearing female snow crabs (DFO 2004c). Christian *et al.* (2004) observed the response of snow crab to seismic shooting and conducted an experimental commercial fishery for snow crab before and after the onset of seismic shooting. No responses were observed, nor was there any observed change in catch rate.

Therefore, the cumulative environmental effects of the Project in combination with other projects and activities are predicted to be *not significant*.

8.5.3 MARINE MAMMALS AND SEA TURTLES

Cumulative Project environmental effects on Marine Mammals and Sea Turtles will be the same as those listed for marine mammal and sea turtle Species at Risk in Section 8.5.1.2. Therefore, the cumulative environmental effects of the Project in combination with other projects and activities are predicted to be *not significant*.

8.5.4 SEABIRDS

Cumulative Project environmental effects on Seabirds will be the same as those listed for seabird Species at Risk in Section 8.5.1.3. Therefore, the cumulative environmental effects of the Project in combination with other projects and activities are predicted to be *not significant*.

8.5.5 COMMERCIAL AND TRADITIONAL FISHERIES

Potential cumulative environmental effects on Commercial and Traditional Fisheries may result from seismic survey program(s) from other operators, marine transportation and tourism/recreation (specifically cruise ships and the local and tourist personal boat use).

Distance between the seismic vessel and other vessels (including commercial fisheries vessels) will be maintained through communication between the operators of each vessel (FLOs on the seismic vessels, who will have to maintain regular contact with each other, as well as other vessels) and the use of navigational equipment (radar). The incremental amount of vessel traffic as a result of this Project will be negligible compared to existing vessel traffic in the area.

Noise generated by the seismic program could result in fish temporarily leaving an area to avoid the sound source. Observed commercial catch reduction resulting from seismic activities have ranged from none (CEF 2002), to one day (Thompson *et al.* 2000) to at least one week Engås *et al.* (1996). Crab larvae and other invertebrates (e.g., shrimp) without swim bladders are likely to be more resistant to the effect of a seismic array than fish eggs and larvae (Pearson *et al.* 1994). Of the two principal commercial species in the Project Area, neither shrimp nor snow crab catch rates are likely to be affected (LGL 2008). Greenland halibut could avoid the sound source, but would likely return after the seismic survey has been completed.

With the mitigative measures in place (including an FLO), the cumulative environmental effects of the Project in combination with other projects and activities are predicted to be *not significant*.

8.5.6 SENSITIVE AREAS

There is minimal overlap with Sensitive Areas and the Project Area (the only sensitive area within the Project Area is part of a representative Parks Canada Marine Area in the Hamilton Bank Area (See Figure 5-32)), with an anticipated lack of environmental effects from seismic surveys, the residual environmental effects of the Project on Sensitive Areas is predicted to be *not significant*. The key activity that could act cumulatively with the Project is the commercial and traditional fishery, as the Hamilton Bank (in combination with the Hawke Channel (See Figure 5-32)) area is host to several major commercial fish species.

The Project will not result in any mortality of fish, although it may temporarily displace juvenile and adult fish if they avoid the sound source. Therefore, the cumulative environmental effects of the Project in combination with other projects and activities are predicted to be *not significant*.

8.6 RESIDUAL ENVIRONMENTAL EFFECTS SUMMARY

Potential cumulative environmental effects external to the Project include seismic program(s) by other operators, commercial and traditional fishing, marine transportation and tourism/recreation. The potential exists that the other seismic survey(s) could occur concurrently, resulting in a temporal overlap with the Project (there would be no immediate spatial overlap as there must be enough distance between streamers as to avoid interfering with data acquisition by individual vessels); therefore, there is some potential for cumulative environmental effects with the Project in this context.

As access of non-Project vessels within close proximity to the source vessel will be restricted during the seismic survey, the residual cumulative environmental effect with noise and traffic external to the Project will be negligible. Compared to existing vessel traffic in the area, the incremental amount of vessel traffic as a result of this Project will be negligible. Cumulative environmental effects resulting from any of the Project activities will not be additive or cumulative because the Project activities are transitory. With the implementation of mitigative measures and the limited spatial (and potentially temporal – if the programs are not run concurrently) overlap with other projects and activities, the residual cumulative environmental effect of the Project in conjunction with other projects and activities is predicted to be *not significant*.

9.0 ACCIDENTS AND MALFUNCTIONS

9.1 POTENTIAL ACCIDENTS AND MALFUNCTIONS RESULTING FROM PROJECT

Accidents and malfunctions resulting from a seismic program are limited to: loss of flotation fluid due to damage to the streamer; loss of diesel fuel due to damage/sinking of the seismic (or picket) vessel; and collision with another vessel (collision with marine mammals or sea turtles, including marine mammal or sea turtle species at risk, are discussed in Section 7.1.3.2).

If the streamer becomes damaged, flotation fluid could be introduced into the marine environment. Most flotation fluid is a synthetic hydrocarbon (isoparaffins) with low toxicity (some formulations meet the requirements for use in food-grade containers). One such fluid, Isopar, meets one or more of the approved criteria for qualification as a non-reportable (as a volatile organic compound) low vapour pressure fluid as prescribed by Environment Canada (ExxonMobil 2002) (i.e., it is stable and hazardous polymerization or decomposition will not occur). Isopar has minimal toxicity (ingestion) and low surface tension, so it will spread rapidly and evaporate rapidly as it has a vapour pressure of 4.1 kilopascals at 38°C.

A complete breach in one section of the streamer would result in a maximum of approximately 180 L of flotation fluid lost. An accidental release of the streamer fluid (Isopar M) can be removed from surface by using suitable sorbent booms.

9.2 ENVIRONMENTAL EFFECTS MANAGEMENT

The potential for damage to streamers will be minimized by:

- timing of the Project (i.e., July to November);
- equipment inspections;
- communication with other vessels to avoid entanglement, etc., that could lead to damage to a streamer.

The seismic vessel (and any support vessel) will have an oil spill response plan, including equipment, systems and protocols in place for prevention of pollution in accordance with international standards and certification authorities. Ship operations will adhere to *Annex I of the International Convention for the Prevention of Pollution from Ships* (MARPOL 73/78).

The Captain of the seismic vessel and the FLO will be responsible for providing detailed information to other users in the vicinity of the survey to alert them to the presence of the seismic vessel to prevent collision between the seismic vessel and other users.

9.3 ENVIRONMENTAL EFFECTS ASSESSMENT OF ACCIDENTS AND MALFUNCTIONS

9.3.1 SPECIES AT RISK

9.3.1.1 MARINE FISH

All fish and shellfish past the egg and larval stage will likely swim away, thereby avoiding interaction with a hydrocarbon spill (Irwin 1997). The local abundance and availability of phytoplankton and zooplankton could be affected and if fish eat contaminated zooplankton, they will accumulate hydrocarbons themselves. However, fish metabolize hydrocarbons, so there is no potential for biomagnification (LGL 2005a). Effects of an oil spill on juvenile and adult marine fish Species at Risk are predicted to be *not significant*.

Eggs and larvae cannot avoid a spill and are not able to metabolize/detoxify hydrocarbons, so are more subject to harmful physiological effects from a fuel spill. Most species are expected to have eggs or larvae present in the water column from July to September. However, more than 50 percent of the larvae in a large portion of the spawning area would have to be lost before recruitment to a population is affected (Rice 1985). No effect was detected at the population level even with a 58 percent reduction in herring larvae survival due to the *Exxon Valdez* spill (Hose *et al.* 1996). Therefore, it is unlikely that the effects of a localized spill on egg and larval survival would be detectable from natural mortality. Effects of accidental spills on marine fish Species at Risk eggs and larvae are predicted to be *not significant*.

9.3.1.2 MARINE MAMMALS AND SEA TURTLES

Potential accidents and malfunctions which may affect marine mammal and sea turtle Species at Risk include:

- loss of streamers or equipment (entanglement); and
- vessel casualty (hydrocarbon release).

Seismic streamers may either be solid-filled or contain a paraffinic hydrocarbon called Isopar, which is used for flotation. It is possible that small quantities of Isopar could leak from the streamers, or there may be a fuel spill from one of the vessels. Spills would likely be small and would be dispersed quickly via wind, waves and the ship’s propeller. An overview of the effects of hydrocarbon spills on marine mammals and sea turtles is available in Labrador Shelf SEA Section 5.6.1.11 (Sikumiut 2008) and is thus not repeated here. All petroleum hydrocarbon handling and reporting procedures on board the vessel will be consistent with Husky’s policy, and handling and reporting procedures. Studies (St. Aubin 1990, Williams *et al.* 1994) suggest that whales and seals do not exhibit large physiological or behavioural responses to limited surface oiling, ingestion of oil, or incidental exposure to contaminated food. Sea turtles are potentially more susceptible to the environmental effects of oiling, but such effects are thought to be sublethal (Husky Oil Operations Limited 2000). Effects of an accidental event or malfunction on marine mammal or sea turtle Species at Risk are expected to be *not significant*.

9.3.1.3 SEABIRDS

Seabirds could be affected by a spill (of either flotation fluid or diesel), depending on the timing, location and environmental conditions of such an event. The nature of diesel fuel is such that it evaporates and disperses from the surface relatively quickly and does not persist in the environment for any length of time. Streamer fluid could create a slick that seabirds resting on the water could come in contact with. A loss of streamer fluid is also unlikely (and nil if as is likely if a solid core streamer is used). However, assessing the worst case a potential spill would be small and evaporation and dispersion rapid, resulting in a low magnitude and small (<1 km^2) geographic extent such that a spill is not expected to cause significant environmental effects on seabird populations and therefore, effects of accidental spills of this nature (i.e., loss of flotation fluid) on seabird Species at Risk are predicted to be *not significant*.

9.3.2 MARINE FISH AND FISH HABITAT

Accidents and malfunctions that may affect Marine Fish are the same as those discussed for marine fish Species at Risk (Section 9.3.1.1) and are expected to be *not significant*.

9.3.3 MARINE MAMMALS AND SEA TURTLES

Accidents and malfunctions that may affect Marine Mammals and Sea Turtles are the same as those discussed for marine mammal and sea turtle Species at Risk (Section 9.3.1.2) and are expected to be *not significant*.

9.3.4 SEABIRDS

Accidents and malfunctions that may affect Seabirds are the same as those discussed for seabird Species at Risk (Section 9.3.1.3) and are expected to be *not significant*.

9.3.5 COMMERCIAL AND TRADITIONAL FISHERIES

While damage to fishing vessels and gear can also result from small spills (less than 50 bbl), the likelihood of loss of streamer flotation fluid, or a diesel spill due to vessel sinking, is minimal. If such an unlikely event did occur, the marine diesel will evaporate and disperse relatively quickly (although access to any fishing area in the vicinity of a sinking would be temporarily prevented (or impeded). The residual environmental effect of an accidental event or malfunction from the Project is predicted to be *not significant*.

9.3.6 SENSITIVE AREAS

All but a portion of one sensitive area is outside the Project Area. It is unlikely sensitive areas would be affected by an accidental event or malfunction, as the primary source of a spill would be release from a damaged streamer (Isopar M), or struck/sunken seismic vessel (diesel). Isopar M can be removed from surface by using suitable sorbent booms and approximately 30 percent of spilled diesel would evaporate from the surface; the remaining diesel will disperse into the water column within a day or two, at most (Labrador Shelf SEA Section 2.6.12.4 (Sikumiut 2008). The residual environmental effect of an accidental event or malfunction from the Project is predicted to be *not significant*.

9.4 RESIDUAL ENVIRONMENTAL EFFECTS SUMMARY

The potential of accidental events is limited to release of the flotation fluid (unless solid core streamers are used), or a diesel spill in the unlikely event of a seismic vessel sinking or a collision with another vessel. Given how unlikely these events are, and the mitigative measures that will be applied to the Project (including an FLO, on-board spill response plan and equipment), the residual environmental effect of an accident or malfunction is predicted to be *not significant*.

10.0 SUMMARY AND CONCLUSIONS

Given the application of planned mitigative measures, significant adverse environmental effects, including cumulative environmental effects, are not predicted to result from the Project.

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APPENDIX A

SCOPING DOCUMENT

1 Purpose

This document provides scoping information for the Environmental Assessment (EA) of the proposed seismic and geohazard surveys on the Labrador Shelf and all other related activities (the Project). Husky Energy (Husky), the proponent, is proposing to collect seismic and geohazard data on exploration licenses (ELs) 1106, 1107, 1108 and 1109 on the Labrador Shelf. A 2-D seismic survey is proposed to commence in the summer of 2009. Other 2-D, 3-D and geohazard surveys may occur at various times between 2010 and 2017.

Included in this document is a description of the scope of the project that will be assessed, the factors to be considered in the assessment, and the scope of those factors.

This document has been developed by the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) in consultation with federal and provincial fisheries and environmental departments[1].

2 CEA Act: Regulatory Considerations

The Project will require authorizations pursuant to Section 138 (1)(b) of the *Canada-Newfoundland Atlantic Accord Implementation Act* and Section 134(1)(a) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (Accord Acts).

The C-NLOPB has determined, in accordance with paragraph 3 (1)(a) of the *Regulations Respecting the Coordination by Federal Authorities of Environmental Assessment Procedures and Requirements* (FCR), that an environmental assessment of the project under section 5 of the *Canadian Environmental Assessment Act* (CEA Act) is required.

Pursuant to Section 12.2 (2) of the CEA Act, the C-NLOPB will be assuming the role of the Federal Environmental Assessment Coordinator (FEAC) for this screening and in this role will be responsible for coordinating the review activities by the expert government departments and agencies that participate in the review.

> ***The C-NLOPB has determined that the environmental assessment report and any supporting documents to be submitted by Husky Energy will fulfill the requirements of a Screening. The C-NLOPB, therefore, pursuant to Section 17 (1) of the CEA Act, formally delegates the responsibility for preparation of an acceptable Screening environmental assessment to Husky Energy, the project proponent. The C-NLOPB will prepare the Screening Report, which will include the determination of significance.***

3 Scope of the Project

The project to be assessed consists of the following components:

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[1] Appendix 1 contains a list of the departments and agencies consulted during the preparation of the document.

3.1 Seismic and geohazard data will be collected on exploration licenses (ELs) 1106, 1107, 1108 and 1109 on the Labrador Shelf (the Project Area), as described in "*Labrador Shelf Seismic Program – Project Description*" (Husky Energy January 2009). A 30 km buffer around the exploration leases is included in the Project Area to accommodate both streamer deployment and seismic vessel turning radius. Seismic survey operations will be carried out such that streamer deployment and end-of-survey line turning operations will not extend into the Labrador Inuit Settlement Area (known as the "Zone").

3.2 Approximately 2,000 to 3,000 km of 2-D seismic data will be collected in 2009. The 2-D seismic survey vessel will tow a sound source, one airgun array 4,000 to 7,000 cubic inches in total volume and towed at depths about of approximately 6 to 15 m. The airguns will be operated with compressed air at pressures of 2,000 to 2,500 psi and producing peak-to-peak pressures of approximately 140 to 165 bar-m. There will be one towed streamer, 6,000 to 10,000 m in length, which will be towed behind the vessel at depths of approximately 8 to 30 m. The wellsite/geohazard survey will be collected over closer lines (250 m) using smaller equipment and lower pressures.

3.3 2-D seismic data will be collected in 2009. Additional 2-D, 3-D, and/or geohazard surveys will be undertaken between 2010 to 2017. The timing of survey activities will be between July 1 and November 30 of any given year. The duration of the initial 2-D survey is estimated at 40 to 60 days and the duration of a typical geohazard survey is approximately 4 days. The estimated duration of a 3-D program, depending on the area to be covered, is approximately 30 to 75 days.

4 Factors to be Considered

The EA shall include a consideration of the following factors in accordance with Section 16 of CEAA:

4.1 The purpose of the project;

4.2 The environmental effects[2] of the Project, including those due to malfunctions or accidents that may occur in connection with the Project and any change to the Project that may be caused by the environment;

4.3 Cumulative environmental effects of the Project that are likely to result from the project in combination with other projects or activities that have been or will be carried out;

4.4 The significance of the environmental effects described in 4.2 and 4.3;

4.5 Measures, including contingency and compensation measures as appropriate, that are technically and economically feasible and that would mitigate any significant adverse environmental effects of the project;

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[2] The term "environmental effects" is defined in Section 2 of the CEAA and Section 137 of the *Species at Risk Act*.

4.6 The significance of adverse environmental effects following the employment of mitigative measures, including the feasibility of additional or augmented mitigative measures;

4.7 The need for, and the requirements of, any follow-up programs in respect of the Project consistent with the requirements of the CEA Act and the SARA. (Refer to the Canadian Environmental Assessment Agency's 2002 "OperationalPolicy Statement" regarding Follow-up Programs[3]); and

4.8 Report on consultations undertaken by Husky with interested parties who may be affected by program activities and/or the general public respecting any of the matters described above.

5 Scope of the Factors to be Considered

Husky Energy will prepare and submit to the C-NLOPB an EA for the above-described physical activity, and as described in the project description "*Labrador Shelf Seismic Program – Project Description*" (Husky Energy January 2009).

The EA will address the factors listed above; the issues identified in Section 5.2, and document any issues and concerns that may be identified by the proponent through regulatory, stakeholder, and public consultation.

If the Valued Ecosystem Component (VEC) approach to focus its analysis is used in the EA, a definition of each VEC (including components or subsets thereof) identified for the purposes of environmental assessment, and the rationale for its selection, shall be provided.

The scope of the factors, to be considered in the EA, will include the components identified in Section 5.2 - Summary of Potential Issues, setting out the specific matters to be considered in assessing the environmental effects of the project and in developing environmental plans for the project, and the "Spatial Boundaries" identified below (Section 5.1). Considerations relating to definition of "significance" of environmental effects are provided in the following sections.

5.1 Boundaries

The EA will consider the potential effects of the proposed seismic program within spatial and temporal boundaries that encompass the periods and areas during and within which the project may potentially interact with, and have an effect on, one or more VECs. These boundaries may vary with each VEC and the factors considered, and should reflect a consideration of:

- the proposed schedule/timing of the seismic program;
- the natural variation of a VEC or subset thereof;
- the timing of sensitive life cycle phases in relation to the scheduling of seismic activities;

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[3] CEA Agency Guidance documents and Operational Policy Statements are available on its web site: http://www.ceaa-acee.gc.ca/012/newguidance_e.htm#6.

- interrelationships/interactions between and within VECs;
- the time required for recovery from an effect and/or return to a pre-effect condition, including the estimated proportion, level, or amount of recovery; and
- the area within which a VEC functions and within which a project effect may be felt.

The proponent shall clearly define, and provide the rationale for the spatial and temporal boundaries that are used in its EA. The Study Area chosen shall be clearly described in the EA report. Boundaries should be flexible and adaptive to enable adjustment or alteration based on field data. The Study Area will be described based on consideration of potential areas of effects as determined by the scientific literature, and project-environment interactions. A suggested categorization of spatial boundaries follows.

5.1.1 Spatial Boundaries

Project Area
The area in which seismic activities are to occur and include the area of the buffer zone normally defined for line changes.

Affected Area
The area which could potentially be affected by project activities beyond the "Project Area".

Regional Area
The area extending beyond the "Affected Area" boundary. The "Regional Area" boundary will also vary with the component being considered (e.g., boundaries suggested by bathymetric and/or oceanographic considerations).

5.1.2 Temporal Boundaries

The temporal scope should describe the timing of project activities. Scheduling of project activities should consider the timing of sensitive life cycle phases of the VECs in relation to physical activities.

5.2 Summary of Potential Issues

The "*Strategic Environmental Assessment (SEA) Labrador Shelf Offshore Area*" (Sikumiut Environmental Management Ltd. 2008) provides a detailed discussion of the biological and physical environmental conditions. The proposed Project Area for the seismic and geohazard surveys falls within the area captured within the recently produced Labrador Shelf SEA. Therefore, the EA report should provide only summary descriptions of those biological and physical parameters, as identified below. Where new information is available, (e.g., fisheries data) the new information should be provided. The Labrador Shelf SEA should be properly referenced; the EA report should specifically reference the section of the SEA report summarized.

Physical, environmental, and monitoring data collected in the past from offshore activities in the area should be considered and incorporated, where applicable, in the EA report.

The EA will contain descriptions and definitions of EA methodologies employed in the assessment of effects. Where information is summarized from existing EA reports, the sections referenced should be clearly indicated. Effects of relevant Project activities on those VECs most likely to be in the defined Study Area will be assessed. Discussion of cumulative effects within the Project and with other relevant marine projects will be included. Issues to be considered in the EA will include, but not be limited to, the following:

Physical Environment

5.2.1 Provide a brief summary description of the meteorological and oceanographic characteristics, including extreme conditions, and any change to the Project that may be caused by the environment.

Marine Resources

5.2.2 Marine and/or Migratory Birds

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- Spatial and temporal species distributions;
- Species habitat, feeding, breeding, and migratory characteristics of relevance to the Study Area;
- Noise disturbance from seismic equipment including both direct effects (physiological), or indirect effects (foraging behaviour, prey species, adult attendance at the nest);
- Physical displacement as a result of vessel presence (e.g. disruption of foraging activities);
- Attraction of birds to vessel lighting;
- Procedures for handling birds that may become stranded on seismic vessels;
- Means by which bird mortalities associated with project operations may be documented and assessed;
- Effects of hydrocarbon spills from accidental events, including fluid loss from streamers;
- Means by which potentially significant effects upon birds may be mitigated through design and/or operational procedures; and
- Environmental effects due to the Project, including cumulative effects.

5.2.3 Marine Fish and Shellfish

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- Distribution and abundance of marine fish and invertebrate species utilizing the Study Area with consideration of critical life stages (e.g., spawning areas, overwintering, juvenile distribution, migration);
- Description, to the extent possible, of location, type, diversity and areal extent of marine fish habitat in the Study Area. In particular, those indirectly or directly

supporting traditional, aboriginal, historical, present or potential fishing activity, and including any essential (e.g. spawning, feeding, overwintering) habitats;

- The means by which potentially significant effects upon fish (including critical life stages) and commercial fisheries may be mitigated through design, scheduling, and/or operational procedures; and
- Environmental effects due to the Project, including cumulative effects.

5.2.4 Marine Mammals and Sea Turtles

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- Spatial and temporal distribution;
- Description of marine mammal and sea turtle lifestyles/life histories relevant to the Study Area;
- Disturbance to/displacement of marine mammals and sea turtles due to noise and the possibility of ship strikes;
- Means by which potentially significant effects upon marine mammals and sea turtles (including critical life stages) may be mitigated through design, scheduling, and/or operational procedures; and
- Environmental effects due to the Project, including cumulative effects.

5.2.5 Species at Risk (SAR)

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- A description, to the extent possible, of SAR as listed in Schedule 1 of the *Species at Risk Act (SARA)*, and those under consideration by COSEWIC in the Study Area, including fish, marine mammal, sea turtles, and seabird species;
- A description of critical habitat (as defined under SARA), if applicable, to the Study Area;
- Monitoring and mitigation, consistent with recovery strategies/action plans (endangered/threatened) and management plans (special concern);
- A summary statement stating whether project effects are expected to contravene the prohibitions of SARA (Sections 32(1), 33, 58(1));
- Means by which adverse effects upon SAR and their critical habitat may be mitigated through design, scheduling, and/or operational procedures; and
- Assessment of effects (adverse and significant) on SAR and critical habitat, including cumulative effects.

5.2.6 “Sensitive” Areas

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- A description, to the extent possible, of any ‘Sensitive” Areas in the Project Area, deemed important or essential habitat to support any of the marine resources identified;

- Environmental effects due to the project, including cumulative effects, on those "Sensitive" Areas identified; and
- Means by which adverse effects upon "Sensitive" Areas may be mitigated through design, scheduling and/or operational procedures.

Marine Use

5.2.7 Noise/Acoustic Environment

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- Disturbance/displacement of VECs and SAR associated with seismic activities;
- Means by which potentially significant effects may be mitigated through design, scheduling and/or operational procedures; and
- Effects of seismic activities (direct and indirect) including cumulative effects, on the VECs and SAR identified within the EA. Critical life stages should be included.

5.2.8 Presence of Seismic Vessel(s)

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- Description of project-related traffic, including routings, volumes, scheduling and vessel types;
- Effects upon access to fishing grounds;
- Effects upon general marine traffic/navigation, including fisheries research surveys, and mitigations to avoid research surveys;
- Means by which potentially significant effects may be mitigated through design, scheduling and/or operational procedures; and
- Environmental effects assessment, including cumulative effects.

5.2.9 Fisheries

Provide a summary description, where applicable, of the information presented in the Labrador Shelf SEA report. New or updated information should be provided, where applicable, to address any changes to the following:

- A description of fishery activities (including traditional, existing and potential commercial, recreational and aboriginal/subsistence and foreign fisheries) in the Project Area;
- Consideration of underutilized species and species under moratoria that may be found in the Study Area as determined by analyses of past DFO research surveys and Industry GEAC survey data, with emphasis on those species being considered for future potential fishers, and species under moratoria;
- Traditional historical fishing activity, including abundance data for certain species in this area, prior to the severe decline of many fish species (e.g., a general overview of survey results and fishing patterns in the survey areas for the last 20 years);

- An analysis of the effects of Project operations and accidental events upon the foregoing. The analysis should include consideration of recent scientific literature on effects of seismic activity on invertebrate species, including identified data gaps;
- Fisheries liaison/interaction policies and procedures;
- Program(s) for compensation of affected parties, including fisheries interests, for accidental damage resulting from project activities;
- Means by which adverse effects upon commercial fisheries may be mitigated through design and/or operational procedures; and
- Environmental effects due to the Project, including cumulative effects.

5.2.10 Accidental Events

- Discussion on the potential for spill events related to the use and maintenance of streamers.
- Environmental effects of any accidental events arising from streamers or accidental releases from the seismic and/or support vessels (e.g., loss of product from streamers). Cumulative effects in consideration of other oil pollution events (e.g., illegal bilge disposal) should be included.
- Mitigations to reduce or prevent such events from occurring.
- Contingency plans to be implemented in the event of an accidental release.

Environmental Management

5.2.11 Husky Energy's environmental management system and its components, including, but not limited to:

- Pollution prevention policies and procedures;
- Fisheries liaison/interaction policies and procedures;
- Program(s) for compensation of affected parties, including fishery interests, for accidental damage resulting from project activities; and
- Emergency response plan(s).

Biological and Follow-up Monitoring

5.2.12 Discuss the need for and requirements of a follow-up program (as defined in Section 2 of the CEA Act) and pursuant to the SARA. The discussion should also include any requirement for compensation monitoring (compensation is considered mitigation).

Details regarding the monitoring and observation procedures to be implemented regarding marine mammals, sea turtles and seabirds (observation protocols should be consistent with the C-NLOPB "*Geophysical, Geological, Environmental and Geotechnical Program Guidelines*" (May 2008)).

5.3 Significance of Adverse Environmental Effects

The Proponent shall clearly describe the criteria by which it proposes to define the "significance" of any residual adverse effects that are predicted by the EA. This definition should be consistent with the November 1994 CEAA reference guide

"*Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects*", and be relevant to consideration of each VEC (including components or subsets thereof) that is identified. SARA species shall be assessed independent of non-SARA species. The effects assessment methodology should clearly describe how data gaps are considered in the determination of significance of effects.

5.4 Cumulative Effects

The assessment of cumulative environmental effects should be consistent with the principles described in the February 1999 CEAA "*Cumulative Effects Assessment Practitioners Guide*" and in the March 1999 CEAA operational policy statement "*Addressing Cumulative Environmental Effects under the Canadian Environmental Assessment Act*". It should include a consideration of environmental effects that are likely to result from the proposed project in combination with other projects or activities that have been or will be carried out. These include, but are not limited to, other seismic activities; fishing activities, including Aboriginal fisheries; other oil and gas activities; and marine transportation. The C-NLOPB website lists all current and active offshore petroleum activity within the NL offshore area, and provides a listing of activities undergoing environmental assessment.

6 Projected Timelines for the Environmental Assessment Process

The following are estimated timelines for completing the EA process. The timelines are offered based on experience with recent environmental assessments of similar project activities.

ACTIVITY	TARGET	RESPONSIBILITY
Submission of EA upon receipt of Scoping Document	8 weeks	Proponent
Prepare for EA review	~1 week	C-NLOPB
EA review	6 weeks	C-NLOPB & Regulatory Agencies
Compile comments on EA	2 weeks	C-NLOPB
Submission of EA Addendum/Response to EA Comments	4 weeks	Proponent
Review of EA Addendum/Response Document	3 weeks	C-NLOPB & Regulatory Agencies
Screening Report (Determination of Significance of Project Effects)	2 weeks	C-NLOPB
Total	26 weeks	

APPENDIX 1

Departments and Agencies Consulted by C-NLOPB

Federal Authorities under the *Canadian Environmental Assessment Act*

Fisheries and Oceans Canada
Department of National Defence
Environment Canada
Natural Resources Canada
Transport Canada
Health Canada

Other Departments/Agencies

Canadian Environmental Assessment Agency

Provincial Departments (Government of Newfoundland and Labrador)

Department of Environment and Conservation
Department of Fisheries and Aquaculture
Department of Natural Resources

Nunatsiavut Government

APPENDIX B

CONSULTATION REPORT (AMEC 2009)

Husky Energy – Labrador Consultation Meetings Associated with the Environmental Assessment of a Seismic Survey Program Proposed for the Labrador Shelf

Summary of Consultations Meetings held from September 21 – October 3, 2009

As per Section 4.8 of the CNLOPB's "Final Scoping Document for Husky Energy Labrador Shelf Seismic Program 2009-2017" dated April 2, 2009, a series of consultation meetings were held in six communities - Happy Valley-Goose Bay, Rigolet, Cartwright, Postville, Hopedale and Nain during the period of September 21 to October 3, 2009. Meetings were also scheduled for Sheshatshiu and Natuashish, but were cancelled at the request of the Innu Nation. A meeting was also scheduled for Makkovik for October1 but poor weather prevented its occurrence. The meeting in Makkovik was held on November 19, 2009. Future plans for meetings in the two Innu communities are being considered.

The consultation team consisted of:

- Steve Anfort, Husky Energy geologist and Team Lead for the Labrador project
- David Taylor, Principal of DG Taylor Inc.
- Brian Power, P.Eng., AMEC Earth & Environmental (subcontract to Stantec)
- Katie Winters, interpreter for the Nunatsiavut communities
- Interpreters had also been arranged for the Innu Nation communities

The meetings and schedule were advertised through a variety of media – advertisement in *The Labradorian* newspaper, *The Evening Telegram*, radio announcements on CBC in Happy Valley-Goose Bay and Okalakatiget Society radio stations (radio stations in each Nunatsiavut community) and public notices posted at town offices and other public places in each community. The public notices are attached as Appendix B1.

The consultation team also made direct contact with several people to determine key people to consult and to arrange for meetings with specific parties. These contacts included:

- Maureen Murphy - One Oceans
- Marina Biasutti, Tom Sheldon, Doug Blake and Minister Todd Broomfield – Nunatsiavut Government
- Paula Reid, Innu Nation
- Dorothy Earle, Labrador Métis Nation
- Wayne King, DFO – Goose Bay
- Robin Saunders, FFAW
- Gilbert Linstead and David Williams, Labrador Fishermen's Union Shrimp Company
- Keith Watts and Peter Crocker, Torngat Fish Producers Co-operative
- Shirley Goudie, Town Manager for Postville
- Sarah Blake, Town Manager for Rigolet
- Shirley Hopkins, Town Manager for Cartwright
- Kitora Abel, Town Manager for Hopedale
- Terry Rice, Town Manager for Makkovik
- Sarah Erickson, AngajukKak (Mayor) of Nain
- Ross Flowers, Fisher in Hopedale
- Roxanne Notley and Pauline Brown, Southeastern Aurora Development Corporation.

These contacts resulted in several meetings with most of the towns, governments, organizations and companies mentioned above.

A mix of public meetings and meetings with governments and organizations were held in the communities. A list of those who attended each meeting is attached as Appendix B2.

Depending on the numbers attending, the meetings were either one on one discussions or a slide presentation interspersed with discussion. The presentation and list of points raised in the introduction to the presentation are attached as Appendices B3 and B4, respectively. Brochures were presented at the meetings and also provided to town offices for subsequent distribution. The brochures were prepared in English, Innu-Aimun and Inuktitut and are attached as Appendices B5, B6 and B7, respectively.

Those who attended demonstrated interest in the project, raised important questions and provided helpful comments and information.

A summary of issues raised during the meetings are provided below.

The following issues were raised regarding the Seismic Survey:

- Senior officials with the Nunatsiavut Government and the Labrador Métis Nation view this project and future opportunities in the oil and gas industry in a positive light with respect to future employment and business opportunities for their people.
- The lands reserved by Husky Energy for seismic surveys are also areas for fishing of shrimp, crab and turbot in the Labrador Sea. Fishing areas change from year to year and very recent fishing history is important for determining where the fishing effort is likely to occur in the near future. Torngat Fisheries management was helpful with information on recent fishing efforts and is willing to discuss further with the environmental assessment authors. It was stressed by Torngat Fisheries that fishers need to receive factual and scientifically sound information to allay fears of negative effects on the fishing industry. It was also stressed by Torngat Fisheries and several others that communications is critical if fishers and oil and gas activities are to work in harmony.
- Husky Energy was congratulated by many during the consultations for this round of consultation. The same people who were positive to the consultation also stressed the need for ongoing discussions and information as the project planning proceeds. It was suggested by some that the poor turnout at the consultation meetings should not be interpreted as a lack of interest in the project. Continued dialogue with people in Labrador will result in a demonstration of the interest that does exist for offshore oil and gas activity. It was recommended by many that additional consultations be held throughout the lead up to the project.
- Public and elected officials and most residents of the Labrador communities who attended the meetings stressed the need for maximizing local opportunities for employment and supply of services and supplies.
- Questions were raised and comments were expressed about the potential effects of the associated noise on whales and other marine mammals. The Environmental Assessment documents need to treat this concern in a thorough manner.
- The use of Traditional Knowledge was stressed at one meeting as being important to the credibility of the project and the quality of information on ice, marine mammals and fishing activity.

Issued raised regarding oil and gas development in Labrador:

- At most meetings questions were asked and comments were expressed about how the ultimate development of any discovered gas fields would occur. There was a consistent opinion of those who provided their thoughts that the gas fields should be developed in a manner that maximized economic benefits for the people along the coast of Labrador. The option of gas being piped to shore, processed in a gas plant near a coastal Labrador community and then conveyed to market was commented on as being preferred over a scenario that would not bring the gas to shore in Labrador.
- The need for employment opportunities in Labrador was stressed at every meeting. While it was explained that the number of jobs associated with seismic surveys would not be great, there was interest in any opportunities. The need for Marine Mammal Observers (MMOs), a Fisheries Liaison Officer FLO) and a guide vessel was viewed as important local opportunities.
- The need to inform young people about the long term prospects was stressed by many. It was suggested that Husky Energy should become involved in providing presentations and information to the school children along the Labrador coast.
- How to conduct future consultations was also raised by some of the participants. These comments were provided:
    - Consultations should continue, even though it is a challenge to get people to attend;
    - Where different companies are planning for similar types of offshore activity, they should consider working together and holding joint sessions;
    - People along the coast have been consulted often in recent years and the better attended meetings have had door prizes offered to enhance the turnout. It was suggested that the oil and gas industry should consider doing this;
    - Those scheduling meetings in the small communities need to consider the other activities that are planned which would present conflicts with timing. For example, there are weekly bingo games in most communities that are well attended. Those nights should be avoided for meetings. Many people in each community have cabins that are accessible by boat and snowmobile and are well used during the weekends. Friday night and weekend meetings are not suggested in future.
    - While the need for an interpreter in the Nunatsiavut communities was not strong, community leaders in Nain and Hopedale commented that it is important to have this capability at meetings in their towns. We were also told that Makkovik officials would likely express the same feelings. The need for interpretation in Rigolet and Postville was not apparent. Meetings were not held in the Innu communities but speculation is that interpretation would be an asset.

Thirteen meetings were held during the two weeks and seven of these were public meetings. A total of 41 people attended the meetings.

The meeting in Makkovik that was ‘weathered out’ was rescheduled and held on November 19, 2009. Five people attended the meeting and an interpreter (a resident of Makkovik) was engaged to provide translation between the English and Inuktitut languages.

The following points were raised:

- Questions from Mayor re the effects of sound on whales and fish
- Questions from Mayor re effects of oil spill (Drilling/Development phases)
- Question from Simeon Noehasak (elder) re reflection of sound from ice
- Question from Town Manager – how do you see marine mammals
- Question from Mayor re discharges from vessels and how controlled

A meeting was held with Sheshatshiu Innu on January 12, 2010. In general, the meeting went very well and lasted over two hours. There was plenty of discussion, interest, comments and questions but overall very positive. They were very complimentary on the presentation and the information presented. Like all other sessions we have had, they expect this not to be a one-time thing but an ongoing engagement.

The following key points were raised during the session:

- It was recommended that consultation include the Innu Business Development Office in Goose Bay – Messers Paul Rich and Fred Hall
- Want to see that companies demonstrate their “responsibility”, which we interpreted as both environmental and social
- Stated that they appreciated the presentation and found it informative; stated that they appreciated the companies coming to them as opposed to being chased by the Innu
- After the presentation Playfair took on role of responding to it and putting a series of points largely focused on how the companies could interact with and support the community
    - Need for tangible presentations to the schools to demonstrate to the students what the oil industry is and what activities it is involved in; oil industry to participate in career days at the schools
    - Need to identify training opportunities in the context of the larger development context – seemed to recognize that little direct impact/effects at the seismic stage
    - They plan to provide notes and information to their leadership on the meeting and circulate to a wider audience in the community
    - Seem to want us to help them communicate what the Innu do in terms of forest management to the wider world
    - Would like company experts to give seminars (courses?) to schools (community?) and provide students with scholarships and “limited” job experience placements
    - Strong case made for companies to help with health promotion activities with examples of upcoming events used to illustrate (i.e., Alex’s nephew and others to do winter walks along the coast ultimately to Sept-Iles).
    - Would like to see the Innu school connected to Oil and Gas Week (Energy Day) if the plan this year involves connecting schools electronically to include the Innu
- We indicated that these were ideas we could follow-up on noting that our level of engagement will be determined by our level of business activity

APPENDIX B1

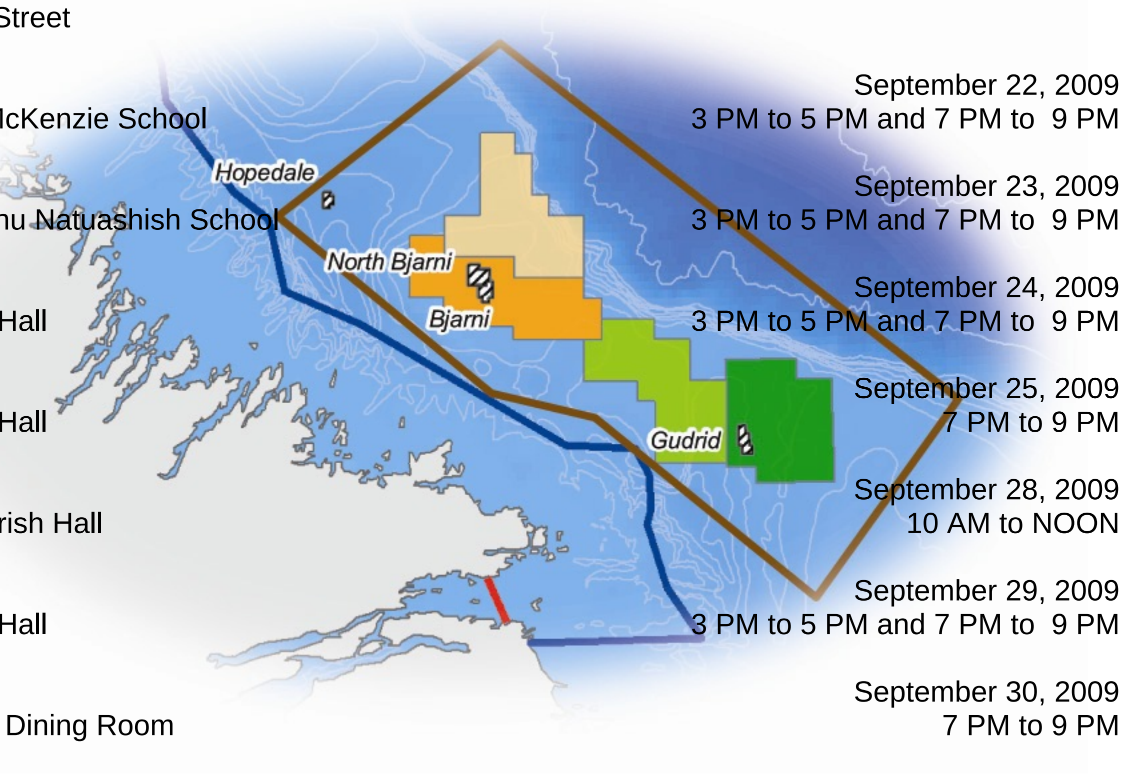
PUBLIC NOTICES

PUBLIC NOTICE

Husky Energy wishes to consult with individuals and communities in Labrador interested in providing input on a seismic survey program proposed for the Labrador Shelf. This input will be included in the environmental assessment for the project that Husky Energy is preparing for submission to regulatory authorities.

To provide opportunity for input, Husky Energy has organized consultation sessions in the communities listed below. At the consultation sessions, Husky Energy will provide details on the proposed seismic surveys to be undertaken on Exploration Leases on the Labrador Shelf east of The Zone between 2010 and 2017 and discuss concerns and questions you may have.

Public Information Sessions will be held at:



Happy Valley - Goose Bay Labrador Friendship Centre 49 Grenfell Street	September 21, 2009 3 PM to 5 PM and 7 PM to 9 PM
Sheshatshiu Peenamin McKenzie School	September 22, 2009 3 PM to 5 PM and 7 PM to 9 PM
Natuashish Mushuau Innu Natuashish School	September 23, 2009 3 PM to 5 PM and 7 PM to 9 PM
Nain Community Hall	September 24, 2009 3 PM to 5 PM and 7 PM to 9 PM
Rigolet Community Hall	September 25, 2009 7 PM to 9 PM
Cartwright Anglican Parish Hall	September 28, 2009 10 AM to NOON
Postville Community Hall	September 29, 2009 3 PM to 5 PM and 7 PM to 9 PM
Hopedale Amaguk Inn Dining Room	September 30, 2009 7 PM to 9 PM
Makkovik Community Hall	October 1, 2009 7 PM to 9 PM

Refreshments will be provided.

For further information about the sessions or to submit comments, please contact:

Francine Wight
Environment Lead
Husky Energy
Suite 901, Scotia Centre, 235 Water Street
St. John's, NL, A1C 1B6
Phone: (709) 724-3965 Fax: (709) 724-4051
Email: francine.wight@huskyenergy.com

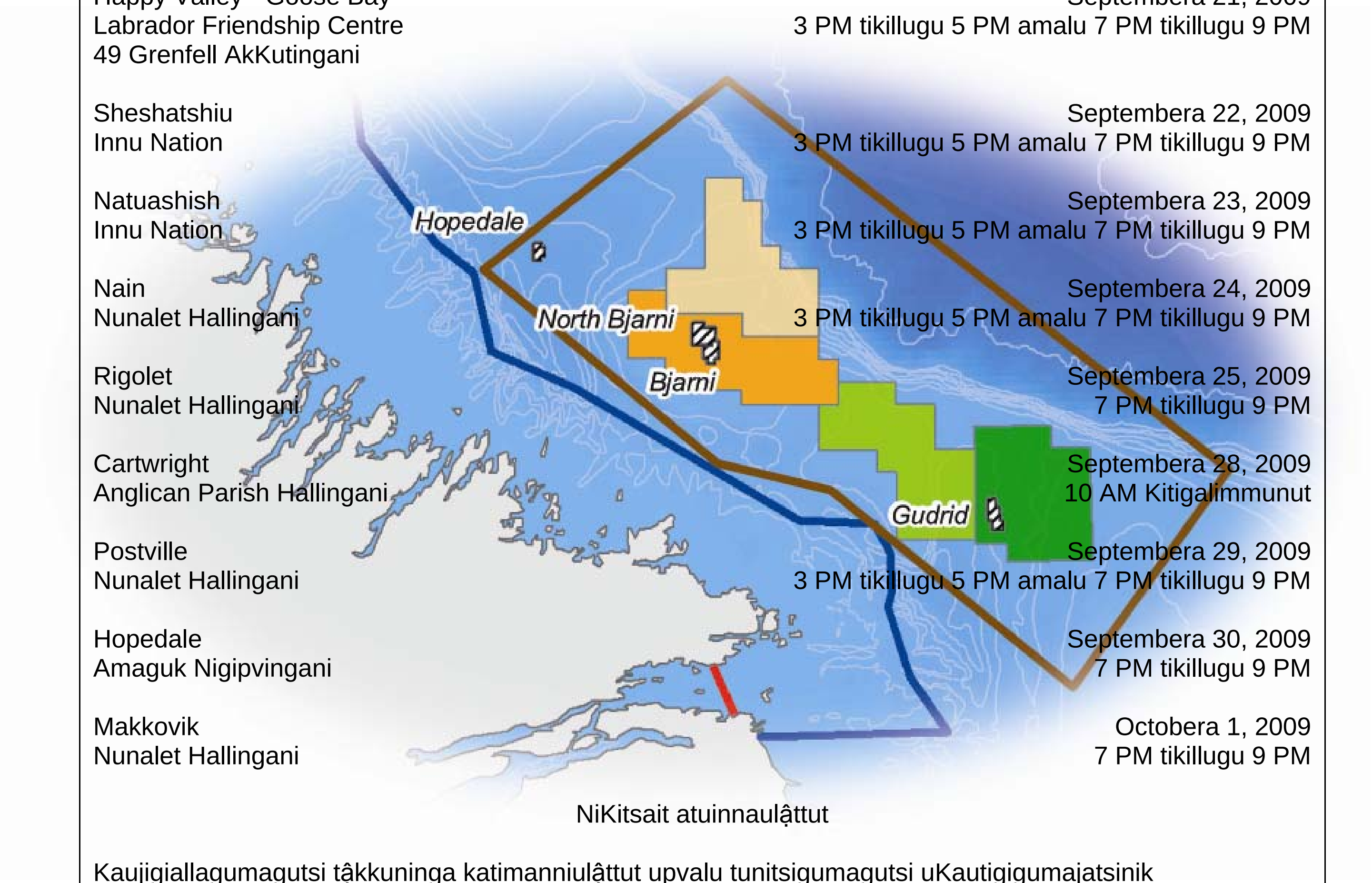
Husky Energy

Inunnut Tusagatsak

Husky Energy Kaujititsigumajut inunnut ammalu nunaliujunut Labradorimi, KanuttogutiKammata Kaujisagiamik ikKanganik Labradorip silatâni imappisuangani. Tânna Kaujititsiutik ilijauKataulâttuk avatik Kaujisattaulippat suliagigumalâttaminik Husky Energy-kut tunitsigiaKalâmmata maligatsaligijiliuttinut pitsatuniKannimut.

PivitsaKattisigiamik uKautaugumajunut, Husky Energy akKisuisimajut katimannisamik Kaujititsigalagiamut nunaliujunut allasimajut atâni. Kaujititsigalalippata, Husky Energy-kut Kaujititsigalalâttut Kaujisagumajanginnik Kinugautaujumut Labradorip kitâni Kaujisagumammata kitâni killiniattausimajumi akungani 2010 ammalu 2017-namut ammalu uKaulautiKallutik isumâlotigijaujunut ammalu apitsugumajunut.

Kaujititsigalalâttut ukuninga inigijaujunut:



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Sheshatshiu Innu Nation	Septembera 22, 2009 3 PM tikillugu 5 PM amalu 7 PM tikillugu 9 PM
Natuashish Innu Nation	Septembera 23, 2009 3 PM tikillugu 5 PM amalu 7 PM tikillugu 9 PM
Nain Nunalet Hallingani	Septembera 24, 2009 3 PM tikillugu 5 PM amalu 7 PM tikillugu 9 PM
Rigolet Nunalet Hallingani	Septembera 25, 2009 7 PM tikillugu 9 PM
Cartwright Anglican Parish Hallingani	Septembera 28, 2009 10 AM Kitigalimmunut
Postville Nunalet Hallingani	Septembera 29, 2009 3 PM tikillugu 5 PM amalu 7 PM tikillugu 9 PM
Hopedale Amaguk Nigipvingani	Septembera 30, 2009 7 PM tikillugu 9 PM
Makkovik Nunalet Hallingani	Octobera 1, 2009 7 PM tikillugu 9 PM

NiKitsait atuinnaulâttut

Kaujigiallagumagutsi tâkkuninga katimanniulâttut upvalu tunitsigumagutsi uKautigigumajatsinik KaujititsigajakKusi:

Francine Wight
Avatik Sivukkatinga
Husky Energy, East Coast Operations
Suite 901, Scotia Centre, 235 Water Street
St. John's, NL, A1C 1B6
Phonnik/Tuavittukut: (709) 724-3965 / (709) 724-4051
Kagitaujatigut: francine.wight@huskyenergy.com

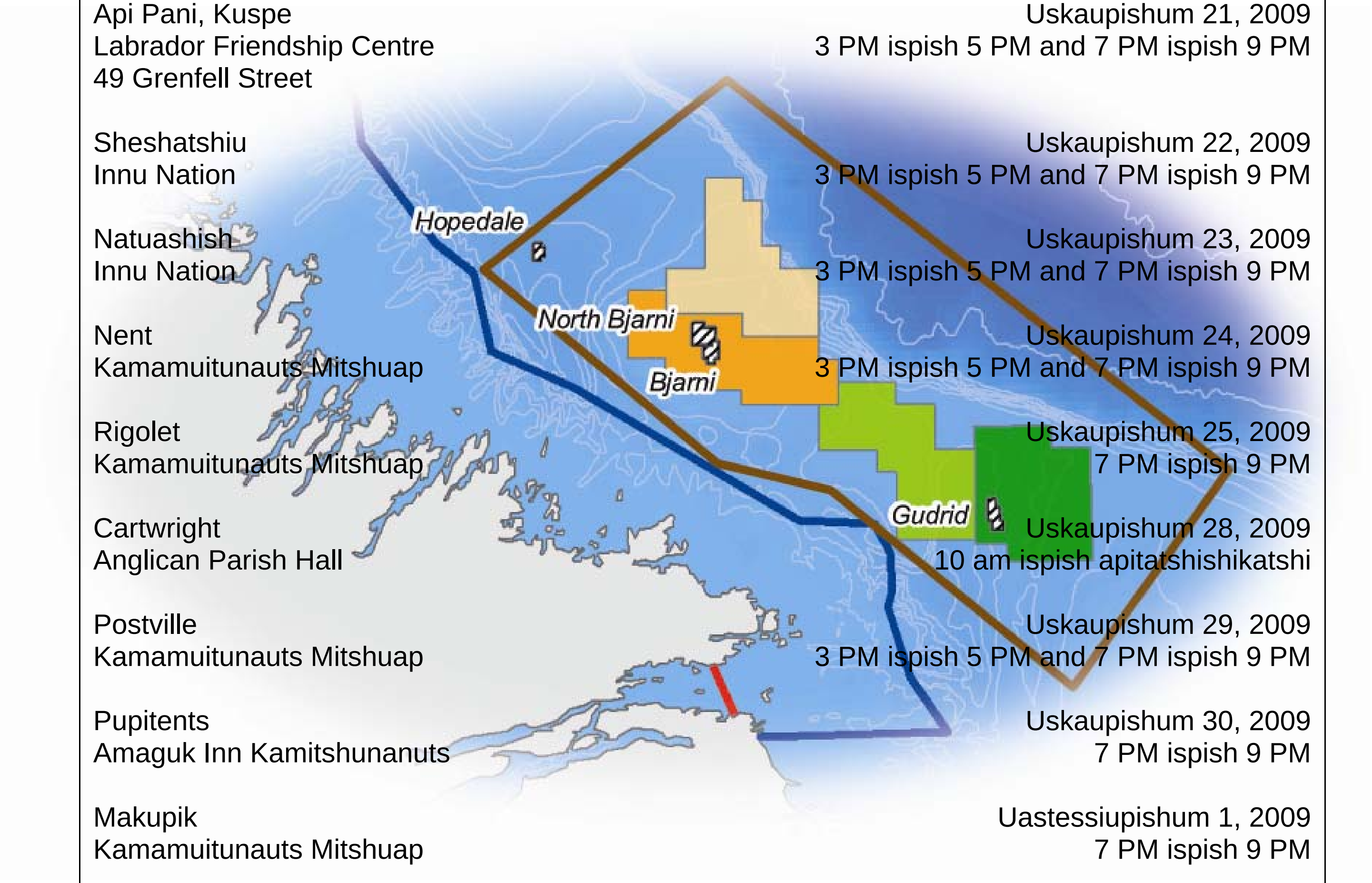
Husky Energy

Tsheminu Tshitapatikant

Husky Kaiaitussenanut tshika uauitamuats tshetshi mamuitunanuts ute napuatua. Tshetshi uauitakananuts tan eshi atuskananuts nete tauts napuatua. Ume tshika uauitamakuanu tsheishinakutakant ne uatutakant.

Ume tshiuiuitamakunau tan etenitamek ueuatutakant Husky Kaiatussenanut shash meshenanikanu mak ueuestakanu tshetshi mamuitunanuts nete pepmau utenaua mak tshika uapatinuaunu nete assi mishinanikanits ne essi atuskatikants shash. Ume tshetshi tshetshishipinant 2010 mak 2017 tshepets uauitamunats tan etenitamek ume uatutakent.

Tshemamuitunanuts:



Api Pani, Kuspe Labrador Friendship Centre 49 Grenfell Street	Uskaupishum 21, 2009 3 PM ispish 5 PM and 7 PM ispish 9 PM
Sheshatshiu Innu Nation	Uskaupishum 22, 2009 3 PM ispish 5 PM and 7 PM ispish 9 PM
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Rigolet Kamamuitunauts Mitshuap	Uskaupishum 25, 2009 7 PM ispish 9 PM
Cartwright Anglican Parish Hall	Uskaupishum 28, 2009 10 am ispish apitatshishikatshi
Postville Kamamuitunauts Mitshuap	Uskaupishum 29, 2009 3 PM ispish 5 PM and 7 PM ispish 9 PM
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Makupik Kamamuitunauts Mitshuap	Uastessiupishum 1, 2009 7 PM ispish 9 PM

Tshika mitshuanu eiapits.

Umak Uitamunek tshekuan uakukuetshiminek:

Francine Wight
Kantussenitak Tshekuanu Eshinakutakanits
Husky Energy, East Coast Operations
Suite 901, Scotia Centre, 235 Water Street
St. John's, NL, A1C 1B6
Phone / Fax: (709) 724-3965 / (709) 724-4051
Email: francine.wight@huskyenergy.com

Husky Energy

APPENDIX B2

MEETINGS HELD AND ATTENDEES

Meetings Held and Attendees

Labrador Métis Nation – September 21, 2009

- - Chris Montague, President
- - Dorothy Earle, General Manager
- - Tammy Lambourne, Manager of Natural Resources

Happy Valley-Goose Bay Public Meeting – September 21, 2009

- Stan Oliver, Deputy Mayor
- Hayward Broomfield, Manager Friendship Centre
- Resident of Goose Bay (name not provided)

Torngat Fish Producers Cooperative Society – September 22, 2009

- Keith Watts, General Manager
- Ron Johnson, Assistant General Manager

Nunatsiavut Government – September 23, 2009

- Doug Blake, Deputy Minister – Lands and Natural Resources

Rigolet Public Meeting – September 25, 2009

- Richard Rich, resident
- Angela Blake, resident

Cartwright Town Office – September 28, 2009

- Rosetta Holwell, Mayor
- Shirley Hopkins, Town Manager

Cartwright Public Meeting – September 28, 2009

- David Williams, Plant Manager – Labrador Fishermen's Union Shrimp Company
- Pauline Brown, Southeastern Aurora Development Corporation

Postville Town Office – September 29, 2009

- Keith Decker, AngajukKak (Mayor)
- Joanne Jacque, Town staff

Postville Public Meeting – September 29, 2009

- Brenda Colbourne, Community Liaison Officer – Nunatsiavut Government
- Cora Edmunds, resident
- Jonathan Edmunds, resident
- Wilfred Lane, Conservation Officer – Nunatsiavut Government
- Keith Decker, AngajukKak

Hopedale Town Office – September 30, 2009

- Judy Dicker, AngajukKâk
- Kitora Abel, Town Manager

Hopedale Public Meeting – September 30, 2009 (evening)

- Christina Goldhar, MUN Geography
- Martin Nochasak, resident
- Sukie Aggek, resident
- Augusta Erving, resident
- Sidney Igloolliorte, resident
- Edward Pottle, resident
- Patty Pottle, MHA and Minister

Nain Public Meeting – October 2, 2009

- Wayne Jenkins, Aivek Holdings
- Alfred Winters, 10 Mile Bay quarry operator
- Martin MerKuratsiuk, student
- Julius Pijogge, student
- Ron Webb, Sikimiut Environmental Consultants
- Lukas John Terriak
- Sarah Erickson, AngajukKak

Nain Public Meeting – October 3, 2009

- Tom Sheldon, Environment Manager, Nunatsiavut Government
- Mandy Arnold, Parks Canada
- Brian Williams, resident and bed/breakfast operator
- Fran Williams, resident and Okalakatiget Society radio manager
- Laura Mille, resident

Makkovik Public Meeting – November 17, 2009

- Herb Jacque, AngajuKâk (Mayor)
- Terry Rice, Chief Admin Officer – Town of Makkovik
- Doreen Winters, Town Clerk
- Joan Andersen, Economic Development/Tourism - Makkovik
- Simeon Noehasak, Elder
- Katie Haye, Interpreter

Sheshatshiu Public Meeting, January 12, 2010

- Alex Andrews
- Leonard Rich
- Guy Playfair
- James Nuna
- Paula Reid
- Paul Pone

APPENDIX B3

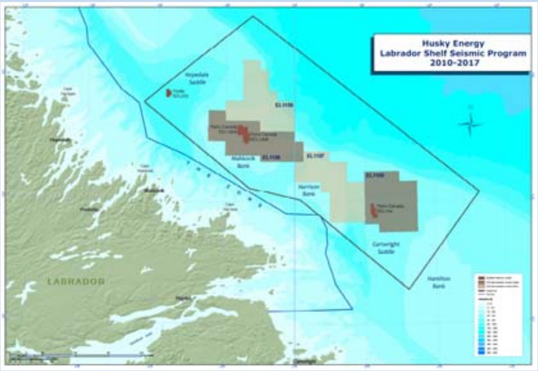
PRESENTATION

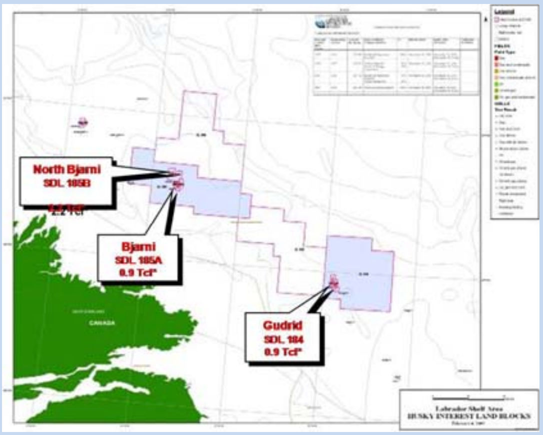
Husky Seismic Survey Program 2010 - 2017

Labrador Community Discussions

September 2009

Where





WHEN

•From 2010 to the end of 2017; but not every year

•From July to the end of November in any year; depending on ice and weather

WHAT

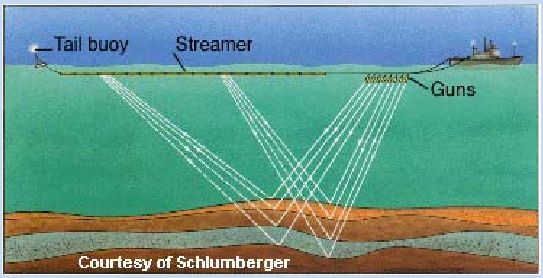
In 2010 or 2011

- 40 to 60 day 2-D survey

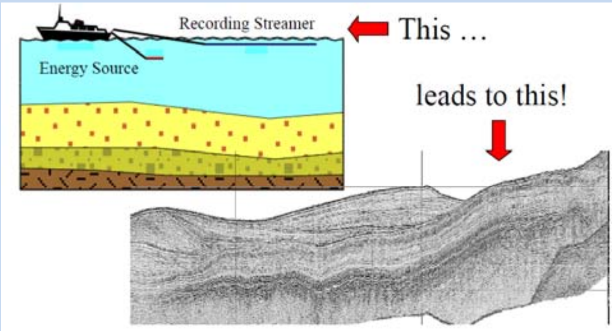
In later years

•2-D surveys, or
• 30 to 75 day 3-D surveys

2D Surveys

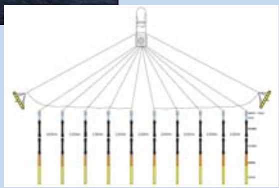


Single "streamer", 6 to 10 kilometres long, 8 to 30 meters deep

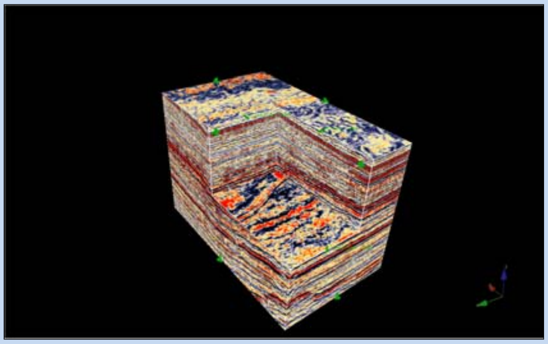


3D Surveys

8 to 10 “streamers”, 6 to 10 kilometres long, 8 to 30 meters deep – whole array up to 1 kilometre wide



3-D “Book”



Managing Survey Effects

- **Consultations** – now and in future
- **Notifications** – just before and during the survey
- **Fishery observer** on the survey to assist communications with fishers
- **Marine Mammal and seabird observers** (2) on the survey; measures to protect marine mammals
- **Compensation** for any damage to fishing gear

Help We Need

- We understand we are new to Labrador and we need to learn
- Need to understand community concerns and interests
- Need to identify community contacts to help communicate information now and in future

Following the Regulatory Process

All regulatory documents are available on the Canada-Newfoundland and Labrador Offshore Petroleum Board’s Website

For information this project go to :

http://www.cnlopb.nl.ca/environment/huskyseis.shtml

Environment

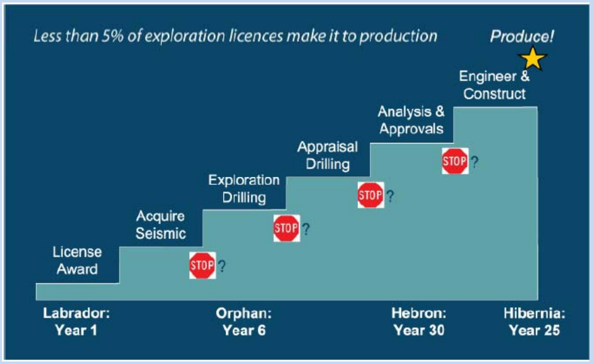
Husky Energy Labrador Shelf Seismic Program

Husky Energy
CEAR No. 09-01-45746

Husky Energy submitted a project description for a proposed 2-D and 3-D seismic and geohazard survey program on the Labrador Shelf over the period 2009 through 2017. The project is listed on the Inclusion List Regulations under the CEA Act and requires a Screening level of assessment. The following is a list of documents available on the public registry for the project.

Date	Record	Author
2-Apr-09	Notice of Determination and Provision of Scoping Document	C-NLOPB
2-Apr-09	Scoping Document	C-NLOPB
2-Apr-09	Draft Scoping Document Review Comments	C-NLOPB
1-Apr-09	Response to PCR Notification	Nunatsiavut Govt.
6-Mar-09	PCR Determination	DFO

Supplementary Slides


Less than 5% of exploration licences make it to production

Produce!

Engineer & Construct

Analysis & Approvals

Appraisal Drilling

Exploration Drilling

Acquire Seismic

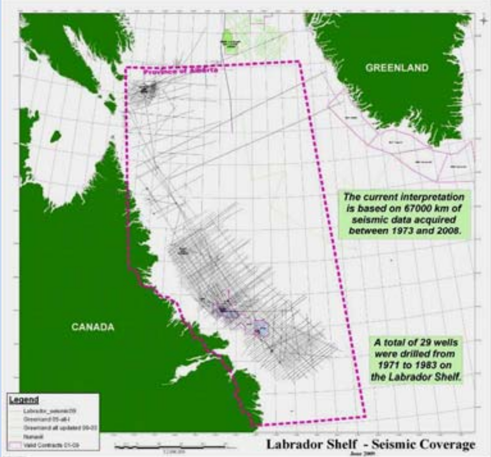
License Award

Labrador: Year 1

Orphan: Year 6

Hebron: Year 30

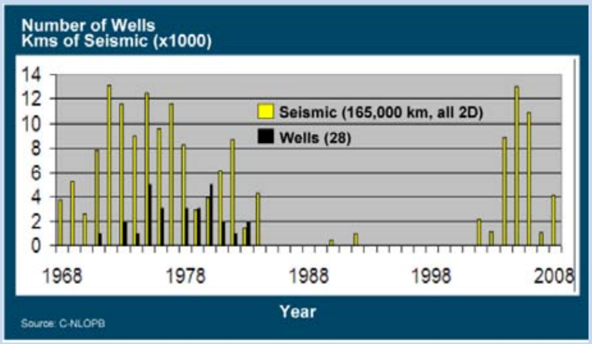
Hibernia: Year 25



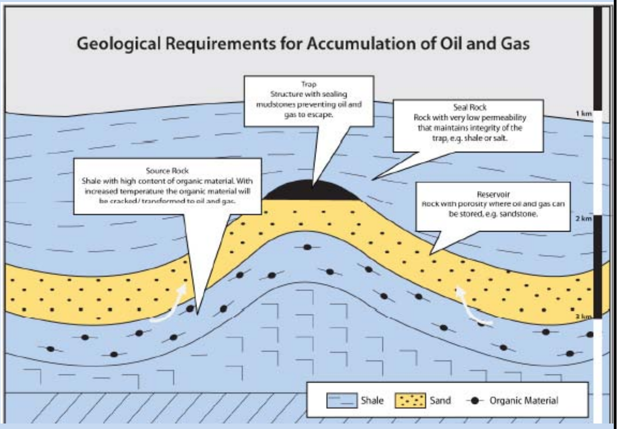
The current interpretation is based on 67000 km of seismic data acquired between 1973 and 2008.

A total of 29 wells were drilled from 1971 to 1983 on the Labrador Shelf.

Labrador Shelf - Seismic Coverage


Number of Wells
Kms of Seismic (x1000)

Source: C-NLOPB


Geological Requirements for Accumulation of Oil and Gas

Federal Scientists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Marine Mammals

EL 1106	Husky Energy(100% OP)
EL 1107	Vulcan Minerals Inc. (50%)
	Investcan Energy (50% OP)
EL 1108	Husky Energy (75% OP)
	Suncor Energy (25%)
EL 1109	Chevron Canada Limited (100% OP)

APPENDIX B4

INTRODUCTORY REMARKS

Introductory Remarks

HUSKY ENERGY SEISMIC PROGRAM
CONSULTATION MEETINGS – COASTAL LABRADOR
SEPTEMBER 21-OCTOBER 2, 2009

Introductory comments included:

- Welcome and thanks for coming out to the meeting.
- Introduction of the Husky Energy consultation team.
- Summary of meeting advertising.
- Overview of the reason for consultations:
    - Husky Energy planning for seismic program in the Labrador Shelf,
    - Planning includes Environmental Assessment,
    - Public consultation is an important component of EA,
    - Consultation meetings are scheduled for Happy Valley-Goose Bay, Rigolet, Cartwright, Postville, Hopedale, Makkovik, Nain, Sheshatshiu and Natuashish,
    - Husky Energy is following the EA process as administered by the CNLOPB on behalf of the Federal and Provincial governments.
- CNLOPB has a website which contains the various documents associated with the Husky Energy seismic project and its EA.
- We will present a summary of the seismic project, information on what seismic is used for and how it is conducted, environmental concerns associated and what is planned to reduce or control environmental effects.
- We are asking for your comments, concerns and interests in the project and all comments are gratefully accepted.
- We will attempt to respond to questions and concerns and promise to get back to you if we do not have the answers.
- Discussions and concerns raised will be noted and included in the EA documentation and comments and concerns could influence the EA and the project planning.
- We are happy to receive comments at this meeting or later (one on one) or later still if you want to write to Husky Energy. Contact information is in the brochure.
- We hope that this meeting and the presented information will be helpful for you to understand seismic programs and the potential environmental issues and help you form an opinion on the activity.

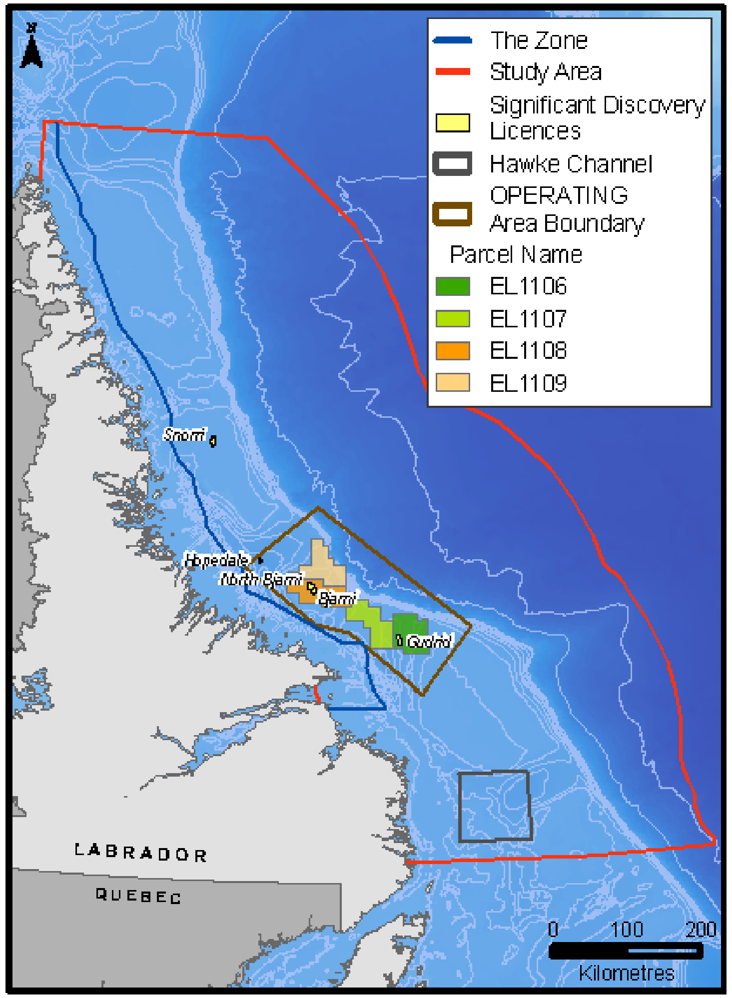
APPENDIX B5

BROCHURE - ENGLISH

Husky Seismic Program, 2010 to 2017

Background

Husky Energy is proposing to conduct seismic and geo-hazard survey operations within the Operating Area, off the coast of Labrador, shown on the map below. This includes Husky Energy's Exploration Licenses 1106 and 1108.



Oil and Gas – Exploration to Production

The development of oil and gas production in any location, and particularly in an offshore situation, is a lengthy process. The period of time from initial interest in an area to the actual production phase can be as long as 20 years or more.

Initial indications that a location may have potential is usually based on its geological history; for example rock formation that can retain oil and gas found near formations that can generate oil and gas would indicate a high probability that oil and gas resources might occur.

The initial step in the development of a potential project involves the use of seismic survey, which starts with a two-dimensional (2-D) seismic survey and, if the results are promising, moves to a three-dimensional (3-D) survey. The purpose of these surveys is to build up an accurate picture of the geology of the area and identify geological formation that may contain gas and oil.

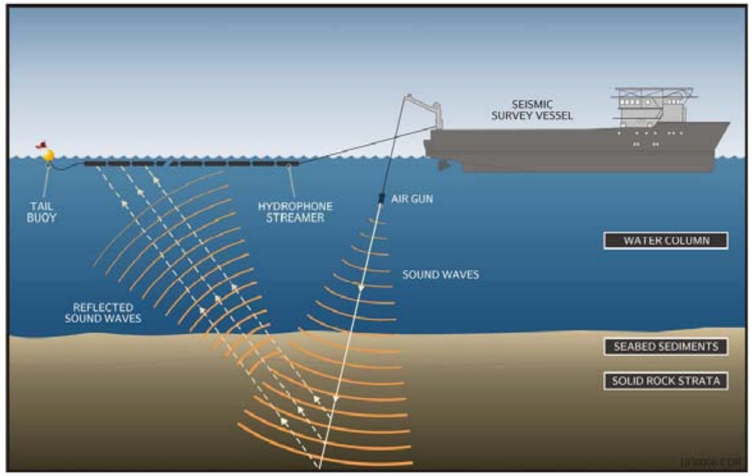
Once geological formations of interest are identified, decisions on exploration drilling can be made, which is the next phase of project development that verifies if oil and gas reserves indeed exist. Several wells may be need during this process. Drilling would be proceeded by localized seismic surveys known as geo-hazard surveys, primarily for ensuring drilling safety.

If the quantities of oil and gas found during exploration drilling are sufficient and can be produced economically, then the design and construction of the necessary production platforms, fixed in place or floating, can proceed.

The Project

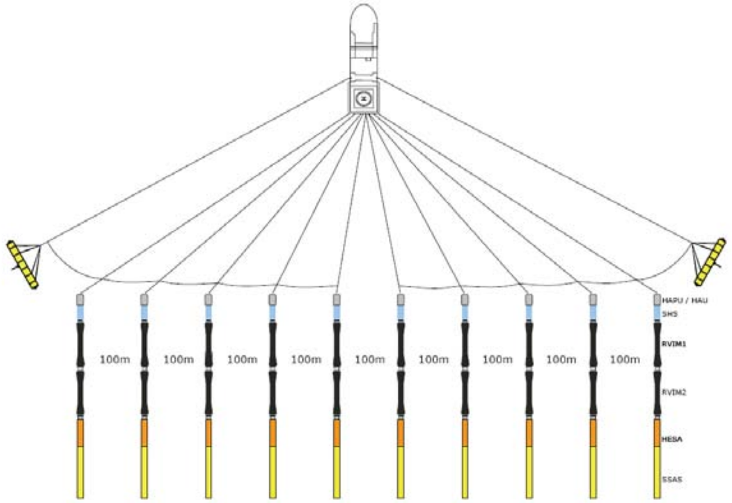
In the summer of 2010 or 2011, Husky Energy is planning to conduct a 40- to 60-day 2-D and/or 3-D seismic survey.

A 2-D survey consists of a sound source that is a single airgun array and a single towed streamer, which is a string of hydrophone sound receivers, 6,000 to 10,000 metres in length, which will be towed behind the vessel at depths of approximately 8 to 30 metres. See the diagram below.



If the results of the 2-D survey show geological formations that have a high probability of containing hydrocarbons, other surveys (more 2-D or 3-D) could be conducted in subsequent years and before 2017 (usually between July 1st and November 30th in any year).

A 3-D survey usually lasts between 30 to 75 days and consists of a larger air gun array and eight to ten streamers of hydrophones 75 to 100 metres apart and 6,000 to 8,000 metres long towed in parallel behind the survey vessel. The streamers array width can be up to 0.5 kilometres either side of the survey vessel. See the next two diagrams.



Environmental Assessment Process

Husky Energy submitted a Project Description on January 16, 2009. The Canada-Newfoundland and Labrador Offshore Petroleum Board provided Husky Energy with a Scoping Document on April 2, 2009, to guide the preparation of the Environmental Assessment.

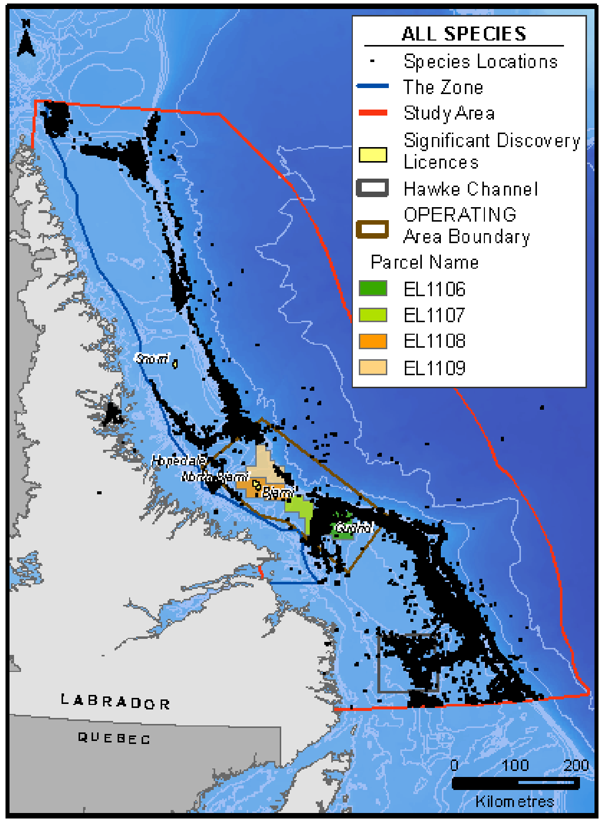
An important component of the Environmental Assessment is the consultation sessions being held in Labrador.

Operating Area

The proposed Operating Area for the environmental assessment includes a 30 km buffer around the Exploration Leases to accommodate the seismic vessel turning radius; streamer deployment and end-of-survey line turning operations will not extend into the Labrador Inuit Settlement Area (also known as the “Zone”).

Fishing and Other Kinds of Resources in the Area

The map below shows the distribution of all species fishing effort (2006 to 2008) in the general area where the proposed seismic survey operations would take place. The environmental assessment will evaluate the possible effects of the seismic survey activity on these and other resources of importance such as seals and other marine mammals, waterfowl and seabirds.



Measures to Minimize Risk to Resources in the Area

In the environmental assessment Husky will describe measures that will be put in place to protect and minimize risk to resource users and resources in the Operating Area such as:

- Advance consultations and planning with resource users in the area
- Support vessel to go ahead of the seismic survey vessel to spot and help avoid fishing gear
- Locally-hired fisheries liaison personnel located on the survey vessel to establish and maintain contact with fishing interests during the survey
- Simple process for handling fishing gear damage claims
- Regular notices to shipping and the local communities to keep them informed as to the progress of the survey
- Qualified personnel aboard the survey vessel(s) to monitor for marine mammals and help with the measures to protect them

Canada-Newfoundland and Labrador Benefits

Husky Energy is committed to providing full and fair opportunity to companies in Newfoundland and Labrador to participate on a competitive basis in the supply of goods and services in accordance with our operating philosophy and legislative requirements.

For further information or if you have any questions or comments about the Project, please contact:

Ms. Francine Wight
Environment Lead
Husky Energy, East Coast Operations
Suite 901, Scotia Centre, 235 Water Street
St. John's, NL, A1C 1B6
Phone: (709) 724-3965 Fax: (709) 724-4051
Email: francine.wight@huskyenergy.com

Husky Energy

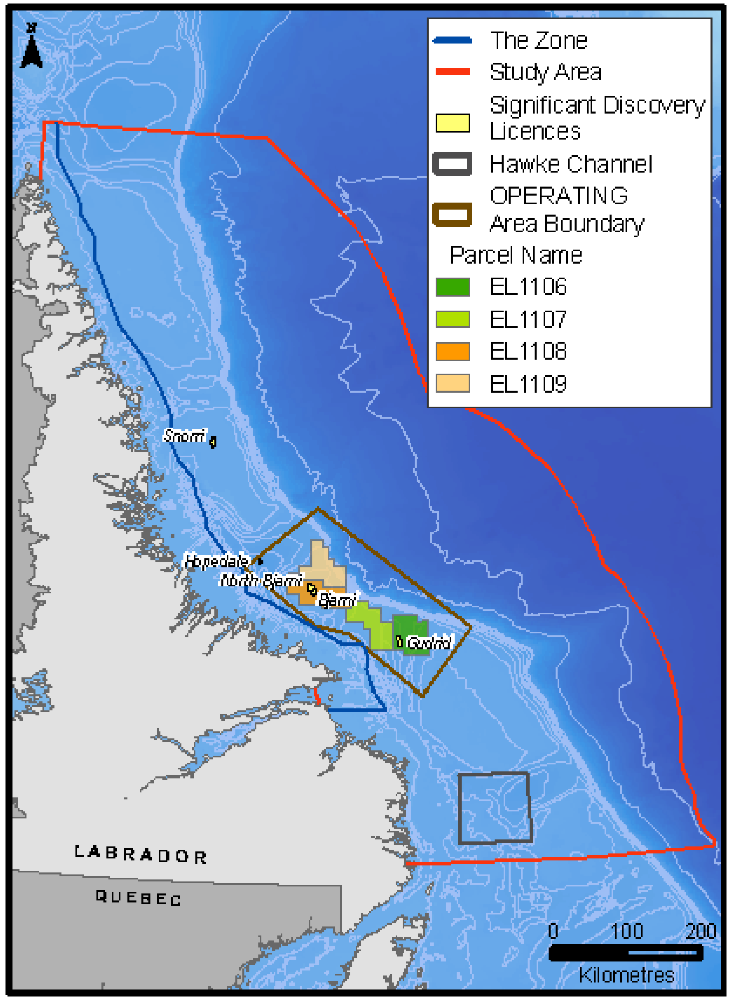
APPENDIX B6

BROCHURE – INNU AIMUN

Husky Tsheishinakuak Tshekuan Tsheishiskutamashunanut nta , 2010 espish 2017

Tan tshishinkunipan

Husky Kaiatussenanut eukun tshemishinakutakant tshetshi uapatinueanuts ume eshinakuats ne tshekustukuats ashini uanuitshikakants uapatinueantshe. Nete uts tauts napuatua tshitapatinueanu assi mishineikan mak mashinanikanu estnuatshitakants, mak euapits uapatinueanu nenu Husky etutakant estinuatshitak ne 1106 mak 1108.



Pimi mak Kastinipimakan pimi –kauinutshikuakant mak uaushitakant

Ume kauinutshikuakant pimi mak kauapatinueanuts nete mak ute tauts kaiatussenanuts mak mishiue mishitakanu shash. Tan tshenispishats tshika ishinakuan uanutshiakant put 20 pupuna put mak nte etu tshenutshiakant.

Nukutakanu tshesiuauitakant mak tsheissinutshikakant put mak ashini eshinakuak nete etat pimi nenu miskuakantshi mak pimi tatshe tan tsheishi tutakant.

Ume uamishinanikant tshekuan uanutshiakant atusseun make tats eiapits kanussenitakuau nenu tshekuanu nete tamatum uinipekuts uinuau shesh (2D) nishuets takunu etutakuau. Mak ume tapuetuakantaue tshetshi tutats, mak etuish tshitshipinitat nistutets (3D) tsheshi takuau eatussetau. Ume uets uaishinakutakant tshetshi etuish mishitakant ne uauapatinueanuts tshetutakant mak mishinanikanuts nenu uets miskuakantshe pimi nte tauts.

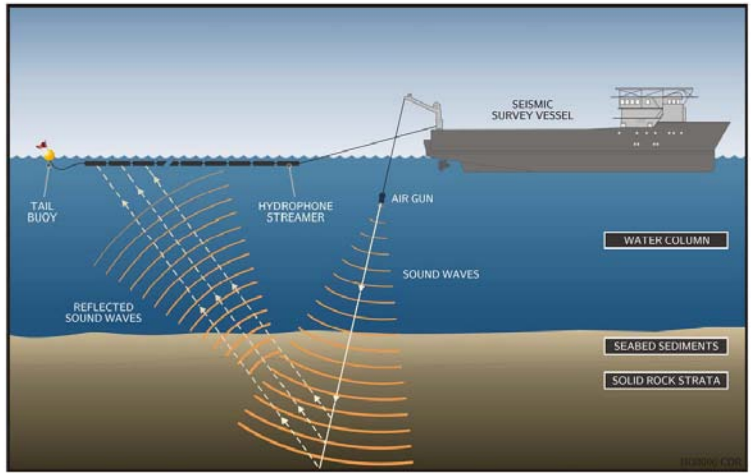
Ume uets tshimeskakantshe nete menuats eukun tshenutshikankant. Eku patush tsheueueshtakanuts tshetshi pukunentsheanuts. Mak euaupits mak tshenutshikankant tshentumiskuakant ne pimi eku patush tenapuenanuts etatakue. Shash passé tykuna enua kantussenimakant pimi nete tauts uinipekuat nenu etussenimakant pimi shash eapits takun utt nenu etussenitak assinu nete tamatum enu ekustikunits tshetshi eka tananants mitshima.

Ume miste meskakentshe pimi ume kapukunenikant eukun miste atuskatakant, mak tsheushitakant kauapatnueant tshetshi stinuatshitakant mak tsheushitakan ne katshimitakant tshekuan tshepikunentshimpints mak put tsheustikutits.

Atusseun

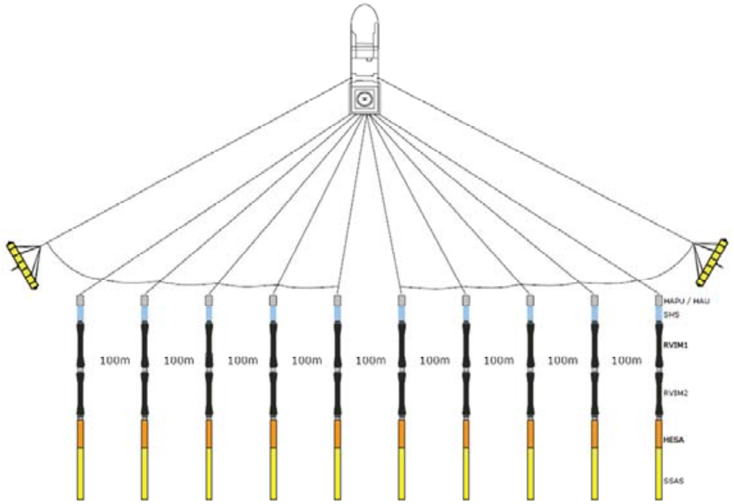
Ume nipitshe 2010 put kie 2011 Husky kaiatussemakats tshetshi ashuuitamatshet neunu (40) espish ashutastatinu (60) nenu nishuets (2D) takunu mak nistutets(3D) ishinakutauts etuskatatatu.

Ne kanishuets (2D) essi tshishipinanuts eukun nanitupetakanu tan etenitakuats nenu mik ett epepemautak tshekuanu kananiuetshimautak, eukun kananiuetshimautatn kapistepimiuniuents eukun kananiuetshimautat kapistepimiuniuents nenu eshipetakunits 6,000 mak 10,000 eispish tapekamu neshekuaiapin uin enitutak ukun 8 mak 30 ispitatekamu tshika uapatenau ume akanukant eshinakuak etutakant ne nashuk.



Ume miskakentshe ne niskuets (2D) katutakant mak eshimiskakant mak eshinakuak mak tan espishats ne kakauishamakuats tshekuan mak etuish (2D) nishuets mak nistuets (3D) tshetshi ishinakutakant eskunte puputshe mak esk 2017 Tshetanpishum 1 mak takuatshipishum 30 esk unte pupuntshe tshetutakant.

Ume kanistueats (3D) katutakant uinuau kaatussekanskatakau nispish 30- 75 tatu tshishikaua makkanitussenitakuau mak pssikan ishinakun ispishau 8 mak 10 espishaua tshekuana enaniutshimautakantshi ustipekutina enanuetshimautakantshi 60,000 – 10,000 essi tshinuapekatshi. Nenua tshekuana eustipekutitshi eukun nanitussenitakantshi ispish etakuats nete utits etakuatshi. Tshka uapatenanu ne eshinakutakant ume akunikanits.



Tsheishinakutakant uatutakant etuskatakant

Husky kaiatusseshuts shash uitamuepants nenu tshetshi ishinakutakuau nta Tshepishum 16, 2009. Ute Kanata, NFLd mak napuatua kapukunetsheshets nete tauts katats uauitamuats nenua Husky kaiatusseshintshi eshitshishipinitakuau uipats nta shiship pishum 2, 2009 uinuau tan eshinakutakanits.

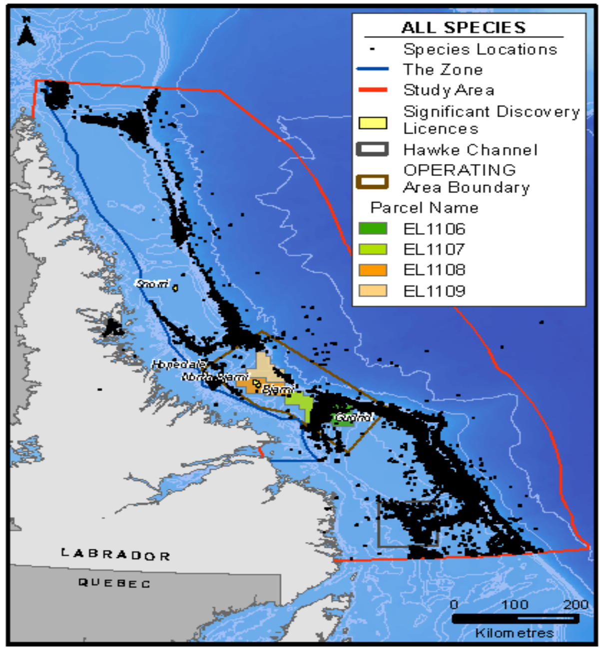
Ume kaianimentakuats kaiatusseskatakant shash miste tshika uauitakanu ute napuatua.

Nete etutakant tshekuan

Ume etutakant tshekuan kauitapuetatunanut ne uanutshiakant shash 30 ispishau essinutshiakant etapuetatunanut tshetshi utt pimpapiniy mak tshetshitshiuepinit minuats make tsheeka nutshiakanits nete mitshima aissimeuts tepenitakuat ute napuata.

Ekussenenanuts mak etutakanuts tshekuan nete

Ume assi mishinanikan kauaupatinueanut eukun kanutimeshets katas nete mishiue nta (2006- 2008) mak shash mishinanikanipan nete uts tshetutakant. Ume kauiatuskatakant mak shash uintshenimakanuts aueshishats tan tshetikuau. Ne atshukukuts, mak netamuk aueshishats katata uinipekuts kamamishitats mak kaiapishishats mak eshinakushets pineshishats uinipekuts katats.



Tan ispitshat tshetshin metinu naktuapatakant netre uaiatuskanut

Ume kauimishinatakuau nenu tsheishi uauitakanitnits mak uinuau Husky tshika minu nakatuenitam make tshetshi minu apatshitakuau. Nenu uaishitshipinitakuau:

- Uipats tshika uitamuts nenu eshi apatshitakuau ne eshinakutakuau nete etutakanits
- Tshetshi tapuetat utta tshetshi pipaminitshi nete eatussenanuts mak naktuapatakuau nete kanutimeshentshi etantshi
- Tshetshi etuish uishamakanits kanutimesheshets tshetshi nakatuapatakuau eishiatuessenanuts mak teshenakatuapamats nenua kakusseshintshi nete eiapits
- Tshetshi eka pikuankuau nete enutshikuaukanits nameshets mak tan eshipikunikanitau
- Mak tshetshinua tsheuauitamuakanits tante etutakanits ute mitshima utenaua mak eshauauitamuakanits nete eatussenanuts.
- Uin etapuetuakanits auen uin tshessenitak eshitutakanits tshekuanu nete uttits. Tshetshi mamu uauitak nenu eishi pimpanits tshekuanu aueshisha mak uauitshinuet tante tsheishi nakautenimakanitshi tan tsheishinakunits

Kanatam, NFLD mak napuatua kaishiuauitshiuananuts

Husky kaatusseshuts tshika minueu essi uauitak tshekuanu nete kuatakua Nfld mak naputatua. Uin mak tshetshi atussetakuau mak minuetau tshekuanu mak tsheuauitamatuts tan eishitutakuau.

Ume kauauitak tshkuanu eishi tshishipinitakanits mak tshekukuetshinmek tshekuaunu:

Francine Wight
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Husky Energy

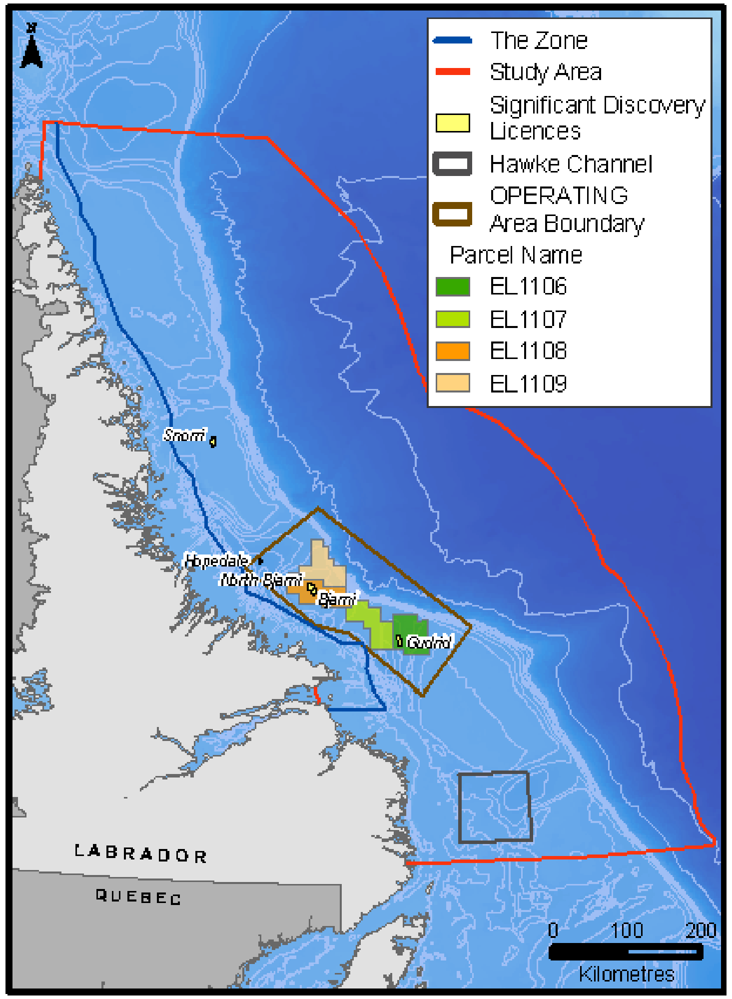
APPENDIX B7

BROCHURE - INUKTITUT

Husky Kaujisagumajut Suliatsak, 2010 tikillugu 2017

PiusituKanga

Husky Energy KinugautiKajut Kaujisagiamut ammalu inigijjanganik nunangata Kaujsiannik aulataunninga, silatâni satjugiami Labradorimi, takutsak atâni nunanguami. Tanna ilautitsivuk Husky Energy Kaujisannisanginnik Laisansimi ilingajumut 1106 ammalu 1108.



Utsualuit ammalu kiasalenet – Kaujisannik suliagijaunnik

Pivalliatitsigiamik utsualunnik ammalu kiasalennimik nanituinnak, ammalu piluattumik imappini, akuni kamagijauKattagialet. Taimamanganit Kanuttogutigijaugiasilluni nanituinnak suliagijaunitsanganut akunialosonguvuk ilagani 20-nik jârinik ununnisanillonet.

Kaujijausot inigijjangit Kanuttogutigijaujuk takunnâtuinnalugu inigijjanganik piusituKagisimajanga; sollu ottotigillugu ujagak ilusinga pitaKagajattuk utsualunnik kiasalenillonet napvâtausot ilusinganit sakKititsigajattunik utsualunnik ammalu kiasaleninillu tigujaugiasisongulluni piviannatuKutingani.

Suliagijaugiasinialluni pivalliataulluni KaujisattauKâlluni inigijjanga, pigiasijauKattajuk maggolingajolluni (2-D) inigijjanga Kaujisattauluni ammalu, Kaujijaujut piujoppata, nottausongunialluni taijaujumut (3-D) – Kaujisattaunik. TugâgutigiluaKattajangit Kaujisannet tukisitsiasonguniammata inigijjanganik ammalu nalunaitsisongullutik Kanuilingagaluammangât inigijjanga pitaKagajattumik kiasaleninik utsualunillu.

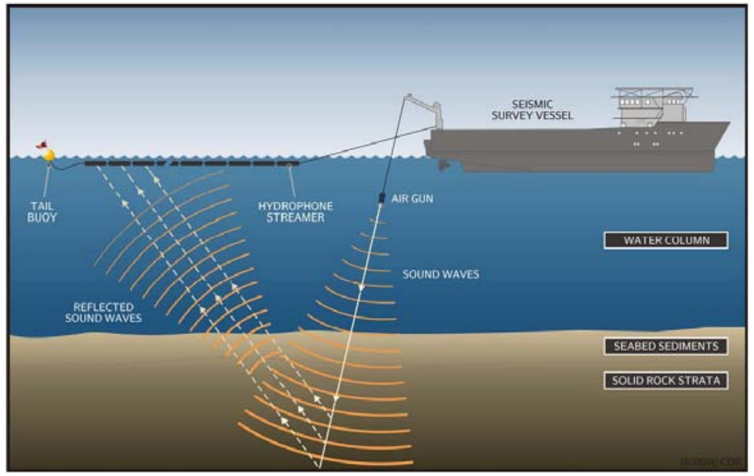
Inigijjanga tigusipviusimalimmat ammalu ilusinga Kaujisattausimalimmat nalunaittausimallunillu Kanuttogutigijaujuk, kajusiutiKasonguniallutik pivalliagiamut Kaujisallutik putogutigigiasillutillu, kingullimik taimâk pinianniKaKattamata utsualuit ammalu kiasalenet tamânettuKagaluammangât. Unuttugalait Kallutet atujaugiasiniallutik suliatsagijaujumut. Puttoggigajattut takunnâtuinnalugu inigijjanga taijaujumut nunangata kappianattunik Kaujisannik, taimâk piluaKattajut putoggilippata kamatsiasongugiamut.

Ununnigijangit kiasalenet ammalu utsualuit napvâtaumajut unuttopata ammalu kenaujaliugutigijautsiasonguppat, piusitsanga ammalu sanajaunitsanga pigiasijaunialluni, ilijaulluni suliaKapvisanga upvalu puttasongulluni initsaKallunim, kajusiutigijausongunialluni.

Suliatsak

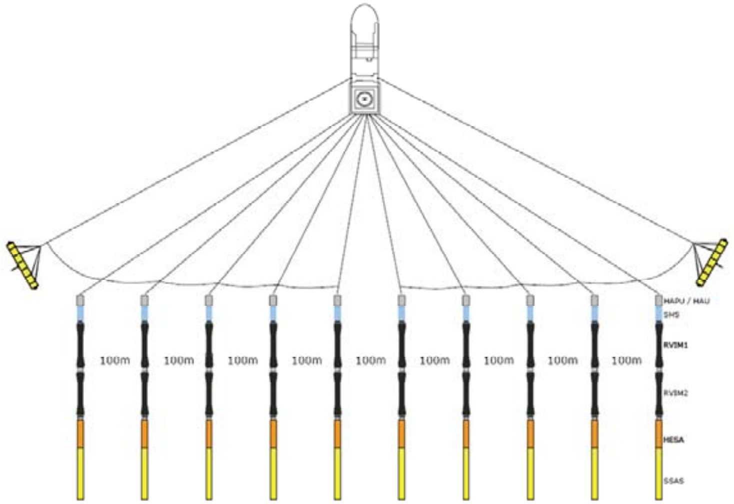
Aujami 2010 upvalu 2011, Husky Energy painaigutiKavut Kaujisallutik ullunik ilinganiKajunut 40-nik tikillugu 60-nut ammalu/ upvalu 3-D inigijjanga Kaujisattaulluni.

2-D Kaujisannik imâk ilinganiKajuk nipanga Kaujisattauluni Kukiutimmik atullutik silamut Kukittauluni ammalu immigolingajuk kalittaujumik kalillutik, taikkua nuluajait nipani tigullaiKattajunik taijaujuk hydrophone, takiniKajut 6,000 tikillugu 10,000 metre-itut, kalittauKattaniattuk umiammut itininganut kivimattitaulluni 8 tikillugu 30 metre-itut. TakugajakKusi adjinguanik atâni.



Kaujijaujut 2-D-Kaujisannikut takutitsipat ininga ilusigijanga pitaKappat angijumik hydrocarbon-niunigâttamik, asigiallait Kaujisattausimajut (unnunnisanit 2-D upvalu 3-D) ottugattausimagajammijut Jârini Kângisimalittuni tikikKâtinnagu 2017 (akunganigalak Juli 1 ammalu Novembera 30 Kangatuinnak jârimi).

3-D Kaujisannik akuniutigijauluaKattavuk 30-nik tikillugu 75-inik ammalu anginitsanik Kukiutinik atuKattajut nipanginnik tigullaigiamut ammalu attanik upvalu senanik kaliKattajut hydrophone-niunigâttanik avittusimaKattajut 75-100 metre-imik ammalu kalittauKattatillugit 6,000 tikillugu 8,000 metre-inik takiniKatillugit umiap tunuangani kalittautillugit. Nuluajait taikkua kalittaujut anginiKasot 0.5 kilometres-itut taikkua aippangit adjinguat takugajattasi.



Avatik Kaujisattauninga piusigiKattajanga

Husky Energy tunitsisimalauttut Suliagigumajamminik Kanuilingagaluammangật Januar 16, 2009-imi. Canada-ammalu Newfoundland ammalu Labrador imappisuanut Utsualunnut AngajukKauKatigenginnut sakKititsitillugit Husky Energy-kut AllaKutiKatlutik Aprel 2, 2009-imi, tigumiagiamut atuinnaguttitauninganut Avatik Kaujisattaunitsanganut.

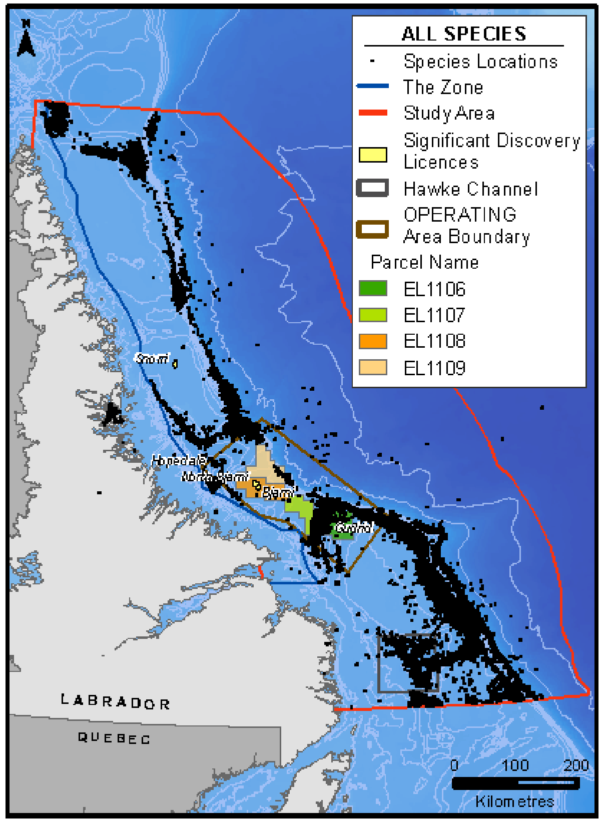
IkKanattumagik ilanga Avatik Kaujisattauninganut unauvuk Kaujimatitsinikkut sakKilậttut Labradorimi.

Aulatauninga Ininga

Kinugautigijaujuk aulataunitsanga Ininga avatik Kaujisattaunitsanga ilautitsivuk 30 kilometre Kanitanga Kaujisattaugiamut attatusimajut ilautitsivullu atuttauluni KaujisanniuKattajuk umiak sanguKattasongulluni; kalilluni nuluajaujunik tusậgutiKajunut ammalu nậjilippata Kaujisannikut tikilậngituk Labrador Inuit Satusasimajangita Ininganik (ammalu taijauKattamijuk ‘killiniattausimajuk’)

Ogannianik ammalu asigiallait piviannatuit inigijangani

Nunanguak atậni sakKititsijuk sunataKammangật omajunik oganik (2006 tikillugu 2008) inigijangani Kaujisattaugumajop aulataunitsanga sakKigumajuk. Avatik Kaujisattauninga takunnậlangajuk Kanuilingatsiamangật ininga piniannigijauKattajut ininga ammalu asigiallait pivianattuit Kaujisattaulutik ikKanattumagiummat puijinut ammalu asigiallanik omajunik imammiutanut, timianut ammalu imappisuamiutait timmiagialait.



Atuttaulangajut sakKititsitailigiamut Ulugianattunik Piviannatunut Inigijangani

Avatiup Kaujisattauningani Husky-kut ilisilậttut atuttaugajattumik paigigasuallugit omajuit sakKititsitailigiamut annitaunitsanginnut omajuKutiujunut iniKajunut piviannatunut tigusiKattajunut aulatsilippata suliagijamminik sollu imậk:

- Tapvainaugasuattumik KaujititsiKattalutik ammalu pannaigutiliuKattajunut atuKattajunut piviannatunik inigijangani
- Ikajutsilutik umiannik kajusiutiKagiamut Kaujisagiamut apviatauKattaniangimata nuluagalannut
- Nunalimmiunik suliatsatậtitsilutik umiammi suliaKaKattaniattumik sakKititsigiamik ammalu uKautjigiajiugajattumik ammalu tigumialluni Kaujigatsanik iganik KanuttogutiKajunut KaujisajuKalippat
- Ajunnangitumik piusitsaKallutik oganut nuluagalait Kinugautigijaulippata
- KaujititsinginnaKattalutik umiat ingigganitsangit nunalimmiunut KaujimanginnaKattaniammata KaujisattuKalippat
- Ilisimallagijunik suliaKattiKallutik umiammi kamagajattumik imammiutanik omajunik ammalu ikajuKattaniattumik paigillugit omajuit

Canada ammalu Newfoundland ammalu Labrador Ikajotingit

Husky Energy sulijugiKatsiajut sakKititsigiamut ilonnậgut ammalu nậmmasiattunik pivitsanik kampaniujunut Newfoundland ammalu Labradorimettunik ilauKataugiamut sakKititsiKattajunik piujunik ammalu kiggatotiujunut uKausingitigut uvagut aulatsiKattajavuttinik ammalu maligatsasuat maligiaKajanginnik.

Kaujigialagumagutsi upvalu apitsotitsaKagutsi upvalu isumậlotiKagutsi tậnna suliatsak pitjutigillugu, Kaujititsilautsiuk:

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Husky Energy

APPENDIX C

HUSKY ENERGY ENVIRONMENTAL MANAGEMENT SYSTEM

APPENDIX C

The following summary of Husky's plans and procedures was prepared as a representative sample of how Element 8 – Environmental Stewardship of the Husky Operational Integrity Management System (HOIMS) is implemented.

Fisheries Damage Compensation Program

Husky Energy undertakes various activities in the Newfoundland and Labrador and Nova Scotia Offshore Area (Offshore Area) and these activities should have no significant operational impacts on commercial fishing vessels nor reduce catches in any manner. Husky Energy recognizes that the fishing industry has a long tradition of fishing in the waters of Newfoundland and Labrador and Nova Scotia and as such has worked with the fishing industry and established efficient and effective mechanisms and procedures that ensure both industries can pursue their operations safely and with the least possible interference and the greatest mutual benefit.

Husky Energy has developed a Fisheries Damage Compensation Program to address any fisheries related damages allegedly caused by any of Husky's operations and to compensate for resulting loss. Liaison and consultations between both industries over the life of Husky Energy's operations in the Offshore Area ensure that any unanticipated problems and issues are addressed and resolved to the mutual satisfaction of both industries. It is also acknowledged that all components of Program should abide fully with the legislative and regulatory requirements of Canada as described in relevant legislation, such as the *Canada-Newfoundland And Labrador Atlantic Accord Implementation Newfoundland And Labrador Act* and Compensation Guidelines Respecting Damages Related to Offshore Petroleum Activity - March 2002.

Seabird Programs

Husky Energy's commitment to environmental responsibility also extends to the wildlife in the water in which Husky operates, including seabirds. Several programs have been established in conjunction with other area operators and external stakeholder such as the Canadian Wildlife Service (CWS). Husky holds a migratory bird handling permit, issued by the CWS which permits Husky under the *Migratory Birds Act* and Regulations to handle any birds which become stranded on any Husky operated platform or vessel.

Husky's Leach's Storm Petrel program was developed to raise awareness among offshore personnel of Leach's storm petrels and their unique handling requirements should they become stranded on a platform or vessel. Leach's storm petrels fly at night and often 'crash' into lights on ships and platforms. The intention of the program is to recover, hold and release any stranded petrels. All handling data are submitted annually to CWS

In rare instances, oiled seabirds are found onboard offshore installations. While the origin of the hydrocarbon contamination may not be ascertained in all cases, probable sources include hydrocarbons of oceanic origin from ships bilges and other sources, or from vessel and platform machinery. Husky, in partnership with other area operators have developed a seabird cleaning/rehabilitation centre and fund a rehabilitation centre. The seabird cleaning centre is leading edge and is a first of its kind in North America to be owned and operated by oil and gas industry operators. Operated year-round by a team of dedicated volunteers, the facility also maintains a wildlife veterinarian on staff.

Chemical Management System

Husky Energy's Chemical Management System and its associated procedures were developed to minimize the potential risks to the health and safety of personnel and harm to the environment from the identification, procurement, transport, use, storage and disposal of chemical products and substances used by Husky Energy. All drilling and production related chemicals undergo a thorough Health, Safety and Environmental screening based in part on the C-NLOPB's Offshore Chemical Selection Guidelines For Drilling & Production Activities On Frontier Lands (April, 2009).

Husky Chemical Management System ensures that:

- chemicals are managed in compliance with all applicable statutory requirements, codes and industry practices;
- the identification, purchase, use, storage, transport and eventual disposal of chemical substances is carried out in a responsible manner that prevents harm to people and the environment;
- all chemicals at Husky Energy's SeaRose FPSO and all drilling related chemicals (does not apply to domestic chemicals) on drilling rigs under contract to Husky Energy undergo a health, safety and environmental screening prior to being accepted for use; and
- all personnel who encounter chemicals in the workplace are adequately trained, Material Safety Data Sheets (MSDSs) are provided and accessible, and the risks associated with chemical use are appropriately communicated.

Waste Management Plan

Husky Energy has overall accountability for the management, control and documentation of all waste materials generated by its operations and activities both onshore and offshore. The duty of care for waste material and its disposal, in most cases, resides with the generator of the waste material notwithstanding the fact that a waste management/disposal contractor may assume liability for the waste material for the time it is in their custody.

The generation, handling, transfer, disposal and documentation of all waste materials is conducted in strict compliance with all applicable legislation, regulations, standards and codes of practice.

Absolutely no waste materials whatsoever are to be dumped into the sea from any rig or vessel contracted to or owned by Husky, unless such dumping is considered necessary in a life-threatening situation. The only exceptions to this rule arise from the legally sanctioned discharges from a production or drilling installation pursuant to the C-NLOPB OWTG or the operations of a vessel in accordance with the *Canada Shipping Act* and international law.

Husky is committed to handling and disposing of wastes from its operations and activities in the most environmentally sound manner using the best available techniques not entailing excessive cost. It has adopted an approach which has minimization of waste as a priority. Raw materials and technologies are selected to avoid generating waste, to promote waste recycling, and to minimize the hazards of the final waste to people and the environment. Husky's Waste Management Plan was developed to ensure that Husky and its contractors:

- Identify and quantify wastes generated;
- Identify optimum disposal methods for waste;
- Document the costs of waste handling, recycling, treatment and disposal; and
- Enable development of improved waste management practices, and where feasible, to minimize disposal requirements.

To the extent possible and practicable Husky and its contractors ensure that the following principles are applied in managing all waste streams and materials in the following order of priority:

- Waste reduction;
- Waste segregation;
- Waste recycling; and
- Waste reuse, where safe, practical and cost effective to do so.

The Waste Management Plan is intended to meet the requirements of the ISO 14001 Environmental Management Systems specification by stating responsibilities and describing the processes and systems which will be applied to the classification, handling, storage, documentation and disposal of wastes generated as a result of both onshore and offshore operations.

Husky expects its contractors to document and implement waste management plans and procedures specific to their operations that are consistent with Husky's Waste Management Plan, with Husky's Health, Safety and Environment policies and procedures and with applicable legislation.

This Waste Management Plan establishes the framework for a consistent approach to waste management for Husky and its contractors by providing guidance to:

- Encourage waste minimization and recycling;
- Ensure all applicable regulatory requirements are met including;
    - Workplace Hazardous Materials Information System;
    - Transportation of Dangerous Goods Act (encompassing onshore, marine and air transport requirements and the IMDG and IATA rules that apply);
    - International Convention for the Prevention of Pollution from Ships (1973) as amended by the Protocol of 1978 (i.e. MARPOL 73/78); and
- Identification, classification, handling, storage, transport and final disposal of wastes.

Emergency Response/Incident Coordination

Husky Energy's Incident Coordination Plan was developed in keeping with Husky Energy's Health, Safety, and Environment Policy. The plan reflects Husky's high regard for the safety of workers and the public, an awareness of the need to protect the environment, and a concern for the integrity of offshore assets.

The Incident Coordination Plan provides a process to be used by the Husky East Coast Emergency Response Team (ERT) in the response to an emergency or an event of public or regulatory concern related to Husky East Coast Operations. It outlines the necessary resources, personnel, logistics, and actions to implement a prompt, coordinated, and rational response to any emergency and it offers an efficient and balanced approach to dealing with the issues resulting directly from the emergency. The plan addresses those situations which result in:

- Concern for current or forecast conditions that cause an operational alert;
- Public or regulatory concern for Husky operations;
- Direct threats to human safety, or actual injury or death;
- Threatened or actual damage to facilities or major equipment;
- Terrorism, sabotage, or criminal acts;
- Oil spills; and
- Unintentional discharge of materials to the natural environment.

The intention of the plan is to ensure that, in the event of an offshore or onshore emergency, personnel are mobilized onshore as soon as possible to provide the necessary support required by the emergency site.

Oil Spill Response Plan

Husky Energy recognizes that prevention is the most effective way to avoid damage to the environment from marine oil spills. Husky has in place the policies, procedures, equipment, and trained personnel necessary to reduce the probability of oil spills related to its East Coast operations and to minimize the effects of spills that do occur.

Husky's East Coast Oil Spill Response Program has been structured to support any of Husky's operations offshore Newfoundland. The program is comprehensive and consists of two components – operational response and response management. The operational component meets or exceeds standards established by the *Canada Shipping Act*. The response management component is linked to Husky's East Coast Emergency Response Program detailed above, and the Eastern Canada Response Corporation (ECRC) spill management system which is certified under the *Canada Shipping Act*.

Incident Reporting

Husky Energy's Incident Reporting and Investigation Reporting Procedure was developed under the guidance of the C-NLOPB's Guideline for the Reporting and Investigation of Incidents (June, 2009). It provides guidance with respect to the reporting and investigation requirements for hazards and incidents and is intended to:

- Communicate Husky Energy's expectation for reporting and investigating of health, safety and environmental hazards and incidents as required under Element 7, Incident Management, Husky Operational Integrity Management System (HOIMS);
- Establish a standard with respect to the reporting and investigation of hazards and incidents; and,
- Facilitate the identification of basic/root causes and implement system improvements to prevent re-occurrence and minimize loss.

Continuous Improvement Plan

Husky Energy is committed to continual improvement in its environmental performance and initiatives. Like other evolving companies, Husky recognizes the importance of achieving environmental sustainability in its operations and having a reputation for environmental responsibility with its various stakeholders including:

- its employees and contractors,
- regulatory agencies,
- non-governmental organizations; and,
- the general public.

The purpose of the Continuous Improvement Plan was to set out the framework for development of an Environmental Stewardship Program for Husky's White Rose operations which clearly demonstrates continual improvement in managing the environmental aspects of oil and gas production and drilling activities in the White Rose Field. The continuous improvement plan is equally applicable to all of Husky Energy's East Coast operations.

A performance driven system helps Husky to minimize environmental and business risks by setting the framework for proactive management of the environmental aspects of its operations. The need for a robust management system to address all aspects of the business is incorporated into Husky's Operations Integrity Management System (HOIMS).

HOIMS identifies a clear set of expectations for all Husky Operations. One of the 14 elements of HOIMS focuses specifically on environment. Element 8 titled "Environmental Stewardship" sets a clear aim to; *"operate responsibly to minimize the environmental impact of how we conduct business"* …and … *"Leave a positive legacy behind us when we leave"*. A clear set of expectations details how Husky intends to meet this aim, one of these expectations centers on continual improvement. Most of the other elements have within them clauses or components that support environmental initiatives and responsibilities.

The first step in development of an environmental performance stewardship program that can bring focus to continuous improvement, is to identify those areas of White Rose operations where management of environmental initiatives is critical to meeting Husky's internal expectations, objectives and standards as well as those of other external stakeholders. A review of East Coast operations has shown six key areas where managing environmental risk is critical. They are the following:

1. Chemical Management.
2. Waste Management.
3. Environmental Event Management.
4. Compliance Management.
5. Emissions Management.

As is the case with any responsible operation, plans and procedures have been put in place to ensure Husky Energy complies with all relevant legislation and guidelines in the above-noted areas. However, true environmental management and stewardship programs are proactive and predictive and allow a company to trend, forecast and project future scenarios, just as they would in any other operational area of its business. Therefore, in each of these areas, a clear set of reasonable goals, objectives and targets have been developed based on sustainability and business planning within Husky's operation, and prioritized based on criticality to overall business objectives. Active benchmarking and internal stewardship reporting is used to track performance indicators on a pre-determined timeline. Timelines, objectives and targets will vary depending on the initiative and between the different management areas.

Compliance with Pollution Regulations

All vessels owned or operated by Husky Energy are required to be certified and compliant with the International Maritime Organization's (IMO) "International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto", or simply known as MARPOL 72/78. The IMO convention was designed to minimize ship-born pollution and manage waste streams including bilge, ballast, sewage, garbage and air pollution. When under the jurisdiction of the C-NLOPB, production platforms and drilling required to manage wastes and comply with the Board's Offshore Waste Treatment Guidelines (OWTG; 2002).

Regardless of the pollution prevention protocols, it is Husky's intent wherever possible, to minimize the volumes of wastes generated during operations and minimize the quantity of substances of potential environmental concern contained within waste streams.

Although the protocols represent the minimum standard for treatment, monitoring and reporting of authorized discharges, under some conditions Husky may perform better than the requirements outlined in either MARPOL 73/78 or the OWTG.

Environmental Effects Monitoring

Husky Energy's Environmental Effects Monitoring (EEM) program, designed for drilling and production related activities in the White Rose and North Amethyst fields, is intended to provide the primary means to determine and quantify project-induced change in the surrounding environment. Where such change occurs, the EEM program enables the evaluation of effects and, therefore, assists in identifying the appropriate modifications to, or mitigation of, project activities or discharges. Such operational EEM programs also provide information for the C-NLOPB to consider during its periodic reviews of the Offshore Waste Treatment Guidelines (2002). Objectives to be met by the EEM program are to:

- Confirm the zone of influence of project contaminants;
- Test biological effects predictions made in the EIS;
- Provide feedback to Husky Energy for project management decisions requiring modification of operations practices where/when necessary;
- Provide a scientifically defensible synthesis, analysis and interpretation of data;
- Be cost-effective, making optimal use of personnel, technology and equipment; and,
- Communicate results to the public.

APPENDIX D

PHYSICAL ENVIRONMENT SETTING DATA (AMEC 2009)

Appendix 1

Temperature and Salinity Statistics (BIO Hydrographic Database, 2009)

January

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-1.70	1.74	-0.64	0.82	59	32.15	33.86	33.02	0.39	59
5	-1.56	1.48	-0.74	0.91	18	31.07	34.07	32.75	0.67	18
10	-1.70	0.39	-0.93	0.48	37	32.44	33.76	33.00	0.33	37
15	-1.18	0.43	-0.69	0.53	12	32.49	33.64	32.95	0.37	12
20	-1.72	1.09	-0.84	0.64	39	32.42	33.88	33.06	0.39	39
25	-1.52	1.77	0.04	1.20	20	32.37	34.09	33.37	0.67	20
30	-1.70	2.26	-0.65	0.81	38	32.42	34.27	33.11	0.44	38
40	-1.49	2.51	-0.31	1.36	12	32.42	34.42	33.08	0.70	12
50	-1.68	2.78	0.08	1.19	52	32.39	34.49	33.32	0.57	52
60	-1.22	2.96	0.33	1.47	11	32.57	34.53	33.38	0.75	11
70	-1.42	3.00	-0.04	1.34	18	32.51	34.57	33.24	0.69	18
80	-1.30	3.24	0.10	1.59	11	32.54	34.60	33.20	0.75	11
90	-1.48	3.58	-0.06	1.50	17	32.48	34.66	33.17	0.73	17
100	-1.48	3.67	0.91	1.32	52	32.48	34.68	33.62	0.60	52
125	-1.34	3.91	0.15	1.50	19	32.56	34.72	33.19	0.70	19
150	-1.33	3.94	0.92	1.39	48	32.58	34.75	33.59	0.69	48
175	-1.13	4.05	0.60	1.45	20	32.61	34.79	33.34	0.65	20
200	-0.97	4.13	2.04	1.47	58	32.62	34.80	34.05	0.62	58
225	-0.88	4.09	0.99	1.63	19	32.72	34.81	33.56	0.72	19
250	-0.65	4.09	2.14	1.35	38	32.82	34.82	34.13	0.60	38
275	-0.30	4.10	1.67	1.55	14	33.08	34.83	33.90	0.64	14
300	-0.10	4.10	2.82	1.11	29	33.22	34.84	34.40	0.46	29
325	-0.48	4.11	1.93	1.65	12	32.93	34.84	34.01	0.67	12
350	0.44	4.08	2.50	1.32	10	33.46	34.85	34.29	0.52	10
375	1.03	4.23	2.94	1.18	11	33.73	34.86	34.42	0.39	11
400	0.73	4.04	2.92	0.99	16	33.60	34.85	34.47	0.37	16
425	1.08	4.03	2.49	1.12	7	33.74	34.86	34.33	0.41	7
450	1.22	4.03	2.78	1.17	6	33.79	34.86	34.45	0.42	6
475	2.14	4.03	2.95	0.87	6	34.26	34.86	34.53	0.27	6
500	2.09	4.02	3.39	0.61	8	34.24	34.86	34.69	0.21	8
600	3.48	3.98	3.75	0.20	6	34.76	34.86	34.82	0.04	6
650	3.38	3.96	3.73	0.26	4	34.68	34.87	34.80	0.09	4
700	3.87	3.94	3.91	0.05	2	34.86	34.87	34.87	0.01	2
750	3.86	3.94	3.90	0.06	2	34.87	34.87	34.87	0.00	2
800	3.58	3.90	3.77	0.17	3	34.82	34.88	34.86	0.03	3
850	3.78	3.88	3.83	0.07	2	34.87	34.88	34.88	0.01	2
900	3.73	3.85	3.79	0.08	2	34.87	34.88	34.88	0.01	2
950	3.68	3.76	3.72	0.06	2	34.87	34.88	34.88	0.01	2
1000	3.65	3.78	3.70	0.07	3	34.87	34.89	34.88	0.01	3
1050	3.62	3.66	3.64	0.03	2	34.87	34.87	34.87	0.00	2
1100	3.59	3.64	3.62	0.04	2	34.87	34.87	34.87	0.00	2
1150	3.57	3.57	3.57	0.00	1	34.87	34.87	34.87	0.00	1
1200	3.56	3.56	3.56	0.00	1	34.87	34.87	34.87	0.00	1
1250	3.54	3.54	3.54	0.00	1	34.87	34.87	34.87	0.00	1
1300	3.52	3.52	3.52	0.00	1	34.87	34.87	34.87	0.00	1
1350	3.52	3.52	3.52	0.00	1	34.87	34.87	34.87	0.00	1
1400	-	-	-	-	-	-	-	-	-	-
1450	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-

February

	Temperature (°C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-1.79	-0.15	-1.43	0.64	6	32.65	33.66	33.07	0.43	6
5	-1.81	-0.15	-1.51	0.57	8	32.65	33.66	33.02	0.38	8
10	-1.79	-0.15	-1.47	0.60	7	32.65	33.66	33.06	0.39	7
15	-1.80	-0.15	-1.50	0.57	8	32.65	33.66	33.02	0.39	8
20	-1.79	0.25	-1.43	0.70	8	32.65	33.77	33.05	0.41	8
25	-1.79	0.62	-1.41	0.80	9	32.65	33.88	33.03	0.44	9
30	-1.79	1.02	-1.30	0.98	8	32.65	34.04	33.10	0.50	8
40	-1.79	1.59	-1.25	1.17	8	32.65	34.23	33.15	0.54	8
50	-1.79	1.84	-1.18	1.25	8	32.65	34.29	33.20	0.55	8
60	-1.79	2.24	-1.06	1.31	9	32.65	34.37	33.26	0.54	9
70	-1.79	2.61	-0.75	1.42	9	32.66	34.45	33.34	0.57	9
80	-1.79	2.66	-0.65	1.52	8	32.66	34.48	33.42	0.62	8
90	-1.79	2.88	-0.44	1.70	8	32.65	34.53	33.49	0.67	8
100	-1.79	3.13	-0.29	1.82	8	32.65	34.58	33.55	0.70	8
125	-1.75	3.48	0.05	1.98	9	32.65	34.66	33.58	0.75	9
150	-1.66	3.52	0.63	1.97	8	32.81	34.71	33.82	0.72	8
175	-1.63	3.56	0.86	1.99	8	32.83	34.74	33.92	0.71	8
200	-0.78	3.56	1.59	1.72	7	33.31	34.79	34.15	0.57	7
225	-0.64	3.56	1.77	1.57	8	33.42	34.78	34.18	0.51	8
250	-0.38	3.59	2.06	1.62	7	33.51	34.81	34.30	0.51	7
275	-0.14	3.57	2.40	1.51	5	33.75	34.74	34.40	0.39	5
300	0.08	3.49	2.60	1.27	6	33.83	34.74	34.48	0.33	6
325	0.34	3.45	2.79	1.21	6	33.90	34.74	34.53	0.31	6
350	0.61	3.45	2.89	1.12	6	33.96	34.75	34.56	0.30	6
375	1.15	3.38	2.63	1.28	3	34.10	34.76	34.51	0.36	3
400	1.68	3.37	2.54	0.95	4	34.24	34.76	34.48	0.28	4
425	2.36	3.42	3.17	0.46	5	34.37	34.77	34.63	0.15	5
450	2.92	3.48	3.30	0.25	4	34.49	34.77	34.65	0.12	4
475	3.32	3.42	3.39	0.06	3	34.58	34.78	34.69	0.10	3
500	3.39	3.52	3.46	0.06	4	34.44	34.78	34.64	0.15	4
600	3.42	3.44	3.43	0.01	2	34.71	34.79	34.75	0.06	2
650	3.42	3.42	3.42	0.00	1	34.80	34.80	34.80	0.00	1
700	3.42	3.42	3.42	0.00	1	34.79	34.79	34.79	0.00	1
750	3.43	3.43	3.43	0.00	1	34.80	34.80	34.80	0.00	1
800	3.44	3.44	3.44	0.00	1	34.80	34.80	34.80	0.00	1
850	3.45	3.45	3.45	0.00	1	34.80	34.80	34.80	0.00	1
900	3.48	3.48	3.48	0.00	1	34.81	34.81	34.81	0.00	1
950	3.48	3.48	3.48	0.00	1	34.81	34.81	34.81	0.00	1
1000	3.48	3.48	3.48	0.00	1	34.81	34.81	34.81	0.00	1
1050	3.48	3.48	3.48	0.00	1	34.81	34.81	34.81	0.00	1
1100	3.49	3.49	3.49	0.00	1	34.81	34.81	34.81	0.00	1
1150	-	-	-	-	-	-	-	-	-	-
1200	-	-	-	-	-	-	-	-	-	-
1250	-	-	-	-	-	-	-	-	-	-
1300	-	-	-	-	-	-	-	-	-	-
1350	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-
1450	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-

March

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-1.79	0.20	-1.19	0.80	6	32.65	33.85	33.23	0.50	6
5	-1.79	-1.67	-1.76	0.06	4	32.64	33.56	33.01	0.42	4
10	-1.79	-1.34	-1.65	0.21	4	32.64	33.72	33.16	0.56	4
15	-1.79	-1.78	-1.79	0.01	2	32.64	32.73	32.69	0.06	2
20	-1.81	-1.64	-1.76	0.08	4	32.64	33.58	33.02	0.43	4
25	-1.79	-1.23	-1.60	0.32	3	32.64	33.79	33.05	0.64	3
30	-1.79	-1.61	-1.73	0.10	3	32.64	33.58	32.98	0.52	3
40	-1.79	-1.78	-1.79	0.01	2	32.64	32.73	32.69	0.06	2
50	-1.79	1.30	-0.85	1.47	4	32.67	34.16	33.30	0.73	4
60	-1.79	-1.77	-1.78	0.01	2	32.71	32.73	32.72	0.01	2
70	-1.79	-1.75	-1.77	0.02	3	32.71	33.19	32.88	0.27	3
80	-1.79	-1.67	-1.73	0.08	2	32.73	32.76	32.75	0.02	2
90	-1.79	0.54	-0.98	1.32	3	32.73	34.22	33.25	0.84	3
100	-1.79	3.57	0.37	2.21	5	32.74	34.56	33.64	0.81	5
125	-1.79	-1.68	-1.74	0.08	2	32.79	33.06	32.93	0.19	2
150	-1.82	4.40	0.55	2.98	4	32.79	34.72	33.78	0.85	4
175	0.79	0.94	0.87	0.11	2	34.27	34.33	34.30	0.04	2
200	2.55	4.81	3.68	1.60	2	34.40	34.80	34.60	0.28	2
225	0.82	0.82	0.82	0.00	1	34.26	34.26	34.26	0.00	1
250	3.46	4.84	4.15	0.98	2	34.56	34.81	34.69	0.18	2
275	0.85	0.85	0.85	0.00	1	34.26	34.26	34.26	0.00	1
300	4.93	4.93	4.93	0.00	1	34.84	34.84	34.84	0.00	1
325	-	-	-	-	-	-	-	-	-	-
350	4.15	4.15	4.15	0.00	1	34.72	34.72	34.72	0.00	1
375	-	-	-	-	-	-	-	-	-	-
400	-	-	-	-	-	-	-	-	-	-
425	-	-	-	-	-	-	-	-	-	-
450	3.92	4.35	4.06	0.25	3	34.79	34.80	34.79	0.01	3
475	-	-	-	-	-	-	-	-	-	-
500	-	-	-	-	-	-	-	-	-	-
600	-0.92	4.73	2.79	3.22	3	33.66	34.90	34.47	0.70	3
650	-	-	-	-	-	-	-	-	-	-
700	4.64	4.64	4.64	0.00	1	34.90	34.90	34.90	0.00	1
750	3.55	3.55	3.55	0.00	1	34.87	34.87	34.87	0.00	1
800	4.40	4.40	4.40	0.00	1	34.89	34.89	34.89	0.00	1
850	-	-	-	-	-	-	-	-	-	-
900	4.32	4.32	4.32	0.00	1	34.91	34.91	34.91	0.00	1
950	-	-	-	-	-	-	-	-	-	-
1000	3.35	4.24	3.69	0.48	3	34.67	34.91	34.82	0.13	3
1050	-	-	-	-	-	-	-	-	-	-
1100	4.14	4.14	4.14	0.00	1	34.91	34.91	34.91	0.00	1
1150	-	-	-	-	-	-	-	-	-	-
1200	4.13	4.13	4.13	0.00	1	34.92	34.92	34.92	0.00	1
1250	-	-	-	-	-	-	-	-	-	-
1300	4.01	4.01	4.01	0.00	1	34.92	34.92	34.92	0.00	1
1350	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-
1450	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-

April

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-1.44	-1.27	-1.36	0.12	2	32.88	33.03	32.96	0.11	2
5	-	-	-	-	-	-	-	-	-	-
10	-1.44	0.60	-0.72	1.14	3	32.83	33.99	33.27	0.63	3
15	-	-	-	-	-	-	-	-	-	-
20	-1.47	0.71	-0.73	1.25	3	32.83	33.99	33.28	0.62	3
25	-	-	-	-	-	-	-	-	-	-
30	-1.54	1.16	-0.19	1.91	2	32.83	33.99	33.41	0.82	2
40	-	-	-	-	-	-	-	-	-	-
50	-1.40	2.04	-0.21	1.95	3	32.85	34.40	33.46	0.83	3
60	-	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-
100	-1.06	2.22	0.58	2.32	2	33.56	34.47	34.02	0.64	2
125	-	-	-	-	-	-	-	-	-	-
150	-0.98	2.54	0.78	2.49	2	33.88	34.60	34.24	0.51	2
175	-	-	-	-	-	-	-	-	-	-
200	-1.01	3.15	1.08	2.08	3	33.24	34.77	34.06	0.77	3
225	1.21	1.21	1.21	0.00	1	34.20	34.20	34.20	0.00	1
250	-	-	-	-	-	-	-	-	-	-
275	-	-	-	-	-	-	-	-	-	-
300	2.00	3.21	2.61	0.86	2	34.39	34.81	34.60	0.30	2
325	-	-	-	-	-	-	-	-	-	-
350	-	-	-	-	-	-	-	-	-	-
375	-	-	-	-	-	-	-	-	-	-
400	2.60	3.42	3.01	0.58	2	34.59	34.88	34.74	0.21	2
425	-	-	-	-	-	-	-	-	-	-
450	-	-	-	-	-	-	-	-	-	-
475	-	-	-	-	-	-	-	-	-	-
500	2.84	2.84	2.84	0.00	1	34.69	34.69	34.69	0.00	1
600	-	-	-	-	-	-	-	-	-	-
650	-	-	-	-	-	-	-	-	-	-
700	-	-	-	-	-	-	-	-	-	-
750	-	-	-	-	-	-	-	-	-	-
800	-	-	-	-	-	-	-	-	-	-
850	-	-	-	-	-	-	-	-	-	-
900	-	-	-	-	-	-	-	-	-	-
950	-	-	-	-	-	-	-	-	-	-
1000	-	-	-	-	-	-	-	-	-	-
1050	-	-	-	-	-	-	-	-	-	-
1100	-	-	-	-	-	-	-	-	-	-
1150	-	-	-	-	-	-	-	-	-	-
1200	-	-	-	-	-	-	-	-	-	-
1250	-	-	-	-	-	-	-	-	-	-
1300	-	-	-	-	-	-	-	-	-	-
1350	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-
1450	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-

May

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-1.39	1.76	-0.43	1.41	6	32.15	33.07	32.58	0.36	6
5	-1.14	1.88	-0.38	1.17	6	31.38	32.96	32.21	0.56	6
10	-1.28	1.42	-0.70	0.82	10	31.40	32.96	32.30	0.42	10
15	-1.33	-0.43	-1.02	0.26	9	32.05	32.97	32.38	0.31	9
20	-1.50	1.83	-0.90	1.01	12	32.23	32.98	32.52	0.22	12
25	-1.65	1.45	-1.17	0.85	12	32.11	33.01	32.59	0.22	12
30	-1.70	0.47	-1.15	0.74	12	32.29	33.06	32.69	0.22	12
40	-1.71	-0.87	-1.30	0.29	10	32.45	33.23	32.80	0.23	10
50	-1.71	1.56	-1.07	1.03	9	32.51	33.34	32.88	0.27	9
60	-1.62	-0.59	-1.32	0.37	7	32.65	33.51	32.93	0.29	7
70	-1.65	-0.42	-1.31	0.44	8	32.78	33.59	32.99	0.27	8
80	-1.65	0.21	-1.12	0.64	7	32.85	33.71	33.09	0.31	7
90	-1.58	0.16	-1.20	0.57	8	32.92	33.78	33.16	0.30	8
100	-1.59	1.37	-0.93	0.98	10	33.00	33.82	33.22	0.28	10
125	-1.25	0.97	-0.71	0.67	12	33.20	33.98	33.45	0.26	12
150	-1.34	1.60	-0.27	0.84	13	33.23	34.13	33.62	0.27	13
175	-0.83	2.03	0.45	0.95	13	33.39	34.35	33.86	0.29	13
200	-0.64	1.87	1.21	1.23	4	33.51	34.26	34.06	0.37	4
225	0.12	3.04	1.85	1.42	5	33.74	34.56	34.27	0.38	5
250	-	-	-	-	-	-	-	-	-	-
275	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-
325	-	-	-	-	-	-	-	-	-	-
350	-	-	-	-	-	-	-	-	-	-
375	-	-	-	-	-	-	-	-	-	-
400	-	-	-	-	-	-	-	-	-	-
425	-	-	-	-	-	-	-	-	-	-
450	-	-	-	-	-	-	-	-	-	-
475	-	-	-	-	-	-	-	-	-	-
500	-	-	-	-	-	-	-	-	-	-
600	-	-	-	-	-	-	-	-	-	-
650	-	-	-	-	-	-	-	-	-	-
700	-	-	-	-	-	-	-	-	-	-
750	-	-	-	-	-	-	-	-	-	-
800	-	-	-	-	-	-	-	-	-	-
850	-	-	-	-	-	-	-	-	-	-
900	-	-	-	-	-	-	-	-	-	-
950	-	-	-	-	-	-	-	-	-	-
1000	-	-	-	-	-	-	-	-	-	-
1050	-	-	-	-	-	-	-	-	-	-
1100	-	-	-	-	-	-	-	-	-	-
1150	-	-	-	-	-	-	-	-	-	-
1200	-	-	-	-	-	-	-	-	-	-
1250	-	-	-	-	-	-	-	-	-	-
1300	-	-	-	-	-	-	-	-	-	-
1350	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-
1450	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-

June

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-1.31	2.78	0.72	1.24	21	30.67	32.86	32.05	0.59	21
5	-1.48	3.40	0.79	1.30	19	30.87	32.90	31.99	0.60	19
10	-1.49	4.20	0.39	1.30	40	30.99	33.22	32.14	0.60	40
15	-1.51	2.49	0.11	1.17	28	31.60	33.32	32.44	0.59	28
20	-1.64	1.01	-0.38	0.97	31	31.79	33.39	32.60	0.54	31
25	-1.69	1.23	-0.63	0.85	41	31.99	33.48	32.75	0.43	41
30	-1.71	0.89	-0.95	0.75	29	32.12	33.51	32.84	0.41	29
40	-1.73	0.64	-0.98	0.72	27	32.48	33.65	33.01	0.38	27
50	-1.73	3.86	-1.11	0.87	45	32.50	34.76	33.12	0.42	45
60	-1.70	-0.12	-1.24	0.40	23	32.71	33.85	33.22	0.40	23
70	-1.72	0.29	-1.15	0.52	27	32.80	33.94	33.32	0.43	27
80	-1.67	0.65	-0.84	0.77	24	32.86	34.09	33.46	0.45	24
90	-1.67	0.98	-0.59	1.00	24	32.91	34.15	33.54	0.46	24
100	-1.70	3.94	-0.62	1.35	43	32.93	34.88	33.51	0.47	43
125	-1.65	2.49	-0.03	1.56	28	33.02	34.48	33.74	0.49	28
150	-1.68	3.69	0.24	1.80	42	33.06	34.87	33.81	0.52	42
175	-1.59	3.94	0.97	1.93	28	33.09	34.76	34.03	0.53	28
200	-1.48	3.48	0.66	1.52	17	33.24	34.88	33.98	0.45	17
225	-1.28	3.73	1.28	1.66	13	33.31	34.74	34.11	0.48	13
250	-1.01	3.81	1.17	2.01	6	33.40	34.74	34.04	0.56	6
275	-0.47	3.94	1.82	2.05	6	33.58	34.79	34.20	0.54	6
300	0.28	3.86	1.97	1.75	5	33.79	34.81	34.31	0.44	5
325	0.13	4.15	2.12	1.62	6	33.75	34.87	34.31	0.45	6
350	0.75	4.09	3.07	1.57	4	33.96	34.90	34.64	0.45	4
375	0.87	4.05	2.46	2.25	2	33.99	34.82	34.41	0.59	2
400	1.10	4.08	2.98	1.42	4	34.05	34.88	34.59	0.38	4
425	1.30	1.30	1.30	0.00	1	34.11	34.11	34.11	0.00	1
450	3.21	4.09	3.76	0.48	3	34.51	34.87	34.74	0.20	3
475	-	-	-	-	-	-	-	-	-	-
500	3.40	4.03	3.72	0.45	2	34.86	34.90	34.88	0.03	2
600	3.88	3.88	3.88	0.00	1	34.86	34.86	34.86	0.00	1
650	3.82	3.82	3.82	0.00	1	34.87	34.87	34.87	0.00	1
700	3.77	3.77	3.77	0.00	1	34.87	34.87	34.87	0.00	1
750	3.39	3.69	3.54	0.21	2	34.86	34.92	34.89	0.04	2
800	-	-	-	-	-	-	-	-	-	-
850	-	-	-	-	-	-	-	-	-	-
900	3.53	3.53	3.53	0.00	1	34.85	34.85	34.85	0.00	1
950	3.48	3.48	3.48	0.00	1	34.84	34.84	34.84	0.00	1
1000	3.30	3.43	3.37	0.09	2	34.84	34.92	34.88	0.06	2
1050	-	-	-	-	-	-	-	-	-	-
1100	-	-	-	-	-	-	-	-	-	-
1150	-	-	-	-	-	-	-	-	-	-
1200	3.36	3.36	3.36	0.00	1	34.83	34.83	34.83	0.00	1
1250	3.19	3.19	3.19	0.00	1	34.90	34.90	34.90	0.00	1
1300	3.37	3.37	3.37	0.00	1	34.83	34.83	34.83	0.00	1
1350	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-
1450	-	-	-	-	-	-	-	-	-	-
1500	3.10	3.10	3.10	0.00	1	34.90	34.90	34.90	0.00	1

July

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	1.46	9.51	4.64	1.50	121	28.64	33.86	31.56	0.95	121
5	-1.12	7.86	4.49	1.84	72	28.09	33.73	31.20	0.99	72
10	-1.38	7.25	3.13	1.91	153	28.98	34.40	31.70	0.87	153
15	-1.55	5.49	1.59	1.70	96	30.49	33.78	32.09	0.62	96
20	-1.70	6.76	0.71	1.56	144	30.79	34.42	32.44	0.56	144
25	-1.71	6.03	0.15	1.50	144	31.17	34.56	32.65	0.47	144
30	-1.73	6.36	-0.23	1.44	139	31.39	34.43	32.76	0.48	139
40	-1.73	4.73	-0.63	1.25	90	31.49	34.35	32.89	0.49	90
50	-1.80	4.14	-0.80	1.03	178	32.04	34.76	33.04	0.41	178
60	-1.74	2.67	-0.90	1.00	90	32.08	34.26	33.10	0.43	90
70	-1.73	2.48	-0.92	0.96	79	32.11	34.32	33.14	0.44	79
80	-1.72	3.23	-0.92	0.99	78	32.16	34.38	33.22	0.44	78
90	-1.70	2.94	-0.90	1.03	82	32.33	34.45	33.28	0.44	82
100	-1.71	3.84	-0.72	1.12	163	32.35	34.76	33.40	0.42	163
125	-1.71	3.75	-0.62	1.30	87	32.54	34.62	33.51	0.44	87
150	-1.71	3.96	-0.32	1.34	161	32.79	34.87	33.66	0.41	161
175	-1.62	4.22	0.04	1.57	80	33.01	34.76	33.79	0.43	80
200	-1.52	4.46	0.54	1.59	106	33.10	34.83	33.97	0.42	106
225	-1.37	4.56	0.93	1.82	55	33.23	34.83	34.05	0.44	55
250	-1.28	4.74	1.37	1.74	61	33.32	34.86	34.19	0.39	61
275	-1.11	4.68	1.66	1.80	40	33.59	34.87	34.28	0.39	40
300	-0.85	4.53	2.29	1.47	46	33.81	34.86	34.43	0.32	46
325	-0.23	4.43	2.90	1.39	29	33.96	34.87	34.55	0.30	29
350	0.16	4.45	3.03	1.36	29	34.06	34.88	34.60	0.28	29
375	-1.55	4.44	2.96	1.52	26	34.12	34.88	34.63	0.24	26
400	0.50	4.45	3.17	1.15	25	34.16	34.87	34.65	0.24	25
425	0.59	4.45	3.34	1.21	18	34.18	34.87	34.70	0.25	18
450	0.94	4.24	3.15	1.19	17	34.18	35.01	34.67	0.27	17
475	2.62	4.22	3.77	0.52	13	34.53	34.88	34.80	0.12	13
500	1.62	4.19	3.65	0.60	17	34.23	34.88	34.80	0.16	17
600	3.33	3.85	3.65	0.21	7	34.78	34.87	34.83	0.04	7
650	3.37	3.86	3.68	0.27	3	34.80	34.89	34.85	0.05	3
700	3.41	3.82	3.61	0.20	7	34.81	34.89	34.86	0.03	7
750	3.44	3.78	3.64	0.18	3	34.82	34.88	34.85	0.03	3
800	3.42	4.12	3.67	0.28	5	34.82	34.88	34.85	0.02	5
850	3.41	3.69	3.55	0.20	2	34.83	34.86	34.85	0.02	2
900	3.42	3.62	3.48	0.10	4	34.84	34.89	34.88	0.02	4
950	3.62	3.62	3.62	0.00	1	34.86	34.86	34.86	0.00	1
1000	3.42	3.58	3.52	0.09	3	34.84	34.88	34.86	0.02	3
1050	3.55	3.55	3.55	0.00	1	34.88	34.88	34.88	0.00	1
1100	-	-	-	-	-	-	-	-	-	-
1150	-	-	-	-	-	-	-	-	-	-
1200	3.49	3.49	3.49	0.00	1	34.88	34.88	34.88	0.00	1
1250	-	-	-	-	-	-	-	-	-	-
1300	-	-	-	-	-	-	-	-	-	-
1350	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-
1450	-	-	-	-	-	-	-	-	-	-
1500	3.34	3.34	3.34	0.00	1	34.88	34.88	34.88	0.00	1

August

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	2.26	12.15	6.49	2.23	46	28.65	33.84	31.72	1.00	46
5	2.29	9.62	5.97	2.13	34	30.43	33.85	31.83	0.80	34
10	-0.15	9.20	4.15	1.36	299	29.77	34.43	32.19	0.78	299
15	-0.43	8.74	3.22	1.44	294	30.56	34.52	32.41	0.75	294
20	-1.04	9.12	2.46	1.70	309	31.29	34.51	32.60	0.69	309
25	-1.43	8.38	1.62	1.77	298	31.71	34.62	32.78	0.61	298
30	-1.41	7.42	1.08	1.75	310	31.79	34.64	32.88	0.59	310
40	-1.49	5.70	0.24	1.55	298	31.89	34.64	33.06	0.55	298
50	-1.60	4.57	-0.21	1.30	315	31.97	34.72	33.14	0.53	315
60	-1.61	4.21	-0.49	1.16	284	32.15	34.73	33.25	0.51	284
70	-1.58	4.31	-0.64	1.07	288	32.15	34.79	33.31	0.49	288
80	-1.56	4.47	-0.62	1.16	282	32.35	34.85	33.41	0.49	282
90	-1.56	4.44	-0.60	1.19	269	32.66	34.86	33.49	0.46	269
100	-1.56	4.45	-0.56	1.23	294	32.41	34.87	33.51	0.47	294
125	-1.56	4.39	-0.25	1.43	277	32.89	34.88	33.71	0.46	277
150	-1.57	4.44	0.20	1.66	260	32.64	34.88	33.86	0.47	260
175	-1.80	4.27	0.50	1.73	232	33.06	34.88	33.98	0.44	232
200	-1.51	4.84	1.01	1.77	230	32.83	34.88	34.10	0.45	230
225	-1.32	4.17	1.79	1.74	163	33.17	34.87	34.31	0.40	163
250	-1.08	4.82	1.60	1.71	30	33.31	34.89	34.19	0.50	30
275	-0.70	4.20	2.07	1.60	23	33.48	34.87	34.34	0.48	23
300	0.02	4.86	2.60	1.32	37	33.72	34.90	34.50	0.40	37
325	0.24	4.35	2.29	1.55	11	33.83	34.88	34.42	0.43	11
350	0.91	4.79	2.60	1.39	10	34.03	34.90	34.52	0.34	10
375	1.17	4.30	2.83	1.11	10	34.11	34.89	34.57	0.31	10
400	1.42	4.74	2.97	1.01	14	34.17	34.90	34.59	0.27	14
425	1.70	4.24	2.99	0.92	10	34.25	34.90	34.62	0.26	10
450	1.93	4.64	3.26	1.02	7	34.31	34.90	34.68	0.26	7
475	2.13	4.09	3.30	0.64	7	34.36	34.89	34.68	0.22	7
500	2.18	4.05	3.42	0.61	7	34.37	34.89	34.76	0.18	7
600	3.42	3.97	3.64	0.23	8	34.72	34.90	34.82	0.06	8
650	3.53	3.84	3.69	0.22	2	34.86	34.90	34.88	0.03	2
700	3.49	3.76	3.69	0.13	4	34.81	34.90	34.87	0.04	4
750	3.46	3.71	3.63	0.12	4	34.78	34.90	34.86	0.05	4
800	3.42	3.68	3.59	0.15	3	34.86	34.90	34.88	0.02	3
850	3.37	3.63	3.54	0.14	3	34.86	34.90	34.88	0.02	3
900	3.42	3.57	3.52	0.08	3	34.87	34.90	34.88	0.02	3
950	3.48	3.53	3.51	0.04	2	34.87	34.90	34.89	0.02	2
1000	3.45	3.53	3.49	0.04	3	34.88	34.90	34.89	0.01	3
1050	3.51	3.51	3.51	0.00	1	34.89	34.89	34.89	0.00	1
1100	3.49	3.49	3.49	0.00	1	34.89	34.89	34.89	0.00	1
1150	3.50	3.50	3.50	0.00	1	34.90	34.90	34.90	0.00	1
1200	3.49	3.49	3.49	0.00	1	34.90	34.90	34.90	0.00	1
1250	3.47	3.47	3.47	0.00	1	34.90	34.90	34.90	0.00	1
1300	3.43	3.43	3.43	0.00	1	34.90	34.90	34.90	0.00	1
1350	-	-	-	-	-	-	-	-	-	-
1400	3.29	3.29	3.29	0.00	1	34.90	34.90	34.90	0.00	1
1450	-	-	-	-	-	-	-	-	-	-
1500	3.21	3.21	3.21	0.00	1	34.90	34.90	34.90	0.00	1

September

Depth (m)	Temperature (^{o}C)					Salinity (psu)				
	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	0.47	10.08	3.79	1.84	88	30.27	34.42	32.43	0.75	88
5	0.90	9.88	2.91	2.00	23	30.30	33.40	32.28	0.69	23
10	0.97	9.52	3.43	1.66	68	30.60	34.11	32.49	0.71	68
15	0.39	8.66	2.81	1.74	29	30.75	33.57	32.38	0.66	29
20	-0.10	7.10	2.72	1.72	71	31.56	34.13	32.71	0.66	71
25	-0.10	6.02	2.26	1.39	49	31.69	34.42	32.48	0.60	49
30	-0.60	7.10	1.99	1.77	61	31.72	34.15	32.75	0.65	61
40	-0.60	4.72	1.74	1.54	33	31.82	33.74	32.68	0.60	33
50	-1.03	5.66	1.38	1.74	78	31.88	34.61	32.95	0.61	78
60	-1.30	5.86	1.30	1.96	34	31.89	34.12	32.96	0.61	34
70	-1.00	6.42	1.05	1.96	29	32.15	34.14	32.94	0.57	29
80	-1.07	5.07	0.75	1.60	31	32.22	34.40	33.00	0.57	31
90	-1.30	3.58	0.36	1.34	26	32.35	34.41	33.07	0.55	26
100	-1.47	5.33	0.44	1.38	68	31.97	34.85	33.34	0.58	68
125	-1.45	5.82	0.48	1.63	37	32.26	34.62	33.25	0.54	37
150	-1.21	4.14	0.98	1.32	67	32.67	34.73	33.67	0.54	67
175	-1.45	3.23	1.03	1.33	36	32.84	34.75	33.65	0.53	36
200	-1.35	4.04	1.62	1.38	59	32.92	34.92	34.01	0.54	59
225	-1.18	3.42	1.82	1.25	26	33.10	34.80	34.01	0.51	26
250	-1.08	4.20	2.20	1.29	44	33.18	34.84	34.21	0.49	44
275	-0.75	3.80	2.10	1.24	18	33.31	34.73	34.13	0.42	18
300	-0.05	4.18	2.88	1.02	36	33.62	34.92	34.48	0.33	36
325	0.36	4.11	3.10	1.00	18	33.82	34.77	34.51	0.27	18
350	0.86	4.25	3.39	0.89	15	33.98	34.77	34.61	0.21	15
375	1.28	3.66	2.67	1.24	3	34.11	34.67	34.44	0.29	3
400	1.43	4.35	3.57	0.61	25	34.15	34.87	34.70	0.17	25
425	1.60	4.35	3.73	0.78	10	34.20	34.84	34.71	0.18	10
450	3.51	4.25	3.93	0.38	3	34.68	34.81	34.75	0.07	3
475	1.85	4.23	3.51	1.13	4	34.27	34.85	34.67	0.27	4
500	3.16	4.18	3.68	0.27	15	34.68	34.90	34.80	0.06	15
600	3.49	3.98	3.71	0.19	8	34.78	34.89	34.82	0.04	8
650	3.39	3.91	3.72	0.29	3	34.68	34.81	34.77	0.08	3
700	3.40	3.94	3.68	0.23	5	34.80	34.84	34.81	0.02	5
750	3.50	3.84	3.70	0.18	3	34.79	34.94	34.84	0.08	3
800	3.40	3.84	3.66	0.15	6	34.81	34.90	34.84	0.03	6
850	3.65	3.77	3.70	0.06	3	34.81	34.83	34.82	0.01	3
900	3.40	3.69	3.55	0.21	2	34.84	34.84	34.84	0.00	2
950	3.67	3.69	3.68	0.01	2	34.82	34.85	34.84	0.02	2
1000	3.40	3.60	3.52	0.09	4	34.84	34.92	34.88	0.05	4
1050	3.61	3.61	3.61	0.00	1	34.84	34.84	34.84	0.00	1
1100	3.40	3.40	3.40	0.00	1	34.86	34.86	34.86	0.00	1
1150	3.64	3.64	3.64	0.00	1	34.85	34.85	34.85	0.00	1
1200	3.40	3.62	3.51	0.10	4	34.85	34.86	34.85	0.01	4
1250	-	-	-	-	-	-	-	-	-	-
1300	3.37	3.40	3.39	0.02	2	34.85	34.88	34.87	0.02	2
1350	-	-	-	-	-	-	-	-	-	-
1400	3.50	3.50	3.50	0.00	1	34.90	34.90	34.90	0.00	1
1450	-	-	-	-	-	-	-	-	-	-
1500	3.30	3.50	3.42	0.11	3	34.87	34.92	34.90	0.03	3

October

Depth (m)	Temperature (^oC) Min	Max	Mean	Std Dev	Total Count	Salinity (psu) Min	Max	Mean	Std Dev	Total Count
0	0.40	5.28	2.30	0.90	259	29.08	34.12	32.61	0.55	259
5	0.54	5.05	2.28	0.80	260	30.54	34.34	32.57	0.49	260
10	0.40	5.06	2.26	0.83	286	30.91	34.34	32.62	0.52	286
15	0.53	5.06	2.23	0.79	261	30.94	34.34	32.62	0.49	261
20	0.40	5.20	2.16	0.87	325	31.04	34.38	32.73	0.53	325
25	0.17	5.72	2.13	0.88	262	31.08	34.41	32.73	0.49	262
30	-0.12	6.04	2.07	0.96	302	31.09	34.41	32.83	0.53	302
40	-0.56	5.95	1.93	0.99	265	31.15	34.43	32.86	0.50	265
50	-0.72	5.40	1.79	1.09	335	31.17	34.45	32.99	0.51	335
60	-1.14	5.32	1.73	1.12	257	31.24	34.46	33.05	0.51	257
70	-1.13	5.21	1.59	1.09	268	31.57	34.48	33.13	0.49	268
80	-1.36	5.07	1.47	1.12	268	31.94	34.52	33.19	0.50	268
90	-1.33	5.37	1.47	1.15	253	32.13	34.64	33.26	0.51	253
100	-1.40	5.24	1.42	1.11	321	32.36	34.68	33.35	0.50	321
125	-1.32	4.73	1.47	1.17	294	32.56	34.71	33.48	0.51	294
150	-1.29	4.59	1.61	1.19	324	32.72	34.74	33.65	0.51	324
175	-1.21	4.62	1.95	1.21	249	32.84	34.78	33.85	0.51	249
200	-0.93	4.66	2.16	1.21	280	32.93	34.80	34.00	0.50	280
225	-0.59	4.70	2.47	1.17	230	32.93	34.83	34.13	0.47	230
250	-0.36	4.73	2.74	1.14	227	33.18	34.86	34.28	0.43	227
275	-0.20	4.82	3.04	1.06	177	33.37	34.87	34.38	0.38	177
300	0.85	4.77	3.23	0.91	183	33.55	34.89	34.49	0.30	183
325	1.39	4.73	3.50	0.81	147	33.64	34.90	34.58	0.24	147
350	1.91	4.71	3.65	0.68	136	34.12	34.90	34.64	0.19	136
375	2.01	4.69	3.75	0.60	126	34.21	34.90	34.68	0.16	126
400	2.24	4.67	3.76	0.54	128	34.36	34.90	34.71	0.13	128
425	2.37	4.82	3.86	0.55	102	34.36	34.90	34.73	0.13	102
450	2.44	4.60	3.88	0.51	91	34.39	34.90	34.74	0.12	91
475	2.71	4.58	3.95	0.44	80	34.40	34.90	34.77	0.11	80
500	2.77	4.67	3.90	0.41	87	34.42	34.91	34.77	0.10	87
600	3.47	4.57	3.97	0.32	52	34.62	34.92	34.82	0.07	52
650	3.50	4.39	4.00	0.31	39	34.66	34.90	34.82	0.06	39
700	3.48	4.34	3.95	0.28	35	34.67	34.90	34.83	0.05	35
750	3.47	4.32	3.99	0.27	29	34.72	34.90	34.85	0.03	29
800	3.49	4.29	3.89	0.26	31	34.79	34.90	34.85	0.03	31
850	3.46	4.30	3.90	0.27	26	34.77	34.90	34.85	0.03	26
900	3.42	4.21	3.82	0.26	20	34.81	34.89	34.86	0.02	20
950	3.37	4.21	3.78	0.25	19	34.82	34.89	34.86	0.02	19
1000	3.32	4.11	3.72	0.23	19	34.81	34.90	34.85	0.02	19
1050	3.27	4.05	3.66	0.23	16	34.84	34.89	34.86	0.02	16
1100	3.25	3.98	3.64	0.21	16	34.84	34.89	34.86	0.02	16
1150	3.25	3.95	3.55	0.18	17	34.84	34.88	34.86	0.02	17
1200	3.24	3.95	3.55	0.20	15	34.84	34.88	34.86	0.01	15
1250	3.23	3.75	3.42	0.17	10	34.85	34.89	34.87	0.02	10
1300	3.17	3.73	3.37	0.20	9	34.85	34.89	34.86	0.02	9
1350	3.20	3.70	3.44	0.20	8	34.85	34.89	34.87	0.02	8
1400	3.22	3.72	3.45	0.20	8	34.84	34.89	34.87	0.02	8
1450	3.20	3.57	3.33	0.21	3	34.85	34.89	34.87	0.02	3
1500	3.41	3.46	3.44	0.04	2	34.85	34.88	34.87	0.02	2

November

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-0.75	2.79	0.69	0.80	175	31.08	34.18	32.57	0.42	175
5	-0.25	3.75	1.02	0.73	222	30.23	34.28	32.53	0.45	222
10	-0.56	3.77	1.03	0.81	204	30.38	34.28	32.59	0.46	204
15	-0.02	3.71	1.15	0.71	170	30.80	33.85	32.58	0.42	170
20	-0.51	4.56	1.01	0.82	204	31.40	34.28	32.65	0.42	204
25	-0.55	5.23	1.12	0.76	171	31.56	33.98	32.65	0.39	171
30	-0.52	5.45	1.01	0.83	212	31.68	34.28	32.71	0.41	212
40	-0.16	5.49	1.07	0.81	178	31.96	34.28	32.73	0.41	178
50	-0.56	5.05	0.98	0.91	218	32.04	34.28	32.84	0.41	218
60	-0.38	4.40	1.10	0.85	183	32.06	34.28	32.88	0.41	183
70	-0.39	3.78	1.05	0.80	194	32.09	34.28	32.95	0.42	194
80	-0.45	3.78	1.05	0.80	187	32.09	34.28	33.00	0.41	187
90	-0.57	3.79	1.00	0.83	186	32.11	34.29	33.04	0.42	186
100	-0.70	3.85	0.96	0.86	215	32.15	34.36	33.15	0.42	215
125	-0.84	4.08	1.01	0.95	252	32.16	34.69	33.25	0.42	252
150	-1.32	4.12	1.11	1.07	252	32.27	34.71	33.45	0.44	252
175	-1.32	4.79	1.32	1.15	211	32.59	34.76	33.57	0.45	211
200	-1.05	4.84	1.63	1.20	217	32.81	34.81	33.77	0.46	217
225	-0.91	4.74	1.86	1.22	168	33.01	34.87	33.91	0.45	168
250	-0.84	4.83	2.14	1.21	170	33.11	34.87	34.05	0.44	170
275	-0.52	4.81	2.38	1.24	138	33.21	34.89	34.18	0.40	138
300	0.00	4.80	2.75	1.26	98	33.47	34.90	34.31	0.39	98
325	0.26	4.76	2.84	1.24	90	33.77	34.91	34.39	0.32	90
350	0.73	4.78	3.27	1.15	70	33.96	34.90	34.52	0.29	70
375	1.37	4.76	3.42	1.08	63	34.12	34.91	34.58	0.25	63
400	1.47	4.71	3.59	0.94	69	34.02	34.91	34.64	0.24	69
425	1.88	4.65	3.64	0.92	57	34.26	34.90	34.66	0.22	57
450	2.04	4.65	3.76	0.83	51	34.30	34.91	34.69	0.20	51
475	2.04	4.57	3.69	0.90	41	34.33	34.90	34.68	0.21	41
500	2.13	4.55	3.80	0.74	48	34.36	34.91	34.73	0.18	48
600	3.31	4.46	4.06	0.31	36	34.72	34.95	34.85	0.06	36
650	3.76	4.40	4.19	0.20	20	34.73	34.97	34.88	0.04	20
700	3.65	4.35	4.14	0.19	19	34.81	34.90	34.87	0.03	19
750	3.60	4.32	4.06	0.21	20	34.81	34.98	34.88	0.04	20
800	3.52	4.31	3.97	0.22	24	34.82	34.97	34.88	0.03	24
850	3.85	4.31	4.04	0.12	16	34.83	34.90	34.88	0.02	16
900	3.66	4.18	3.93	0.14	16	34.76	34.90	34.87	0.03	16
950	3.70	4.16	3.87	0.13	14	34.84	34.90	34.88	0.01	14
1000	3.33	4.06	3.79	0.18	15	34.85	34.90	34.88	0.01	15
1050	3.49	3.99	3.78	0.14	11	34.87	34.90	34.88	0.01	11
1100	3.65	3.94	3.75	0.11	11	34.85	34.90	34.88	0.01	11
1150	3.47	3.87	3.69	0.11	12	34.85	34.89	34.88	0.01	12
1200	3.20	3.82	3.59	0.17	11	34.86	34.89	34.88	0.01	11
1250	3.53	3.80	3.64	0.11	6	34.87	34.89	34.88	0.01	6
1300	3.29	3.74	3.52	0.18	5	34.86	34.89	34.88	0.01	5
1350	3.29	3.70	3.50	0.16	5	34.85	34.90	34.88	0.02	5
1400	3.45	3.66	3.57	0.11	3	34.87	34.90	34.89	0.02	3
1450	3.16	3.64	3.44	0.21	4	34.86	34.90	34.88	0.02	4
1500	3.36	3.62	3.51	0.14	3	34.89	34.91	34.90	0.01	3

December

	Temperature (^{o}C)					Salinity (psu)				
Depth (m)	Min	Max	Mean	Std Dev	Total Count	Min	Max	Mean	Std Dev	Total Count
0	-1.77	1.29	-0.28	0.78	162	30.63	34.05	32.81	0.41	162
5	-0.86	1.13	0.08	0.51	95	31.90	33.67	32.73	0.28	95
10	-1.80	1.24	-0.19	0.68	150	32.07	34.05	32.86	0.35	150
15	-0.86	1.28	0.10	0.50	94	32.21	33.76	32.77	0.29	94
20	-1.77	1.29	-0.16	0.73	153	32.19	34.08	32.92	0.39	153
25	-0.84	1.55	0.17	0.50	98	32.37	34.06	32.81	0.31	98
30	-1.71	1.67	-0.02	0.70	145	32.30	34.11	32.96	0.40	145
40	-0.79	2.10	0.27	0.53	95	32.42	34.27	32.88	0.36	95
50	-1.78	2.36	0.12	0.75	145	32.33	34.31	33.07	0.44	145
60	-0.64	2.77	0.40	0.61	96	32.47	34.36	32.96	0.40	96
70	-0.62	3.00	0.48	0.68	95	32.51	34.42	33.00	0.43	95
80	-0.59	3.12	0.55	0.71	98	32.54	34.47	33.04	0.44	98
90	-0.58	3.24	0.63	0.74	100	32.54	34.49	33.09	0.46	100
100	-1.44	3.34	0.58	0.89	166	32.54	34.52	33.26	0.51	166
125	-0.90	3.61	0.95	0.88	101	32.58	34.60	33.27	0.50	101
150	-1.46	3.78	1.15	1.05	158	32.61	34.65	33.55	0.53	158
175	-0.52	4.08	1.45	1.08	89	32.64	34.71	33.59	0.51	89
200	-1.76	4.11	1.76	1.21	136	32.72	34.77	33.87	0.53	136
225	-0.09	4.29	2.09	1.17	74	32.89	34.80	33.90	0.53	74
250	-0.07	4.22	2.37	1.13	109	32.96	34.84	34.15	0.48	109
275	0.28	4.23	2.62	1.08	56	33.06	34.85	34.16	0.48	56
300	0.54	4.22	2.89	0.97	80	33.40	34.86	34.38	0.40	80
325	0.88	4.24	2.91	1.00	39	33.49	34.87	34.32	0.41	39
350	1.30	4.28	3.10	0.85	37	33.80	34.90	34.44	0.32	37
375	1.67	4.40	3.27	0.80	36	33.94	34.93	34.52	0.30	36
400	2.20	4.40	3.52	0.59	59	34.23	34.94	34.65	0.21	59
425	2.42	4.41	3.51	0.61	32	34.32	34.94	34.63	0.20	32
450	2.76	4.32	3.57	0.57	27	34.34	34.93	34.66	0.19	27
475	2.81	4.39	3.65	0.52	26	34.37	34.93	34.69	0.18	26
500	2.86	4.52	3.80	0.36	41	34.40	34.94	34.77	0.13	41
600	3.42	4.33	3.95	0.19	30	34.71	34.94	34.85	0.06	30
650	3.91	4.25	4.09	0.10	8	34.78	34.95	34.90	0.05	8
700	3.99	4.18	4.07	0.07	7	34.89	34.95	34.91	0.03	7
750	3.84	4.07	3.99	0.08	9	34.84	34.95	34.89	0.04	9
800	3.60	4.04	3.87	0.14	19	34.82	34.96	34.88	0.04	19
850	3.75	4.00	3.91	0.08	8	34.82	34.95	34.90	0.04	8
900	3.80	3.97	3.90	0.05	9	34.83	34.95	34.89	0.04	9
950	3.72	3.95	3.83	0.07	8	34.85	34.95	34.91	0.03	8
1000	3.46	3.90	3.69	0.13	15	34.85	35.03	34.90	0.05	15
1050	3.45	3.87	3.73	0.15	6	34.87	34.95	34.90	0.03	6
1100	3.70	3.84	3.74	0.06	5	34.88	34.95	34.90	0.03	5
1150	3.38	3.70	3.61	0.13	5	34.86	34.95	34.90	0.03	5
1200	3.46	3.67	3.59	0.08	5	34.89	34.95	34.91	0.03	5
1250	3.54	3.64	3.60	0.05	3	34.88	34.95	34.91	0.04	3
1300	3.40	3.60	3.49	0.09	5	34.88	34.95	34.90	0.03	5
1350	3.46	3.56	3.51	0.05	3	34.88	34.94	34.90	0.03	3
1400	3.43	3.51	3.48	0.05	3	34.88	34.95	34.91	0.04	3
1450	3.46	3.49	3.48	0.02	2	34.89	34.89	34.89	0.00	2
1500	-	-	-	-	-	-	-	-	-	-

Appendix 2

Significant Wave Height versus Peak Period, MSC50 Climatology Grid Point M3013763 on the Labrador Shelf

Overall Statistics

Tp (s)	Hs (m)							
	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	1073	0	0	0	0	0	1073	1.1
4-6	18146	713	0	0	0	0	18859	19.3
6-8	21101	11473	35	0	0	0	32609	33.4
8-10	12101	8555	1833	15	0	0	22504	23.1
10-12	4495	7867	2831	461	31	0	15685	16.1
12-14	1499	1510	1282	532	242	40	5105	5.2
14-18	463	648	446	166	28	8	1759	1.8
Total	58878	30766	6427	1174	301	48	97594	100
% Exceed	39.7	8.1	1.6	0.4	0.0	0.0	0.0	0.0

January

Tp (s)	Hs (m)							
	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	6	0	0	0	0	0	6	0.1
4-6	284	66	0	0	0	0	350	7.1
6-8	270	821	4	0	0	0	1095	22.1
8-10	235	463	218	0	0	0	916	18.5
10-12	197	861	417	61	11	0	1547	31.2
12-14	81	280	248	87	44	14	754	15.2
14-18	31	137	87	30	7	0	292	5.9
Total	1104	2628	974	178	62	14	4960	100
% Exceed	77.7	24.8	5.1	1.5	0.3	0.0	0.0	0.0

February

Tp (s)	Hs (m)							
	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	1	0	0	0	0	0	1	0.1
4-6	48	3	0	0	0	0	51	4.5
6-8	57	75	1	0	0	0	133	11.7
8-10	91	155	40	0	0	0	286	25.2
10-12	50	218	77	26	0	0	371	32.7
12-14	36	61	49	33	39	0	218	19.2
14-18	8	42	21	4	1	0	76	6.7
Total	291	554	188	63	40	0	1136	100
% Exceed	74.4	25.6	9.1	3.5	0.0	0.0	0.0	0.0

March

Tp (s)	Hs (m)							
	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	3	0	0	0	0	0	3	0.2
4-6	92	2	0	0	0	0	94	6.3
6-8	121	127	0	0	0	0	248	16.7
8-10	125	239	28	0	0	0	392	26.4
10-12	90	309	128	11	0	0	538	36.2
12-14	35	34	20	9	0	0	98	6.6
14-18	15	57	19	17	5	0	113	7.6
Total	481	768	195	37	5	0	1486	100
% Exceed	67.6	15.9	2.8	0.3	0.0	0.0	0.0	0.0

April

Tp (s)	Hs (m)							
	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	32	0	0	0	0	0	32	1.1
4-6	279	15	0	0	0	0	294	10.2
6-8	514	235	0	0	0	0	749	26.0
8-10	542	454	39	0	0	0	1035	36.0
10-12	179	299	139	9	0	0	626	21.8
12-14	28	17	19	9	7	0	80	2.8
14-18	14	28	10	7	2	0	61	2.1
Total	1588	1048	207	25	9	0	2877	100
% Exceed	44.8	8.4	1.2	0.3	0.0	0.0	0.0	0.0

May

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	129	0	0	0	0	0	129	2.3
4-6	931	15	0	0	0	0	946	16.6
6-8	1503	319	0	0	0	0	1822	31.9
8-10	1399	527	21	0	0	0	1947	34.1
10-12	396	298	42	7	0	0	743	13.0
12-14	67	34	4	4	0	0	109	1.9
14-18	8	0	0	0	0	0	8	0.1
Total	4433	1193	67	11	0	0	5704	100
% Exceed	22.3	1.4	0.2	0.0	0.0	0.0	0.0	0.0

June

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	181	0	0	0	0	0	181	1.9
4-6	2224	20	0	0	0	0	2244	24.0
6-8	3032	534	0	0	0	0	3566	38.1
8-10	1916	491	25	0	0	0	2432	26.0
10-12	500	186	67	1	0	0	754	8.1
12-14	114	1	1	4	0	0	120	1.3
14-18	58	3	0	0	0	0	61	0.7
Total	8025	1235	93	5	0	0	9358	100
% Exceed	14.2	1.0	0.1	0.0	0.0	0.0	0.0	0.0

July

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	327	0	0	0	0	0	327	2.8
4-6	3883	8	0	0	0	0	3891	33.4
6-8	4598	370	0	0	0	0	4968	42.6
8-10	1435	323	2	0	0	0	1760	15.1
10-12	373	97	9	0	0	0	479	4.1
12-14	192	1	0	0	0	0	193	1.7
14-18	35	0	0	0	0	0	35	0.3
Total	10843	799	11	0	0	0	11653	100
% Exceed	7.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

August

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	276	0	0	0	0	0	276	2.2
4-6	4044	21	0	0	0	0	4065	32.1
6-8	4588	661	0	0	0	0	5249	41.5
8-10	1657	411	8	0	0	0	2076	16.4
10-12	493	152	27	0	0	0	672	5.3
12-14	214	14	0	0	0	0	228	1.8
14-18	77	2	0	0	0	0	79	0.6
Total	11349	1261	35	0	0	0	12645	100
% Exceed	10.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0

September

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	63	0	0	0	0	0	63	0.5
4-6	2567	112	0	0	0	0	2679	21.5
6-8	3070	1513	1	0	0	0	4584	36.7
8-10	1958	1055	94	2	0	0	3109	24.9
10-12	722	667	105	15	2	0	1511	12.1
12-14	250	124	40	28	12	0	454	3.6
14-18	38	41	1	0	0	0	80	0.6
Total	8668	3512	241	45	14	0	12480	100
% Exceed	30.5	2.4	0.5	0.1	0.0	0.0	0.0	0.0

October

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	31	0	0	0	0	0	31	0.2
4-6	1838	155	0	0	0	0	1993	15.5
6-8	1694	2323	6	0	0	0	4023	31.2
8-10	1409	1648	263	0	0	0	3320	25.7
10-12	622	1582	395	62	0	0	2661	20.6
12-14	225	185	179	51	19	11	670	5.2
14-18	87	77	16	15	3	0	198	1.5
Total	5906	5970	859	128	22	11	12896	100
% Exceed	54.2	7.9	1.2	0.3	0.1	0.0	0.0	0.0

November

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	15	0	0	0	0	0	15	0.1
4-6	1327	159	0	0	0	0	1486	11.9
6-8	1099	2508	11	0	0	0	3618	29.0
8-10	880	1533	580	5	0	0	2998	24.0
10-12	550	1740	647	133	9	0	3079	24.7
12-14	148	378	290	113	50	3	982	7.9
14-18	70	96	93	29	6	8	302	2.4
Total	4089	6414	1621	280	65	11	12480	100
% Exceed	67.2	15.8	2.9	0.6	0.1	0.0	0.0	0.0

December

	Hs (m)							
Tp (s)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
0-2	0	0	0	0	0	0	0	0.0
2-4	9	0	0	0	0	0	9	0.1
4-6	629	137	0	0	0	0	766	7.7
6-8	555	1987	12	0	0	0	2554	25.7
8-10	454	1256	515	8	0	0	2233	22.5
10-12	323	1458	778	136	9	0	2704	27.3
12-14	109	381	432	194	71	12	1199	12.1
14-18	22	165	199	64	4	0	454	4.6
Total	2101	5384	1936	402	84	12	9919	100
% Exceed	78.8	24.5	5.0	1.0	0.1	0.0	0.0	0.0

Appendix 3

Significant Wave Height versus Direction, MSC50 Climatology Grid Point M3013763 on the Labrador Shelf

Overall Statistics

Direction (from)	Hs (m) 0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	6557	5172	1532	342	126	17	13746	14.1
NNE	5872	2987	657	168	55	4	9743	10.0
NE	4290	2036	364	74	8	0	6772	6.9
ENE	4200	2163	541	126	15	3	7048	7.2
E	5615	2389	678	167	18	0	8867	9.1
ESE	6290	1764	270	32	2	0	8358	8.6
SE	5714	1174	145	9	0	0	7042	7.2
SSE	3243	1018	128	0	0	0	4389	4.5
S	2187	691	55	0	0	0	2933	3.0
SSW	1898	537	48	0	0	0	2483	2.5
SW	1713	625	32	0	0	0	2370	2.4
WSW	1550	724	51	2	0	0	2327	2.4
W	1480	1098	107	4	0	0	2689	2.8
WNW	1677	1731	244	28	4	0	3684	3.8
NW	2498	2525	498	49	20	1	5591	5.7
NNW	4094	4133	1077	173	53	23	9553	9.8
Total	58878	30767	6427	1174	301	48	97595	100.0
% Exceed	39.7	8.2	1.6	0.4	0.1	0.0	0.0	0.0

January

Direction (from)	Hs (m) 0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	170	438	207	56	19	9	899	18.1
NNE	98	230	92	30	11	0	461	9.3
NE	66	187	31	6	3	0	293	5.9
ENE	69	164	91	19	4	0	347	7.0
E	39	165	121	43	8	0	376	7.6
ESE	46	130	47	5	2	0	230	4.6
SE	51	80	30	4	0	0	165	3.3
SSE	32	62	34	0	0	0	128	2.6
S	50	45	23	0	0	0	118	2.4
SSW	37	42	11	0	0	0	90	1.8
SW	28	33	6	0	0	0	67	1.4
WSW	34	64	10	0	0	0	108	2.2
W	45	83	15	0	0	0	143	2.9
WNW	72	143	20	0	0	0	235	4.7
NW	93	236	48	0	0	0	377	7.6
NNW	174	526	188	15	15	5	923	18.6
Total	1104	2628	974	178	62	14	4960	100.0
% Exceed	77.7	24.8	5.1	1.5	0.3	0.0	0.0	0.0

February

Direction (from)	Hs (m) 0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	56	167	62	37	28	0	350	30.8
NNE	56	95	45	9	12	0	217	19.1
NE	36	57	23	12	0	0	128	11.3
ENE	15	56	26	4	0	0	101	8.9
E	8	33	3	0	0	0	44	3.9
ESE	7	27	1	0	0	0	35	3.1
SE	17	9	0	0	0	0	26	2.3
SSE	4	6	0	0	0	0	10	0.9
S	2	4	0	0	0	0	6	0.5
SSW	7	3	0	0	0	0	10	0.9
SW	3	0	0	0	0	0	3	0.3
WSW	8	0	1	0	0	0	9	0.8
W	14	4	7	0	0	0	25	2.2
WNW	14	11	3	0	0	0	28	2.5
NW	15	17	5	0	0	0	37	3.3
NNW	29	65	12	1	0	0	107	9.4
Total	291	554	188	63	40	0	1136	100.0
% Exceed	74.4	25.6	9.1	3.5	0.0	0.0	0.0	0.0

March

	Hs (m)							
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	75	179	57	0	0	0	311	20.9
NNE	67	172	41	12	0	0	292	19.6
NE	71	101	19	5	0	0	196	13.2
ENE	65	63	4	9	0	0	141	9.5
E	57	105	59	9	5	0	235	15.8
ESE	31	37	5	0	0	0	73	4.9
SE	10	1	0	0	0	0	11	0.7
SSE	4	1	0	0	0	0	5	0.3
S	1	3	0	0	0	0	4	0.3
SSW	3	4	0	0	0	0	7	0.5
SW	17	9	0	0	0	0	26	1.8
WSW	14	4	0	0	0	0	18	1.2
W	13	6	0	0	0	0	19	1.3
WNW	9	3	0	0	0	0	12	0.8
NW	19	11	0	0	0	0	30	2.0
NNW	25	69	10	2	0	0	106	7.1
Total	481	768	195	37	5	0	1486	100.0
% Exceed	67.6	15.9	2.8	0.3	0.0	0.0	0.0	0.0

April

	Hs (m)							
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	238	229	77	7	7	0	558	19.4
NNE	326	243	44	0	0	0	613	21.3
NE	237	113	32	0	0	0	382	13.3
ENE	158	143	27	0	0	0	328	11.4
E	126	113	18	9	2	0	268	9.3
ESE	61	55	5	5	0	0	126	4.4
SE	61	16	0	0	0	0	77	2.7
SSE	47	2	0	0	0	0	49	1.7
S	38	7	0	0	0	0	45	1.6
SSW	40	6	0	0	0	0	46	1.6
SW	45	5	0	0	0	0	50	1.7
WSW	18	3	0	0	0	0	21	0.7
W	16	12	0	0	0	0	28	1.0
WNW	29	20	0	0	0	0	49	1.7
NW	38	22	2	0	0	0	62	2.2
NNW	110	59	2	4	0	0	175	6.1
Total	1588	1048	207	25	9	0	2877	100.0
% Exceed	44.8	8.4	1.2	0.3	0.0	0.0	0.0	0.0

May

	Hs (m)							
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	545	213	8	11	0	0	777	13.6
NNE	628	177	14	0	0	0	819	14.4
NE	386	88	1	0	0	0	475	8.3
ENE	294	142	12	0	0	0	448	7.8
E	532	180	5	0	0	0	717	12.6
ESE	600	157	1	0	0	0	758	13.3
SE	462	56	2	0	0	0	520	9.1
SSE	219	9	0	0	0	0	228	4.0
S	186	19	0	0	0	0	205	3.6
SSW	126	12	0	0	0	0	138	2.4
SW	67	6	0	0	0	0	73	1.3
WSW	53	4	0	0	0	0	57	1.0
W	35	6	0	0	0	0	41	0.7
WNW	43	6	0	0	0	0	49	0.9
NW	63	19	1	0	0	0	83	1.5
NNW	194	99	23	0	0	0	316	5.5
Total	4433	1193	67	11	0	0	5704	100.0
% Exceed	22.3	1.4	0.2	0.0	0.0	0.0	0.0	0.0

June

			Hs (m)					
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	744	236	29	5	0	0	1014	10.8
NNE	780	152	0	0	0	0	932	10.0
NE	738	139	18	0	0	0	895	9.6
ENE	710	129	19	0	0	0	858	9.2
E	1217	167	16	0	0	0	1400	15.0
ESE	1190	112	3	0	0	0	1305	13.9
SE	860	64	0	0	0	0	924	9.9
SSE	501	50	0	0	0	0	551	5.9
S	239	9	0	0	0	0	248	2.6
SSW	207	9	0	0	0	0	216	2.3
SW	127	5	0	0	0	0	132	1.4
WSW	76	3	0	0	0	0	79	0.8
W	58	4	0	0	0	0	62	0.7
WNW	80	11	0	0	0	0	91	1.0
NW	183	49	0	0	0	0	232	2.5
NNW	315	96	8	0	0	0	419	4.5
Total	8025	1235	93	5	0	0	9358	100.0
% Exceed	14.2	1.1	0.1	0.0	0.0	0.0	0.0	0.0

July

			Hs (m)					
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	751	120	2	0	0	0	873	7.5
NNE	887	63	0	0	0	0	950	8.2
NE	678	74	2	0	0	0	754	6.5
ENE	951	152	0	0	0	0	1103	9.5
E	1241	113	0	0	0	0	1354	11.6
ESE	1851	56	0	0	0	0	1907	16.4
SE	1704	74	0	0	0	0	1778	15.3
SSE	870	31	0	0	0	0	901	7.7
S	452	9	0	0	0	0	461	4.0
SSW	298	2	0	0	0	0	300	2.6
SW	224	3	0	0	0	0	227	2.0
WSW	121	4	0	0	0	0	125	1.1
W	89	2	0	0	0	0	91	0.8
WNW	93	10	0	0	0	0	103	0.9
NW	230	26	0	0	0	0	256	2.2
NNW	403	60	7	0	0	0	470	4.0
Total	10843	799	11	0	0	0	11653	100.0
% Exceed	7.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0

August

			Hs (m)					
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	1157	225	20	0	0	0	1402	11.1
NNE	1066	123	0	0	0	0	1189	9.4
NE	758	77	0	0	0	0	835	6.6
ENE	820	123	0	0	0	0	943	7.5
E	1264	149	0	0	0	0	1413	11.2
ESE	1333	81	0	0	0	0	1414	11.2
SE	1306	42	0	0	0	0	1348	10.7
SSE	701	40	0	0	0	0	741	5.9
S	398	17	0	0	0	0	415	3.3
SSW	359	17	0	0	0	0	376	3.0
SW	349	14	0	0	0	0	363	2.9
WSW	227	11	0	0	0	0	238	1.9
W	189	9	0	0	0	0	198	1.6
WNW	227	23	0	0	0	0	250	2.0
NW	448	68	3	0	0	0	519	4.1
NNW	747	242	12	0	0	0	1001	7.9
Total	11349	1261	35	0	0	0	12645	100.0
% Exceed	10.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0

September

	Hs (m)							
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	1142	611	78	26	8	0	1865	14.9
NNE	904	332	19	3	0	0	1258	10.1
NE	626	276	20	3	0	0	925	7.4
ENE	553	267	7	5	0	0	832	6.7
E	539	246	2	0	0	0	787	6.3
ESE	573	188	7	0	0	0	768	6.2
SE	602	131	4	0	0	0	737	5.9
SSE	424	135	1	0	0	0	560	4.5
S	445	83	3	0	0	0	531	4.3
SSW	372	53	2	0	0	0	427	3.4
SW	323	59	0	0	0	0	382	3.1
WSW	317	84	2	0	0	0	403	3.2
W	270	166	6	0	0	0	442	3.5
WNW	334	204	9	1	0	0	548	4.4
NW	478	223	29	1	1	0	732	5.9
NNW	766	454	52	6	5	0	1283	10.3
Total	8668	3512	241	45	14	0	12480	100.0
% Exceed	30.5	2.4	0.5	0.1	0.0	0.0	0.0	0.0

October

	Hs (m)							
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	810	1105	262	43	8	7	2235	17.3
NNE	540	478	54	9	1	1	1083	8.4
NE	339	260	37	13	0	0	649	5.0
ENE	263	293	45	20	0	0	621	4.8
E	340	368	44	14	3	0	769	6.0
ESE	332	316	28	0	0	0	676	5.2
SE	327	254	21	2	0	0	604	4.7
SSE	221	257	18	0	0	0	496	3.9
S	177	178	4	0	0	0	359	2.8
SSW	218	102	1	0	0	0	321	2.5
SW	240	165	4	0	0	0	409	3.2
WSW	312	159	5	0	0	0	476	3.7
W	324	232	13	0	0	0	569	4.4
WNW	347	302	39	0	0	0	688	5.3
NW	467	621	72	7	1	0	1168	9.1
NNW	649	880	212	20	9	3	1773	13.8
Total	5906	5970	859	128	22	11	12896	100.0
% Exceed	54.2	7.9	1.3	0.3	0.1	0.0	0.0	0.0

November

	Hs (m)							
Direction (from)	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	534	935	326	53	23	0	1871	15.0
NNE	293	478	163	48	16	3	1001	8.0
NE	239	356	104	21	0	0	720	5.8
ENE	189	304	154	28	8	3	686	5.5
E	181	352	128	27	0	0	688	5.5
ESE	201	347	79	14	0	0	641	5.1
SE	234	235	28	0	0	0	497	4.0
SSE	173	281	26	0	0	0	480	3.9
S	149	191	13	0	0	0	353	2.8
SSW	173	172	22	0	0	0	367	2.9
SW	206	204	7	0	0	0	417	3.3
WSW	259	206	13	0	0	0	478	3.8
W	263	320	34	2	0	0	619	5.0
WNW	282	567	103	15	3	0	970	7.8
NW	279	631	187	22	8	0	1127	9.0
NNW	434	835	234	50	7	5	1565	12.5
Total	4089	6414	1621	280	65	11	12480	100.0
% Exceed	67.2	15.8	2.9	0.6	0.1	0.0	0.0	0.0

December

Direction (from)	Hs (m)							
	0-2	2-4	4-6	6-8	8-10	10-12	Total	% Total
N	335	714	404	104	33	1	1591	16.0
NNE	227	444	185	57	15	0	928	9.3
NE	116	308	77	14	5	0	520	5.2
ENE	113	327	156	41	3	0	640	6.5
E	71	398	282	65	0	0	816	8.2
ESE	65	258	94	8	0	0	425	4.3
SE	80	212	60	3	0	0	355	3.6
SSE	47	144	49	0	0	0	240	2.4
S	50	126	12	0	0	0	188	1.9
SSW	58	115	12	0	0	0	185	1.9
SW	84	122	15	0	0	0	221	2.2
WSW	111	182	20	2	0	0	315	3.2
W	164	254	32	2	0	0	452	4.6
WNW	147	431	70	12	1	0	661	6.7
NW	185	602	151	19	10	1	968	9.8
NNW	248	748	317	75	17	10	1415	14.3
Total	2101	5385	1936	402	84	12	9920	100.0
% Exceed	78.8	24.5	5.0	1.0	0.1	0.0	0.0	0.0

Appendix 3

Current Records (BIO Ocean Data Inventory Database, 2009)

Event_Spec	Event ID	Inst.	Latitude	Longitude	Start	End	Min Inst. depth	Max Inst. depth	Sounding	Sampling
MCM_76002_107_1953_600	25875	AANDERAA	56.3616	-56.7683	2/3/1976	1/4/1976	2340	2340	0	600
MCM_80996_1_3013_600	26603	AANDERAA	55.8167	-58.45	4/8/1980	9/10/1980	477	477	0	600
MCM_80996_1_3015_600	26604	AANDERAA	55.8167	-58.45	4/8/1980	30/09/1980	246	246	0	600
MCM_80998_73_3691_3600	26691	RCM-4	56.042	-57.0697	4/7/1980	12/9/1980	101	101	706	3600
MCM_80998_73_4076_3600	26692	RCM-4	56.042	-57.0697	4/7/1980	12/9/1980	200.1	200.1	706	3600
MCM_80998_73_4077_3600	26693	RCM-4	56.042	-57.0697	4/7/1980	12/9/1980	656	656	706	3600
MCM_83910_649_1702_900	27287	AANDERAA	56.4822	-58.1636	20/07/1983	14/10/1983	50	50	340	900
MCM_83910_650_1705_900	27288	AANDERAA	56.2761	-58.3225	20/07/1983	14/10/1983	50	50	350	900
MCM_83910_650_1709_900	27289	AANDERAA	56.2761	-58.3225	20/07/1983	14/10/1983	285	285	350	900
MCM_83910_651_3670_900	27290	AANDERAA	56.2778	-58.4869	20/07/1983	13/10/1983	50	50	350	900
MCM_83910_651_3679_900	27291	AANDERAA	56.2778	-58.4869	20/07/1983	13/10/1983	285	285	350	900
MCM_83910_652_3695_900	27292	AANDERAA	56.1419	-59.1536	18/07/1983	13/10/1983	50	50	350	900
MCM_83910_652_4075_900	27293	AANDERAA	56.1419	-59.1536	18/07/1983	13/10/1983	285	285	350	900
MCM_83910_653_4240_900	27294	AANDERAA	56.1819	-58.3492	17/07/1983	14/10/1983	50	50	415	900
MCM_83910_653_4294_900	27295	AANDERAA	56.1819	-58.3492	17/07/1983	14/10/1983	285	285	415	900
MCM_83910_653_6068_900	27296	AANDERAA	56.1819	-58.3492	17/07/1983	14/10/1983	385	385	415	900
MCM_83910_654_6070_900	27297	AANDERAA	55.9278	-57.9086	17/07/1983	12/10/1983	50	50	325	900
MCM_83910_654_6071_900	27298	AANDERAA	55.9278	-57.9086	17/07/1983	12/10/1983	285	285	325	900
MCM_76002_107_1953_600	25875	AANDERAA	56.3616	-56.7683	2/3/1976	1/4/1976	2340	2340	0	600
MCM_83943_1_6072_1200	27465	AANDERAA	55.9994	-58.1322	17/07/1983	17/10/1983	44	44	438	1200
MCM_83943_1_6072_3600	27466	AANDERAA	55.9994	-58.1322	17/07/1983	17/10/1983	44	44	438	3600
MADCPS_HUD2002075_1466_511-35_3600	32363	ADCP	55.408	-58.0591	2/12/2002	22/07/2003	31.6	35.6	98.7	3600
MADCPS_HUD2002075_1466_511-63_3600	32361	ADCP	55.408	-58.0591	2/12/2002	22/07/2003	59.6	63.6	98.7	3600
MADCPS_HUD2002075_1466_511-91_3600	32362	ADCP	55.408	-58.0591	2/12/2002	22/07/2003	87.6	91.6	98.7	3600
MCM_76018_164_30_600	25902	HYDROW	55.1171	-58.9335	1/9/1976	30/09/1976	5	5	0	600
MCM_79019_352_4299_300	30172	AANDERAA	55.4638	-57.6925	15/08/1979	25/08/1979	138	138	139	300
MCM_80998_4_3679_900	26619	AANDERAA	55.6077	-57.7902	3/7/1980	12/9/1980	55.1	55.1	0	900
MCM_80998_4_4075_900	26620	AANDERAA	55.6077	-57.7902	4/7/1980	12/9/1980	144.7	144.7	0	900
MCM_80998_71_4240_3600	26632	RCM-4	55.0833	-58.099	3/7/1980	12/9/1980	63.4	63.4	274	3600
MCM_80998_71_4294_3600	26696	RCM-4	55.0833	-58.099	3/7/1980	12/9/1980	160.5	160.5	274	3600
MCM_80998_7_2501092_120	26694	NEIL BROWN	55.609	-57.7775	4/7/1980	12/9/1980	25	25	0	120
MCM_81996_6_92_180	26705	NEIL BROWN	55.609	-57.778	22/06/1981	6/10/1981	20	20	0	180
MCM_83939_1_1241_1200	27450	N BROWN	55.8091	-58.8467	23/07/1983	16/08/1983	11	11	575	1200
MCM_83939_1_6141_1200	27451	AANDERAA	55.8091	-58.8467	17/07/1983	17/08/1983	292	292	575	1200
MCM_83939_1_6227_1200	27452	AANDERAA	55.8091	-58.8467	17/07/1983	17/08/1983	565	565	575	1200
MCM_80998_2_3673_900	26611	AANDERAA	54.6232	-56.1285	6/7/1980	16/09/1980	58.3	58.3	0	900
MCM_80998_2_3701_900	26612	AANDERAA	54.6232	-56.1285	6/7/1980	16/09/1980	156.1	156.1	0	900
MCM_80998_3_4221_900	26613	AANDERAA	54.856	-55.7982	6/7/1980	6/10/1980	269.1	269.1	0	900
MCM_80998_53_3681_3600	26624	RCM-4	55.0173	-55.1013	11/7/1980	13/09/1980	274.3	274.3	326	3600
MCM_80998_53_4245_3600	26626	RCM-4	55.0173	-55.1013	11/7/1980	13/09/1980	157.5	157.5	326	3600
MCM_80998_8_2501091_120	26695	NEIL BROWN	54.8618	-55.7872	6/7/1980	6/10/1980	30.5	30.5	0	120
MCM_81996_5_4240_1200	26704	AANDERAA	54.42	-55.248	27/06/1981	5/10/1981	150	150	0	1200
MCM_82038_510_822_3600	26960	AANDERAA	54.4997	-55.4378	2/11/1982	5/8/1983	197	197	200	3600
MCM_83021_569_6404_1800	27197	AANDERAA	54.4997	-55.4397	5/8/1983	12/11/1983	197	197	200	1800
MCM_83036_572_6411_3600	27245	AANDERAA	54.497	-56.318	12/11/1983	3/7/1984	190	190	193	3600
MCM_84026_627_4601_1800	31831	AANDERAA	54.4931	-56.3535	3/7/1984	29/09/1984	190	190	200	1800
MCM_84038_656_5573_3600	31733	AANDERAA	54.49	-56.3439	29/09/1984	6/7/1985	198	198	200	3600
MCM_86021_795_7133_3600	29074	AANDERAA	54.4605	-55.4388	5/8/1986	31/07/1987	200	200	200	3600