Environmental Assessment
MKI Labrador Sea Seismic Program
2014-2018

Prepared by

LGL LIMITED
environmental research associates

Prepared for

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Lilleaker, 0216, Oslo, Norway

and

TGS-NOPEC Geophysical Company ASA
1051 Clay Road
Houston, Texas, 77043, USA

February 2014
Project No. SA1245

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1.0 Introduction

This is an Environmental Assessment (EA) prepared by LGL Limited (LGL) for Multi Klient Invest AS (MKI) and TGS-NOPEC Geophysical Company ASA (TGS)'s proposed 2014–2018 2-Dimensional (2D) and/or 3-Dimensional (3D) marine seismic program in the Labrador Sea, Newfoundland and Labrador. The EA is designed to apply to the Project conducted over the area of operations during a five-year period and intended to enable the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) to fulfill its responsibilities under Section 138 (1)(b) of the *Canada-Newfoundland Atlantic Accord Implementation Act* and Section 134(1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (Accord Acts). This EA has been guided by the Scoping Document prepared by the C-NLOPB, as well as by advice and information received, and issues identified through various communications and consultations with other agencies, interest groups, stakeholders and beneficiaries.

The temporal scope of the Project is a five-year period (2014 to 2018) with seismic operations potentially occurring between May and November in any given year. The present document focuses primarily on the proposed 2D seismic program which is anticipated to occur in 2014. It is currently uncertain if MKI and TGS will undertake seismic surveys in the Labrador Sea during 2015–2018, as future surveys will depend on results of the initial survey and other factors. However, it is anticipated that there will be one seismic survey a year, with the possibility of 2D and 3D seismic surveys occurring in the same year. The geographic scope of the Project is the Project Area in any year shown in Figure 1.1. Note that the Hawke Channel Fishery Closure Area (area in the southern Study Area with dashed red-line border) is not a part of the Project Area.

1.1 Relevant Legislation and Regulatory Approvals

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* and the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*. Pursuant to the Accord Acts, the C-NLOPB is responsible for seeking to identify the federal departments or agencies that may have expertise required in the completion of the assessment. Because seismic survey activities have the potential to affect seabirds, marine mammals, sea turtles, and fish and fisheries, Fisheries and Oceans Canada (DFO) and Environment Canada are the agencies that have most involvement in the EA process. Legislation that is relevant to the environmental aspects of the Project includes:

- *Canada-Newfoundland Atlantic Accord Implementation Act*;
- *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*;
- *Oceans Act*;

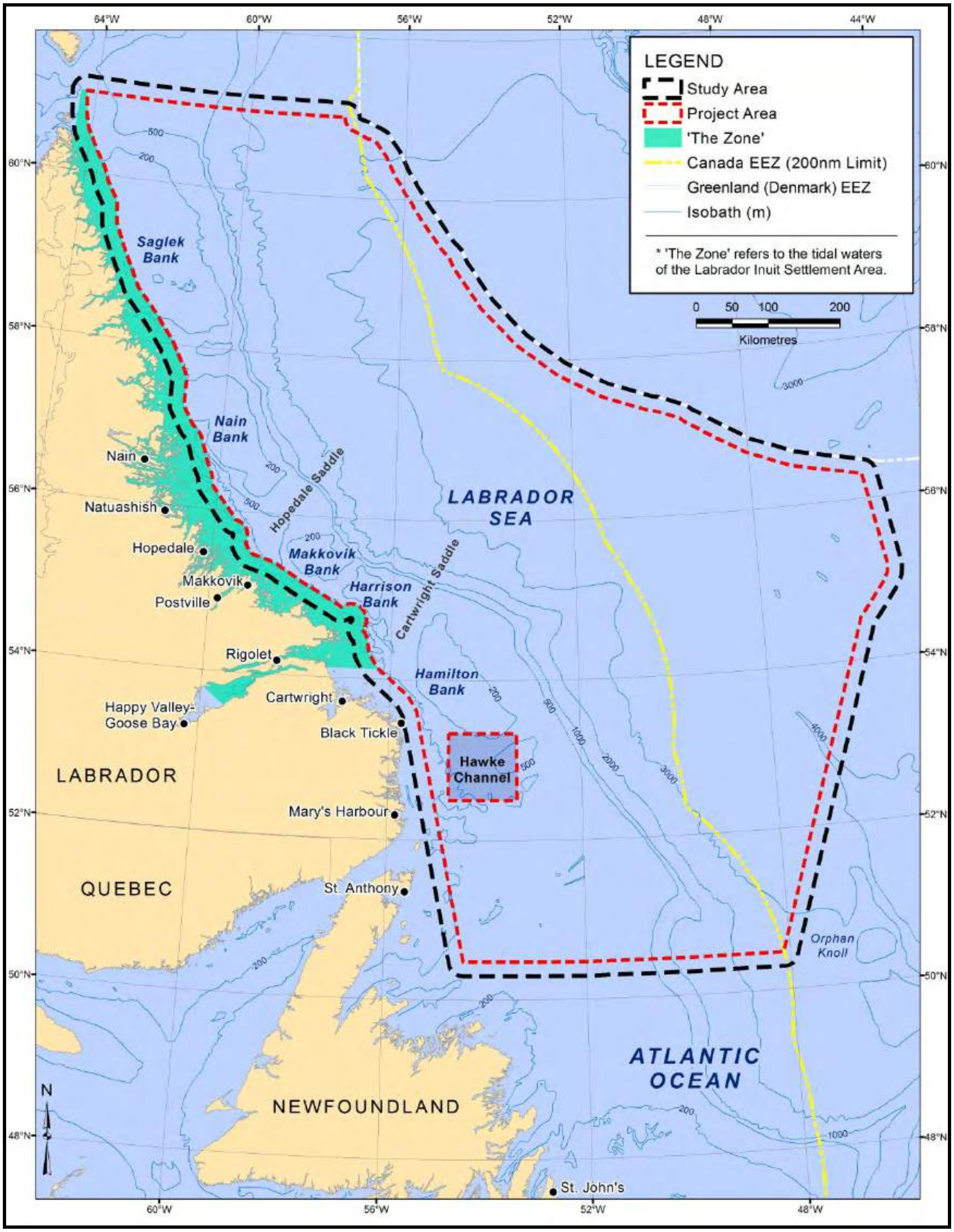

Figure 1.1 Project and Study Areas for Proposed Labrador Sea Seismic Project, 2014 to 2018.

- *Fisheries Act*;
- *Navigable Waters Act*;
- *Canada Shipping Act*;
- *Migratory Birds Convention Act*;
- *Species at Risk Act (SARA)*; and
- *Canadian Environmental Protection Act.*

MKI and TGS will follow guidelines issued by the C-NLOPB, the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (January 2012). These guidelines outline mitigation and monitoring requirements for marine mammals and sea turtles for the program. The Project will also follow DFO's *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment* and other advice received during the consultations for this Project.

1.2 The Proponents: MKI and TGS

The Operator, MKI, is a wholly owned subsidiary of Petroleum Geo-Services ASA (PGS), headquartered in Oslo, Norway. MKI has entered into a cooperation agreement with TGS, headquartered in Houston, Texas, to conduct this seismic program. PGS is a leading provider of seismic and electromagnetic survey services, data acquisition, processing, and reservoir analysis for the global oil and gas industry. PGS was founded in Norway in 1991 and currently has a presence in over 25 countries with regional centers in London, Houston, and Singapore.

TGS provides multi-client geoscience data to oil and gas exploration and production companies worldwide. In addition to extensive global geophysical and geological data libraries that include multi-client seismic data, magnetic and gravity data, digital well logs, production data and directional surveys, TGS also offers advanced processing and imaging services, interpretation products, permanent reservoir monitoring and data integration solutions

1.3 Canada-Newfoundland and Labrador Benefits

An important aspect of the C-NLOPB's mandate is the administration of provisions in the Accord Acts relating to industrial and employment benefits from the development of oil and gas resources in the Newfoundland and Labrador Offshore Area for Canada in general and for the Province of Newfoundland and Labrador in particular.

The Acts require that before any work or activity is authorized in the offshore area, a Canada-Newfoundland and Labrador Benefits Plan must be approved by the Board. In general terms, a benefits plan must describe a plan for the employment of Canadians and, in particular, members of the labour force of the province; and for providing manufacturers, consultants, contractors, and service companies in the province and other parts of Canada with a full and fair opportunity to participate on a competitive basis in the supply of goods and services. MKI will manage its east coast operations from St. John's, NL. MKI supports the principle that first consideration be given to personnel, support and other services that can be provided within NL, and to goods manufactured in NL, where such goods and services can be delivered at a high standard of Health, Safety and Environmental competency, be of high quality and are competitive in terms of fair market price. All contractors and sub-contractors working for MKI in NL must comply with the approved MKI Canadian-Newfoundland and Labrador Benefits Plan.

1.4 Contacts

Relevant contacts at MKI and TGS for the proposed seismic program are provided below.

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2.0 Project Description

In 2014, MKI and TGS are proposing to conduct a 2D single streamer marine seismic survey in open (ice-free) waters of the Labrador Sea (see Figure 1.1), potentially starting as early as 1 May and, depending on start date, concluding as late as 30 November. One or more 2D and 3D seismic programs are also anticipated to occur between 2015–2018, depending on the results of the initial survey in 2014 and/or the availability of seismic vessels. No acquisition or line turns will occur within the Nunatsiavut Zone (the Tidal Waters of the Labrador Inuit Settlement Area, as defined in the Labrador Inuit Land Claims Agreement). However, part of the survey is within the "Ocean Areas Adjacent to the Zone" (as defined in Part 6.1.1 of the Agreement).

The timing of the survey and/or individual survey lines is subject to regulatory approvals, and such factors as weather and ice conditions, vessel availability, location of fishing activities, and regulatory approvals. Any subsequent seismic surveys conducted during 2015–2018 would also occur during the same temporal window of 1 May to 30 November.

2.1 Spatial and Temporal Boundaries

In terms of spatial boundaries, the Project Area is located in the Labrador Sea, with the "corner" coordinates (decimal degrees, WGS84 projection) of the extents of the Project Area as follows (see Figure 1.1):

- Northwest: 61.000°N, 64.253°W;
- Northeast: 61.000°N, 57.587°W;
- Southwest: 50.481°N, 54.424°W;
- Southeast: 50.463°N, 48.130°W; and
- Eastern extent: 55.144°N, 45.187°W.

The Project Area is within Canada's Exclusive Economic Zone (EEZ) but does not enter the waters of Canada's Territorial Sea and does not include the Hawke Channel (area closed to mobile fishing gear) as shown on the maps in this report. As noted above, there will be no acquisition within the Nunatsiavut Zone, and acquisition lines will end 20 km short of the Zone boundary to ensure that line turns can be made without entering the Zone.

The Study Area includes the Project Area plus a 20 km buffer area around the Project Area (see Figure 1.1) to account for the propagation of seismic survey sound that could potentially affect marine biota. The areas of the Study Area and Project Area are 766,631 km^2 and 679,758 km^2, respectively. Nearly all of the proposed 2014–2018 Project is within the Study Area used for the Strategic Environmental Assessment (SEA) Labrador Shelf Offshore Area (Sikumuit 2008).

The temporal boundaries of the proposed Project encompass the 1 May to 30 November period in each year, potentially from 2014 to 2018. The duration of a seismic survey is estimated at 60 to <120 days in a given year.

2.2 Project Overview

The proposed Project is a ship-based geophysical program that includes approximately 10,000 km of 2D seismic survey lines planned for 2014. Additional seismic surveys may be conducted within the Project Area during 2015–2018 with a proposed maximum annual acquisition of 10,000 km. The proposed 2D program will use a conventional seismic ship, the M/V *Sanco Spirit* (described below) which will tow the sound source (airgun array) and a single streamer containing receiving hydrophones. The support vessel will be the M/V *Blain M.* (described below). The seismic survey and support vessels used during subsequent 2D or 3D surveys are unknown at present but will be approved for operation in Canadian waters by Transport Canada and C-NLOPB and will be typical of the worldwide fleet.

Proposed mitigation procedures for this survey (detailed in Section 5.6) are based on a variety of sources, including:

- Discussions and advice received during consultations for this Project;
- The C-NLOPB Scoping Document, and the Environmental Planning, Mitigation and Reporting guidance in Appendix 2 of the Board's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012);
- DFO's "Statement of Practice with respect to the Mitigation of Seismic Sound in the Marine Environment";
- National and international acts, regulations or conventions, such as the *Fisheries Act* and Regulations, *International Convention for the Prevention of Pollution from Ships* (MARPOL), and International Maritime Organization (IMO) standards;
- Other standards and guidance, such as the One Ocean Protocol for Seismic Survey Programs in Newfoundland and Labrador (2013), and the Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys (2010);
- Stranded seabird handling and release protocols;
- Industry best practices; and
- Expert judgement / experience from past surveys.

These mitigations include such procedures as close communications with fish harvesting interests, avoidance of active fishing areas, the use of a Single Point of Contact to help communications between the survey and fishers, the establishment of a Fishing Gear Compensation Program, ramp-up (i.e., soft start) of the airgun arrays, the use of at least two dedicated Marine Mammal Observers (MMOs) to monitor for marine mammals and sea turtles, to record seabird and other wildlife data and to implement shut downs of the seismic sound source array when required, and the use of two Fisheries Liaison Officers (FLOs) to aid in coordination with fishing activities. One FLO, provided by the Fish, Food and Allied Workers (FFAW), will be on board the seismic vessel to ensure implementation of communication procedures intended to minimize conflict with the commercial fishery, and another FLO representing Inuit/Nunatsiavut interests will be onboard the picket vessel. An additional observer representing Inuit/Nunatsiavut interests will also be onboard the seismic vessel to assist with marine mammal observations.

2.2.1 Objectives, Rationale and Alternatives

The primary objective of the Project is to determine the presence and likely locations of geological structures that might contain hydrocarbon deposits. Existing 2D and 3D seismic data in the area do not provide sufficient coverage to serve the needs of the energy companies in their exploration, development and production activities. Acquisition of new 2D/3D seismic data is required to provide images of higher resolution and quality that will reduce the possibility of unnecessary drilling activity.

2.2.2 Project Phases

The Project may have two phases. The actual timing of these activities within the temporal scope will be dependent on economic feasibility, vessel availability and results of data interpretation of survey work from preceding phases.

1. Phase 1 will include a 2D survey in 2014 in the Project Area shown in Figure 1.1; and
2. Phase 2 will include 2D and/or 3D surveys in the Project Area that may be identified through analyses of existing and acquired data.

During Phase 2, it is anticipated that there will be one seismic survey a year, but there is a possibility of 2D and 3D seismic surveys occurring in the same year, i.e., two seismic vessels operating in the same season.

2.2.3 Project Scheduling

It is anticipated that annual seismic surveys will occur sometime within the period 1 May to 30 November from 2014 to 2018. The timing of the acquisition of specific lines within the Project Area in any year will depend on several factors, including commercial fish harvesting, the local weather, sea state, and ice conditions in specific locations. The estimated duration of the proposed 2014 survey is approximately 90 days.

2.2.4 Site Plans

The 2014 acquisition program has not yet been finalized but will not exceed 10,000 km of 2D seismic data. Interpretation of data acquired in 2011 and 2012 is near completion and the results of this work will drive the position and the amount of data to be acquired during the current year.

The Labrador Sea seismic program will occur within and beyond Canada's EEZ but does not enter the waters of Canada's Territorial Sea, i.e., 0–12 nmi offshore (see Figure 1.1). There will be no acquisition within the Nunatsiavut Zone, and seismic survey lines will end 20 km short of the Zone boundary to ensure that line turns can be made without entering the Zone. No portion of the survey will be acquired within Gilbert Bay, Nain Bight or Hamilton Inlet; survey lines will also remain outside of the Hawke Channel.

2.2.5 Personnel

The *Sanco Spirit* can accommodate approximately 47 people. Personnel on seismic vessels typically include individuals from the Proponent (i.e., MKI), the vessel owner/operator (ship's officers and marine crew), and technical and scientific personnel from the main seismic contractor. The seismic vessels will also have FLOs and MMOs on board (see Section 5.6), as well as an MKI/TGS representative(s) who supervises Client Quality Control and Processing Quality Control. All project personnel will have all of the required certifications as specified by relevant Canadian legislation and the C-NLOPB. Regular personnel for the survey will include ship's officers and marine crew.

2.2.6 Project Ships

A single conventional seismic ship will be used for data acquisition. In 2014, the 86-m M/V *Sanco Spirit*[1] will serve as the survey vessel with support, as needed, planned to be from the 47-m *Blain M*. Ship re-supply, re-fuelling and transfers of personnel will take place in port during 2014, but in future years, may occur offshore using a support vessel for re-supply, crew changes and refuelling. Although the seismic vessel has a helideck, no helicopter or other support vessel use is planned for 2014.

2.2.6.1 Seismic Vessel

The M/V *Sanco Spirit* will tow the sound source (airgun) array and hydrophone streamer in 2014 (Figure 2.1). The specifications of the vessel are detailed below. The seismic ship will likely deploy a workboat to repair the streamer when necessary and will carry a Fast Rescue Craft. This Norwegian built (in 2009) vessel is 86 m long, 16 m wide, and is registered in Gibraltor. MKI will apply for a Coasing Trade Permit issued under the *Coasting Trade Act*. It has a draft (loaded) of 5.8 m, cruises at 13 knots, and is equipped with a helideck. The *Sanco Spirit* has diesel-electric propulsion systems (main and thrusters) and operates on marine gas oil (MGO).

2.2.6.2 Support Vessel

In 2014, it is proposed that the seismic ship will be accompanied by a support vessel, the M/V *Blain M* (Figure 2.2). The support vessel will have responsibilities for communications with other vessels (primarily fishing vessels) that may be operating in the area and for scouting ahead to look for hazards. The *Blain M.* was built in Nova Scotia in 1981 and is registered in Ottawa. The vessel is 47.1 m long and about 11 m wide, with a draft of 2.5 m, and a cruising speed of 9 knots. The support vessel will be used as an additional method to obtain information on commercial fishing activity in the area and to warn other vessels in order to avoid gear losses for all parties involved. It would also be used to scout ahead of the seismic vessel for hazards such as ice and floating debris. Re-supply, re-fuelling and transfers of personnel will be done in port during 2014, but may take place via the support vessel during subsequent years.

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[1] Although this is the planned vessel, it is possible that a different ship may need to be used in some years, given the realities of contract finalization and other considerations. If another vessel is used as the seismic source ship, it will be equivalent in all respects related to environment and safety. This would not alter acquisition methods, mitigations or impact predictions.

Figure 2.1 Seismic Source Vessel MV *Sanco Spirit.*

***Sanco Spirit* Specifications**

Call sign: ZDJN 3
IMO number: 9429936
MMSI Number: 2365380000
Owner: Sanco Shipping AS
Classification: Research Vessel
Length overall: 86.5 m
Beam: 16.0 m
Draft Loaded: 5.8 m
Gross Tonnage: 4396 Tonnes
Net Tonnage: 1319 Tonnes
Cruising Speed: 13 knots
Accommodation: 47 persons

Figure 2.2 Support Vessel MV *Blain M.*

***Blain M.* Vessel Specifications**

IMO number: 7907099
Owner: McKeil Marine Limited
Classification: Fishery Science Vessel
Length overall: 47.1 m
Beam: 11.0 m
Draft: 4.3 m
Gross Tonnage: 925 Tonnes
Net Tonnage: 225 Tonnes
Cruising Speed: 9 knots
Endurance: 40 days
Accommodation: 34 persons

2.2.7 Seismic Energy Source Parameters

The proposed 2D or 3D survey sound source will consist of one or more airgun arrays with a total discharge volume of 3,000 to 6,000 in^3, operating at tow depth of 6 to 15 m. The airgun arrays are comprised of individual airguns ranging in size from 22 to 250 in^3 each. The airguns will be operated with compressed air at pressures of 2,000–2,500 psi and produce approximate peak-to-peak pressures of 100 to 200 bar-m. A typical airgun array used by PGS for 2D surveys consists of four sub-arrays with a total volume of 4,808 in^3, operated at a pressure of 2,000 psi. This array is generally towed at a depth of 9 m and produces peak-to-peak pressures of 179 bar-m. The airguns in the array are strategically arranged to direct most of the energy vertically downward rather than sideways. The shot interval will be one shot every 19 to 25 s, and the survey speed will be around 4.5 knots (8.3 km/h).

2.2.8 Seismic Streamer

For 2D surveys, the seismic ship will also tow a single seismic hydrophone cable (streamer) up to 10 km long, deployed near the ocean surface, at a depth of approximately 15–25 m. This is a passive listening device, which will receive the sound waves reflected from structures underneath the ocean floor and transfer the data to an on-board recording and processing system. The cable is a solid streamer, PGS GeoStreamer®. In subsequent 2D and 3D seismic surveys (2015–2018), streamer equipment specifications will be provided when program design is complete. Streamers will be solid with an expected length of 8,000 to 10,000 m, depending on survey design, and deployed at depths ranging from 15 to 25 m. As many as 16 streamers may be towed during a 3D seismic survey.

2.2.9 Other Equipment

The seismic vessel is equipped with a Furuno FE-700 echosounder. The downward-facing echosounder operates at a frequency of 50 kHz or 200 kHz and will be used to collect water depth information. For this Project, sound velocity profiles will also be acquired in the water column at various locations within the survey area. This is a routine practice during seismic programs. Sound velocity profiles allow for more accurate interpretation of the acoustic data (i.e., seismic pulses) recorded by the seismic streamer. These data are acquired with a small, passive device that will be deployed by the support vessel. The device measures pressure, temperature, and salinity, from which the speed of sound can be calculated.

2.2.10 Logistics and Support

As described above, the 2014 operations will consist of a single seismic ship, the MV *Sanco Spirit*, towing a sound source (airgun) array and a hydrophone streamer over widely spaced survey lines, working in ice-free marine areas. The project will also use a support ship, the MV *Blain M*. The survey will follow planned, pre-plotted seismic lines to the extent possible, given possible local ice conditions. In 2014, crew changes will occur every five weeks via port calls. The port will be St. John's, Cartwright, or another port in Newfoundland and Labrador, depending on vessel location. It is not known at this time whether helicopters, vessel-to-vessel transfers, or port-calls will be used for crew changes during seismic program(s) in 2015–2018. If required, aircraft support would be provided by twin-engine helicopters. Helicopters may be used to ferry personnel and lightweight supplies to and from the seismic vessel. In addition, helicopter emergency response support will be available to the seismic vessel.

The seismic lines will be acquired in the most efficient manner practical. Typically the vessel will have a 6-km run-in to the start of a seismic line and a 4 to 5 km run-out at the end of a seismic line. The ship will travel at approximately 8–9 km/hr when in data acquisition mode. The vessel will aim to operate continuously, though typically about 60% of the time is spent in production with the remainder of the time for line changes, standby (e.g., for weather, marine mammal mitigation), maintenance and/or other technical operations.

MKI will have a shore representative based in St. John's for the duration of seismic. No new shorebase facilities will be required for the Project for the seismic surveys. Existing port infrastructure will be used for this Project

2.2.11 Discharges

Vessel discharges will not exceed those of standard vessel operations and will adhere to all applicable regulations. The main discharges include grey water (wastewater from washing, bathing, laundry, and food preparation), black water (human wastes), bilge water, deck drainage and discharges from machinery spaces. All discharges will comply with requirements in the International Convention for the Prevention of Pollution of Ships, 1973, as modified by Protocol of 1978 (MARPOL 73/78) and its annexes. It is estimated that the seismic vessel will generate 0.25 m^3 of black and grey water per day and the picket vessel will generate less. Ground galley food waste can be discharged when a vessel is more than 3 miles offshore. Non-ground galley food waste can be discharged when a vessel is more than 12 miles offshore.

2.2.12 Waste Management

Wastes produced from the seismic and support vessels, including hazardous and non-hazardous waste material, will be managed in accordance with MARPOL and with the vessel-specific waste management procedures. All solid wastes will be sorted by type, compacted where practicable, and stored on board before disposal to an appropriate certified reception facility. Non-toxic combustible material and waste oil from the vessels will be burned on-board in approved incinerators. The shipboard incinerators will have been examined and tested in accordance with the requirements of the shipboard incinerators IMO Res. MEPC 76(40) for disposing of ships-generated waste appended to the Guideline for the Implementation of Annex V of MARPOL 73/78. Sufficient and adequate facilities will be available on vessels to store solid wastes to the extent required. The MKI waste management procedures will be filed with the C-NLOPB. Only ports with licensed waste contractors will be used for any waste returned from offshore.

2.2.13 Atmospheric Emissions

The vessels will have an International Air Pollution Prevention Certificate issued under the provisions of the Protocol of 1997 as amended by resolution MEPC.176(58) in 2008, to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as the Convention). Atmospheric emissions will be those associated with standard operations for marine vessels in general, including the seismic vessel and support vessel. Vessels will only use diesel and gasoil with a sulphur content of no more than 1% (weight) following the *International Convention for the Prevention of Pollution from Ships* (MARPOL) Annex VI, for the North American Emission Control Area, which was implemented in Canada in August 2012 (see http://www.tc.gc.ca/eng/marinesafety/bulletins-2013-06-eng.htm). It is expected that the ships will use ~1,000,000 L of fuel within Canadian waters per survey. There are no anticipated implications for the health and safety of workers on these vessels form atmospheric emissions.

2.2.14 Accidental Events

In the unlikely event of the accidental release of hydrocarbons during the Project, MKI will implement the measures outlined in its oil spill response plan which will be filed with the C-NLOPB. In addition, MKI has an emergency response plan in place which bridges the emergency plans of all project entities and vessels to the local facilities and the Halifax Search and Rescue Region; this plan will be filed with the C-NLOPB. The MKI representative onboard will represent MKI in all offshore Quality, Health, Safety & Environment (QHSE) activities. The MKI Project Manager will represent MKI onshore from an office in St. John's.

2.3 Mitigation

Mitigation measures are referenced throughout the EA. The measures are described in detail in Section 5.6.

3.0 Physical Environment

The Scoping Document required that the EA provide a brief summary description of the meteorological and oceanographic characteristics, including extreme conditions, in order to provide the basis for assessing the effects of the environment on the Project. The physical environment of the Study Area was described in the Labrador Shelf SEA (Sikumiut 2008). A summary of the physical environment in the Study Area, based primarily on the Labrador Shelf SEA, is provided below, with reference to weather, oceanography, and ice conditions, particularly during May to November.

3.1 Bathymetry

The bathymetry in the Study Area is relatively complex with depths ranging from ~100 m to depths over 3,000 m, including continental shelves, slopes, and the abyssal plain. The Study Area is bounded on the northwest by Saglek Bank and the entrance to Hudson Strait, and in the south by Orphan Knoll and the continental shelf waters of Newfoundland. Other major bathymetric features include Nain Bank, Makkovik Bank, Hamilton Bank, Harrison Bank, Hopedale Saddle, Cartwright Saddle, and the Labrador Marginal Trough.

3.2 Geology

The surficial geology of the Labrador Shelf has been discussed in NORDCO (1982) and Josenhans et al. (1986) and has been summarized in the Labrador Shelf SEA (Sikumiut 2008). The bedrock geology of the Study Area is comprised primarily of Precambrian and Tertiary bedrock. The Precambrian bedrock dominates the seafloor on the inner shelf. Five surficial sedimentary formations are found in the Study Area and include till (Lower Till, Upper Till), pro-glacial and sub-glacial sediments (Qeovik Silt), and post-glacial marine sediments (Makkaq Clay, Sioraq Silt, and Gravel). Additional information on surficial sediments, as they relate to fish and fish habitat, is provided in Section 4.2.1.2.

3.3 Climatology

Every marine seismic survey program is influenced by weather conditions both from routine operational and environmental safety perspectives. During routine activities, data quality and hence, survey time on site can be affected by weather, particularly wind and wave conditions. This section provides a general overview of climatic conditions in the Study Area.

3.3.1 Air Temperature

Data from the National Climate Data and Information Archive, Climate Normals and Averages for four land based weather stations near the Study Area, Hopedale, Cartwright, Battle Harbour (Loran; 1961-1990), and Nain (1971-2000) were used to calculate average air temperatures from May to November (Table 3.1). Air temperature means ranged from -5.1 to 12.3°C (Environment Canada 2013a), with coldest temperatures in Nain in November.

Table 3.1 Mean Daily Air Temperatures (°C) for the Period of May to November at Four Weather Stations along the Labrador Coast.

Weather Station	Mean Monthly Air Temperature (°C)						
	May	June	July	Aug	Sep	Oct	Nov
Nain (1971-2000)	1.0	6.2	10.1	10.7	7.0	1.1	-5.1
Hopedale (1961-1990)	1.3	6.0	10.3	10.6	7.0	1.9	-3.2
Cartwright (1961-1990)	2.9	8.0	12.3	11.9	8.1	2.9	-2.0
Battle Harbour, Loran (1961-1990)	1.9	6.1	10.1	10.9	8.2	3.5	-0.8

Source: Environment Canada (2013a).

3.3.2 Wind

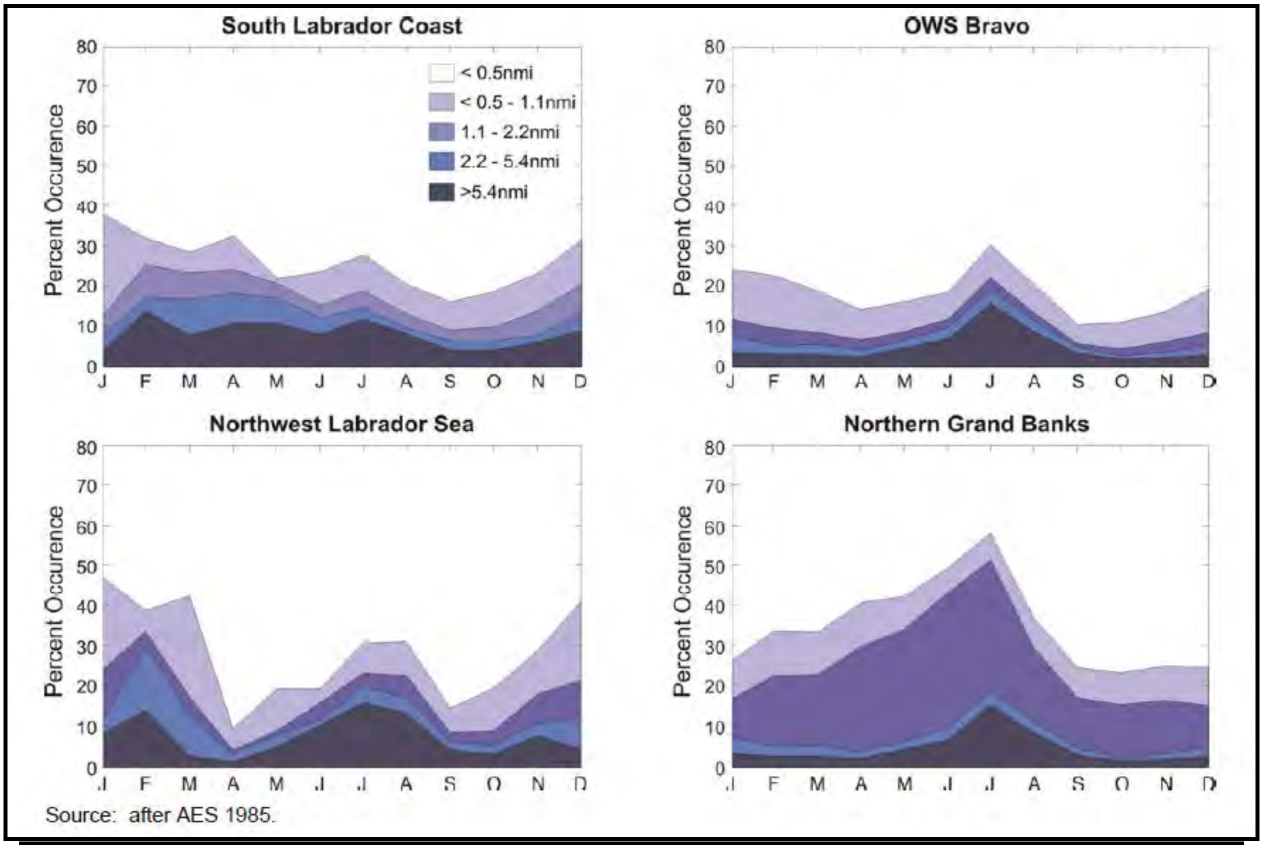
Wind speed is an important characteristic of the physical environment that can directly affect project activities. Within the Study Area, the lowest mean monthly wind speeds are experienced in July. MSC50 hind cast data from the Meteorological Service of Canada, taken from Section 3 of the Labrador Shelf SEA (Sikumiut 2008) are used here to describe wind speeds in the Study Area. A series of nine grid point locations distributed north to south throughout the Study Area (see Figure 3.22 *in* Sikumiut 2008) were used. Mean monthly wind speeds for the period of May to November ranged from 4.97 to 9.54 m/s in the north (grid point 60°N, 61°W) and 5.97 to 10.53 m/s in the south (grid point 52°N, 51°W). July had the lowest mean wind speed at all nine locations, with wind speeds increasing through the fall and into the winter. Maximum monthly wind speeds of 28.69 m/s were recorded in November at grid point location 58°N, 59°W. The maximum wind speed for July was 19.65 m/s at grid point location 53°N, 51°W. The 100-year maximum wind speed was determined to be 28.04 m/s at the most northern grid point (60°N, 61°W) and 31.02 m/s at the most southerly point (52°N, 51°W).

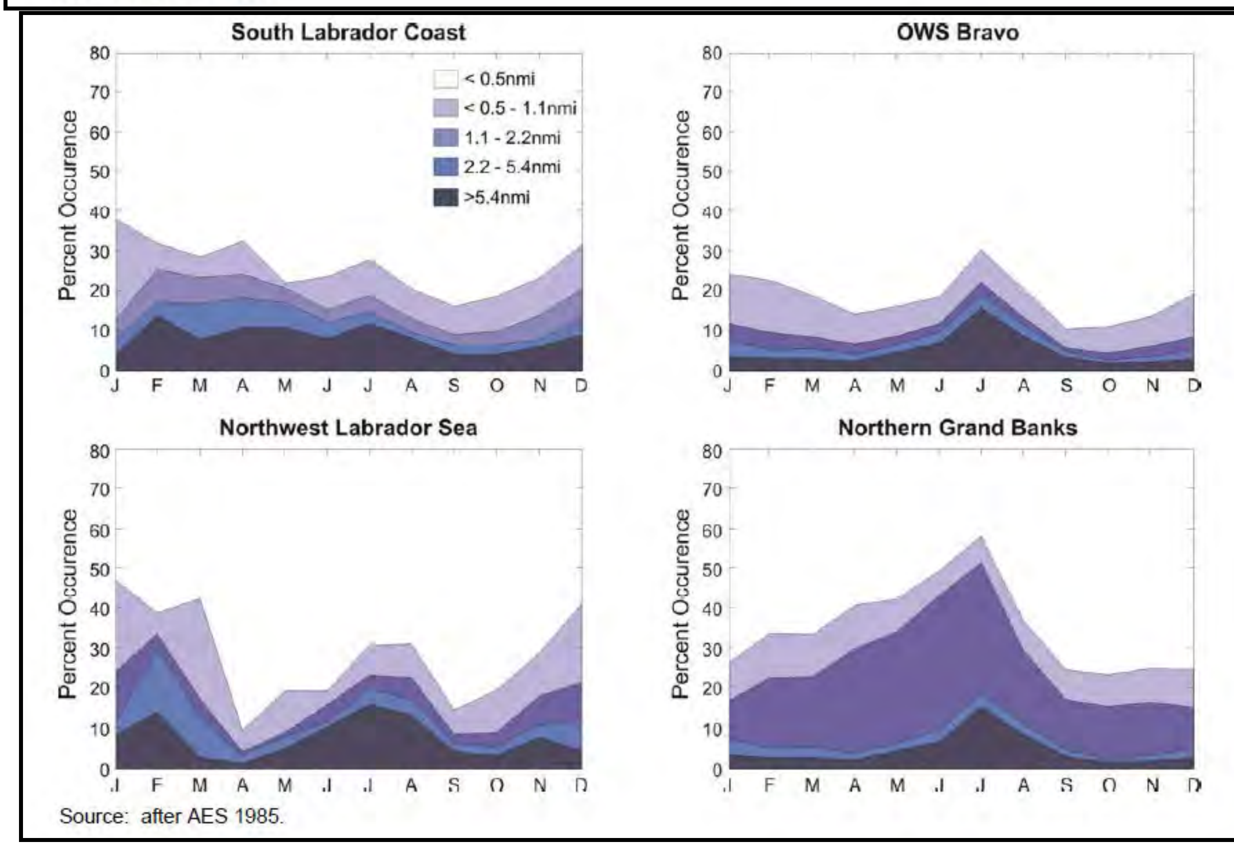
3.3.3 Visibility

Shipping visibility categories (i.e., ranges of distances) are used here as an indicator of visibility conditions influenced by precipitation, fog, and freezing spray. The ranges of shipping visibility are as follows:

- <0.5 nm;
- 0.5 –1.1 nm;
- 1.1 – 2.2 nm;
- 2.2 – 5.4 nm; and
- ≥ 5.4 nm.

Within the Study Area, annual visibility statistics for the south Labrador coast, Offshore Weather Station Bravo (OWS), and northwest Labrador Sea, indicate more variable visibility during summer months (June – August), with a higher percent occurrence of reduced visibility, and increased visibility through the fall to November (Sikumiut 2008; Figure 3.1). In comparison to the northern Grand Banks, visibility conditions in the Study Area during May to November are much better.





Source: Sikumiut (2008).

Figure 3.1 Regional Visibility Conditions based on Shipping Criteria.

3.3.4 Waves

Wave conditions can potentially affect vessel operations for the Project; however, since wind conditions in the Study Area are relatively low during the summer and fall, usual wave conditions are also relatively minimal. Using 50 years of hind cast data from the same nine MSC50 grid locations as for the wind conditions (Figure 3.22 *in* Sikumiut 2008), the lowest monthly mean significant wave heights are experienced in July increasing through the fall, peaking in December and January. At the most northern grid point (60°N, 61°W), the range of mean significant wave heights between June and November was 1.20 – 2.63 m and at the most southerly point (52°N, 51°W), 1.53 – 3.41 m. Maximum monthly significant wave heights recorded in the Study Area reached up to 12.59 m in November (grid point 54°N, 53°W). In July, maximum significant wave height reached 6.00 m at the most southerly station (grid point 52°N, 51°W).

3.4 Physical Oceanography

3.4.1 Currents

The Labrador Current, originating in the Davis Strait, runs south along the Labrador coast, with contributions from the warmer, more saline waters of the West Greenland Current, and the colder, less saline waters of the Baffin Island Current and Hudson Bay. In the middle of the Study Area, near Hamilton Bank, the Labrador Current branches into a smaller inshore and larger offshore stream (Lazier and Wright 1993). The inshore stream, comprised of water from Hudson Strait and the Baffin Current, flows along the coast and in the Marginal Trough, whereas the offshore stream is comprised of water from the West Greenland current and flows along the outer edge of the banks and over the continental slope. The minimum mean velocity, occurring in March/April is 3.1 cm s^{-1} and the maximum mean velocity, typically in October, is 35.1 cm s^{-1}. The steepest portion of the continental slope generally experiences stronger currents than over the continental shelf or areas further offshore. For a general illustration of the Labrador Current, see Figure 3.25 *in* Sikumiut (2008).

3.5 Ice Conditions

3.5.1 Sea Ice

Ice conditions are an important component of the physical environment, directly affecting offshore activities in the area. The average start of the ice season in the Study Area ranges from mid-November in the more northern areas and December in the southern extent. Pack ice thickness in the area has been measured from a minimum of 1.5 m to a maximum of 14–17 m. Ice growth continues until late spring, when the pack ice begins to melt and dissipate through the month of July. First signs of break-up occur around Notre Dame Bay in mid-March. The southern ice edge retreats to the Strait of Belle Isle by late-May and northward again to 55°N by late-June. More northern coastal regions see the end of ice season in late-July/early-August. The majority of the Study Area will be free of sea ice from late June to November. In 1983, the drilling vessel *Petrel* observed some medium first-year ice in strips and patches in the area from 11 July to 17 August (LGL 2010).

3.5.2 Icebergs

Icebergs are well known for causing concern with regard to navigation and offshore activities along the coast of Newfoundland and Labrador. The major source, contributing ~90% of icebergs in Canadian waters (including the Study Area), are from glaciers on the west coast of Greenland (Environment Canada 2013b). Prevailing northwest winds and the strong Labrador Current move icebergs south along the coast of Labrador from July to October. Miller and Hotzel (1984) estimated the number of icebergs crossing a series of transects on the Labrador Shelf at a rate of 6–15 icebergs km^{-1} per year, with the total number of icebergs estimated at 1,400–3,000 per year. Data from the International Ice Patrol (IPP) Iceberg Sightings Database for the period of May to November, 2001-2011, show a total of 20,253 icebergs observed offshore Labrador (north of 50°N and west of 48°W; NSIDC 1995, updated annually; Table 3.2). These observed sightings may not include all icebergs passing through offshore Labrador but indicate where they are most likely to occur in the area and the relative abundance by month and year. Of the 20,253 icebergs observed during the May to November periods, most were sighted in June (40.6%), followed by May (26.0%), and July (25.3%). Additionally, there is a great deal of inter-annual variation in the numbers of observed icebergs. For example, during May to November of 2005, there were 36 observed icebergs whereas for that same time period in 2011, there were 4,974 icebergs. Iceberg size is typically characterized by waterline length, defined as the maximum dimension of the iceberg along the waterline, with small being defined as 16–60 m, medium as 61–122 m, and large or very large as >123 m. About 47% of the 20,253 icebergs recorded during May to November, 2001-2011, were classified as medium, large or very large size.

Table 3.2 Number of Icebergs Observed from May to November, 2001-2011, Offshore Labrador (north of 50°N and west of 50°W; IPP database).

Year	Month (Total Number of Icebergs Observed)							Total	% of Total
	May	Jun	Jul	Aug	Sep	Oct	Nov		
2001	97	235	64	-	-	-	-	396	1.96
2002	72	592	107	-	-	-	-	771	3.81
2003	498	126	24	-	-	-	-	648	3.20
2004	916	14	9	7	-	-	-	946	4.67
2005	15	21	-	-	-	-	-	36	0.18
2006	601	2581	-	-	-	-	3	3185	15.73
2007	556	1232	1816	2	-	-	-	3606	17.80
2008	431	649	383	28	16	-	-	1507	7.44
2009	589	1069	870	180	18	-	-	2726	13.46
2010	513	667	220	51	6	-	1	1458	7.20
2011	980	1041	1620	970	358	5	-	4974	24.56
Total	5268	8227	5113	1238	398	5	4	20253	
% of Total	26.01	40.62	25.25	6.11	1.97	0.02	0.02		

4.0 Biological Environment

4.1 Study Area Ecosystem

An ecosystem is an inter-related complex of physical, chemical, geological, and biological components that can be defined at many different scales, including a Project Area level (i.e., a deep ocean basin ecosystem) to a Regional Area ecosystem that is topographically and oceanographically complicated with shelves, slopes, and valleys and several major water masses and currents. Many important components of the ecosystem, such as certain species and stages of fish, seabirds and marine mammals that are ecologically, economically, and/or socially important may be affected by the Project. Information concerning biological characteristics of these species is discussed in the following sections.

4.2 Fish and Fish Habitat

This section provides a description of the existing fish and fish habitat in the Study Area. Fish habitat is considered first, followed by a discussion of macroinvertebrates and fishes in the Study Area.

4.2.1 Fish Habitat

In this EA, 'fish habitat' includes both the physical and biological aspects of the marine environment used by macroinvertebrate and fish species in the Study Area. The physical and chemical nature of the water column (i.e., water temperature, depth, salinity, etc.) and bottom substrate (i.e., surficial sediment) are critical factors affecting the characterization of associated marine biological communities. The biological component of fish habitat refers to phytoplankton, zooplankton, and benthos (i.e., infaunal and epibenthic invertebrates not typically harvested during commercial fisheries in the Study Area [e.g., polychaetes, echinoderms]).

4.2.1.1 Bathymetry

The bathymetry within the Study Area ranges from just under 100 m to 4,200 m (Figure 4.1). More than half of the Study Area is characterized by water depths exceeding 500 m. Only a small proportion of the Study Area is composed of areas where water depths are less than 200 m (e.g., Saglek Bank, Nain Bank, Makkovik Bank, Harrison Bank, Hamilton Bank). Essentially the entire portion of NAFO Division 3K that comprises a part of the Study Area has water depths greater than 200 m. The Hopedale Saddle and the Cartwright Saddle are the deep water areas between Nain Bank and Makkovik Bank, and Harrison Bank and Hamilton Bank, respectively (Figure 4.1). The Study Area extends beyond the 200 nmi Canadian EEZ into international waters.

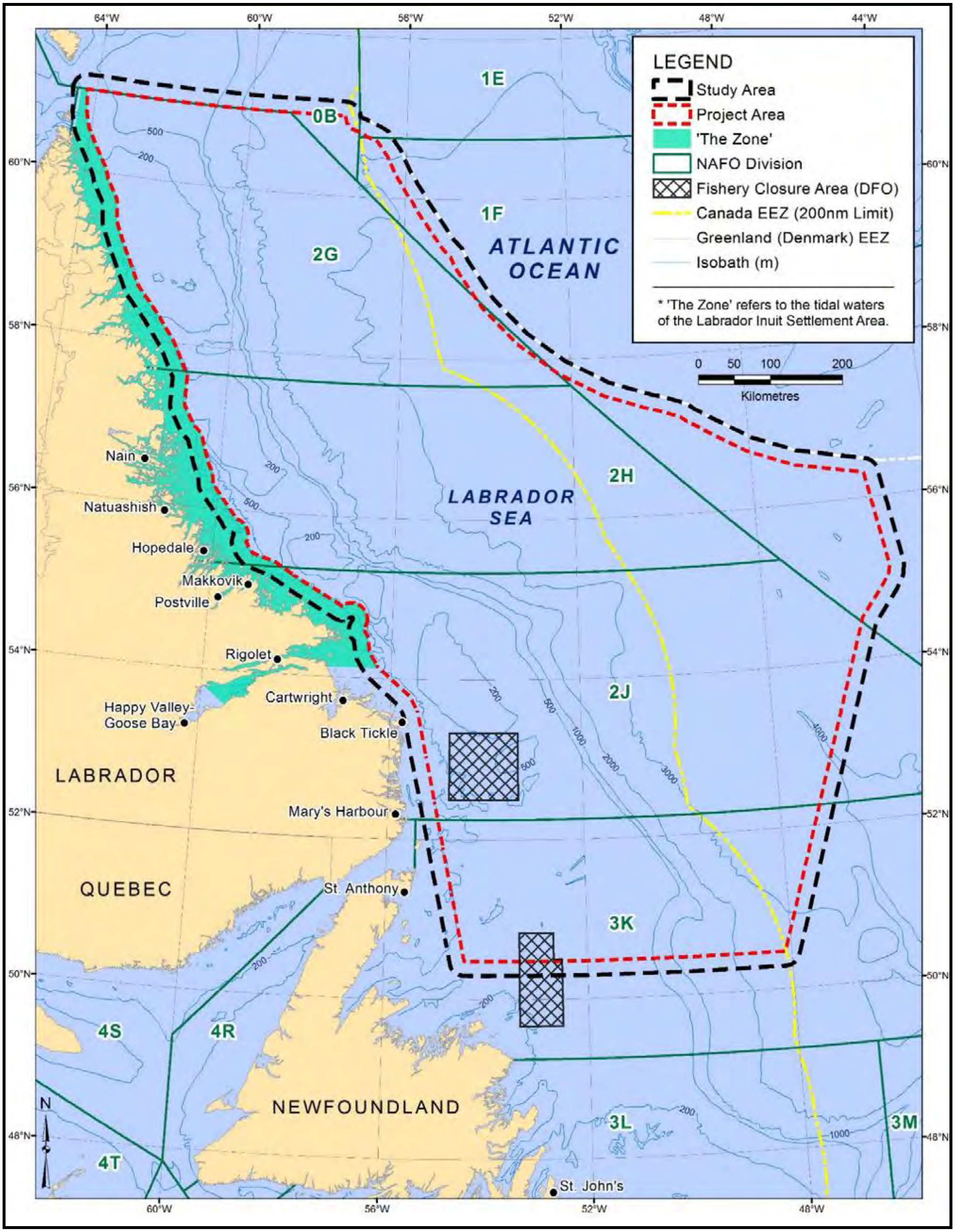


Figure 4.1 Bathymetric Features in the Study Area.

4.2.1.2 Surficial Sediment

The surficial geology of the Labrador Shelf has been discussed in NORDCO (1982) and Josenhans et al. (1986) and subsequently summarized in the Labrador Shelf SEA (Sikumiut 2008). The bedrock geology of the Study Area is composed primarily of Precambrian and Tertiary bedrock. The Precambrian bedrock dominates the seafloor on the inner shelf. Five surficial sedimentary formations are found in the Study Area and include till (Lower Till, Upper Till), proglacial and subglacial sediments (Qeovik Silt), and post glacial marine sediments (Makkaq Clay and Sioraq Silt and Gravel). Figure 3.1 in the Labrador Shelf SEA (Sikumiut 2008) displays the offshore Labrador surficial sediment distribution by soil type between the 200 m and 1,000 m isobaths in part of the Study Area. These distributions are based on information from the Geological Survey of Canada. The four sediment classes displayed include clay, sand, silt, and till.

4.2.1.3 Plankton

Plankton is composed of free-floating organisms that form the basis of the pelagic ecosystem. It includes bacteria, fungi, phytoplankton, zooplankton, and ichthyoplankton (i.e., fish eggs and larvae). In simplest terms, phytoplankton (e.g., diatoms) produce carbon compounds through the utilization of sunlight, carbon dioxide, and nutrients (e.g., nitrogen, phosphorus, and silicon), a process called primary production. Herbaceous zooplankton (e.g., calanoid copepods, the dominant component of the northwest Atlantic zooplankton) feed on phytoplankton, a process called secondary production. The herbivores in turn are fed upon by predators (i.e., tertiary production) such as predacious zooplankton (e.g., chaetognaths, jellyfish, etc.), all of which may be grazed by higher predators including invertebrates, fishes, seabirds, sea turtles, and marine mammals. This food web also links to the benthic ecosystem through bacterial degradation processes, dissolved and particulate carbon, and direct predation. An understanding of plankton production is important because areas of enhanced production and/or biomass are areas where marine biota tend to congregate for feeding.

The information on plankton of the Labrador Shelf has been reviewed extensively in the Labrador Shelf SEA (Sikumiut 2008) and is summarized briefly here. Some of the key points concerning the various components of planktonic communities for the Labrador Shelf Area are highlighted below:

- Microbiota consisting of bacteria and fungi are ubiquitous in the marine environment, including Labrador Shelf waters. These microflora occupy a unique niche in marine ecosystems in that they serve as a food source as well as degrade organic matter (Bunch 1979). Typically, microflora are most abundant in the upper layers, and their numbers decrease with depth (Li and Harrison 2001);
- Phytoplankton distribution, productivity, and growth regulation in high-latitude ecosystems (e.g., Labrador Shelf) is a complex system with light, nutrients, and herbivore grazing being the principal factors limiting phytoplankton regulations (Harrison and Li 2008);
- The spring bloom of phytoplankton is the driving force of high-latitude marine ecosystem dynamics and its initiation in the Labrador Sea is strongly regionally dependent (Wu et al. 2008). The spring bloom in the southern Labrador Sea starts in March as a continuation of

the bloom that commences on the Grand Banks and spreads northward. In the northern Labrador Sea, the spring bloom starts in early April with the bloom occurring earlier in both the north and south Labrador Sea areas as compared to the central Labrador Sea (Wu et al. 2008);

- Irradiance has been considered the limiting factor for development of the spring bloom; however, factors such as latitude, water column stratification, and freshwater inputs (ice melt, precipitation) are also important factors in Labrador Shelf waters (Wu et al. 2008);
- There also appears to be a fall bloom over shelf and slope regions in October for the Labrador Shelf area. Labrador Shelf waters display elevated chlorophyll biomass over most of the growing season from April through September – October (Cota et al. 2003);
- The role of sea-ice dynamics on the phytoplankton dynamics in the Labrador Shelf area is significant in that the marginal ice zones release freshwater via melting thereby strengthening stratification and affecting salinity and temperature distributions of the upper mixed layer. Retreat of the sea ice also influences the timing and magnitude of the phytoplankton bloom as well as penetration of light into the water column (Wu et al. 2007);
- The Labrador Shelf area is highly productive because of upwelling along the slopes of the offshore banks and channels and the outflow of nutrient rich water from the Hudson Strait (Drinkwater and Harding 2001; Breeze et al. 2002);
- The highest phytoplankton biomass (near surface) tends to be in the northern Labrador Sea area (Drinkwater and Harding 2001);
- There is the potential for both nitrate and silicate limitation in the Labrador Sea in summer, nitrate limitation in the central Labrador Sea, and a high probability that nutrients and irradiance may result in co-limitations during peak summer months, which affects the overall phytoplankton biomass (Harrison and Li 2008);
- Silicate concentrations are high and nitrate concentrations are low for both the Labrador Shelf and the shelf edge (AZMP 2007);
- Seasonal fluctuations in phytoplankton biomass into the Newfoundland and Labrador region are dominated by changes in the abundance of diatoms (DFO 2007). The spring bloom trends to be dominated by diatoms while the fall bloom dominant species are flagellates and dinoflagellates (Buchanan and Foy 1980a,b; DFO 2007);
- Chlorophyll concentrations were found to be higher near the coast and in bays as compared to further offshore. This may be attributed to nutrients associated with riverine input, tidal mixing, wind events, and localized upwelling (Buchanan and Foy 1980b);
- Zooplankton comprise the main link between primary production and higher-level organisms in the marine ecosystem. They transfer organic carbon from phytoplankton to fish, marine mammals, and birds higher in the food chain. Zooplankton are a food source for a broad spectrum of species, and they contribute faecal matter and dead zooplankton to the benthic communities;

- Arctic water masses that influence the Labrador Current are dominated by calanoid copepods (*Calanus finmarchicus*, *Calanus glacialis*, and *Calanus hyperboreus*) and the cyclopoid *Oithona similis* (Huntley et al. 1983);
- Zooplankton reproduction is tied to the phytoplankton bloom, which either coincides with or immediately follows the brief but intense phytoplankton blooms in the high latitudes (Huntley et al. 1983; Head et al. 2000; Head and Pepin 2008);
- Zooplankton reproduction would be expected to occur in or around May in the northern and southern areas of the Labrador Sea with the central Labrador Sea lagging until sometime in June. The presence of stage I and II copepodites in the central Labrador Sea in October and November has suggested that there may be a second breeding period in late summer or early fall (Huntley et al. 1983) and that this aggregate is significantly smaller;
- The pre-adult *C. finmarchicus* develop in the surface waters over the summer and early autumn after which the majority migrates to deeper waters to enter a period of dormancy. This seasonal descent to deeper waters means that *C. finmarchicus* are largely absent from the Labrador shelf regions during winter months and then re-populate the shelf regions in the spring (Head and Pepin 2008); and,
- Sea ice biota are fauna and flora of all trophic levels that live in, on, or associated with sea ice during all or part of their life cycle. Some of these species become part of the plankton when the ice melts. Communities are found at the surface, interior, and bottom of the ice. There are different mechanisms for the formation of these communities depending on where the community is located within the ice (Horner et al. 1992).

The pattern and scale of long-term variability among northwest Atlantic plankton communities based on continuous plankton recorder (CPR) data collected between 1958 and 2006 were investigated by Head and Pepin (2010) and Pershing et al. (2010). A portion of the area considered overlaps with the extreme southeast portion of the proposed Study Area. It was concluded that changes in the plankton community corresponded to changes in the physical environment suggesting that physical conditions are strong drivers of interannual variability in northwest Atlantic Shelf ecosystems (Pershing et al. 2010). Head and Pepin (2010) showed that the increases in phytoplankton abundances in the shelf region in the early 1990s, primarily in winter, occurred along with increased contribution of Arctic-derived freshwater to the Newfoundland and Labrador shelves. This increased influx of arctic water was also likely directly responsible for the increased abundances of the two arctic species, *C. glacialis* and *C. hyperboreus*, and indirectly responsible for the decreased abundance of *C. finmarchicus* likely due to changes in food composition. In a recent paper by Yashayaev et al. (2013), it is stated that *C. finmarchicus* dominates the zooplankton biomass throughout the central region of the Labrador Sea while *C. glacialis* and *C. hyperboreus* dominate on the Labrador shelf. Furthermore, *C. finmarchicus* abundances are generally low on the Labrador Shelf and central Labrador Sea in the spring owing to fewer young stages of the zooplankton present from the new years' generations. Total abundances steadily increase up to and during the summer. *C. finmarchicus* abundances are generally higher in the eastern Labrador Sea rather than in the west during the spring because the earlier start of the spring bloom in this region lends to earlier reproduction in *C. finmarchicus* (Yashayaev et al. 2013). It is thought that increased melting of sea ice from ocean warming will increase overall plankton productivity and alter plankton community composition in Newfoundland and Labrador Shelves in the future (Harrison et al. 2013).

Planktonic organisms are so ubiquitous and abundant, and many have such rapid generation times, that there will be essentially no effect on planktonic communities from the seismic program. Planktonic stages of commercial invertebrates (e.g., crab) and fish (e.g., cod) that occur in the Study Area are described in the Labrador Shelf SEA (Sikumiut 2008) and in Section 4.2.2.2 of this EA related to reproduction in macroinvertebrates and fishes.

4.2.1.4 Benthos

Benthic invertebrates are bottom-dwelling organisms that can be classified into three categories: infaunal organisms, sessile organisms, and epibenthic species (Barrie et al. 1980). Infaunal organisms live on or are buried in soft substrates and include bivalves, polychaetes, amphipods, sipunculids, ophiuroids, and some gastropods. Sessile organisms live attached to hard substrates and would include barnacles, tunicates, bryzoans, holothurians, and some anemones. The epibenthic organisms are active swimmers that remain in close association to the seabed and include mysiids, amphipods, and decapods.

The benthic invertebrate communities of the Labrador Shelf area are described in the Labrador Shelf SEA (Sikumiut 2008). There have been a limited number of benthic studies conducted in the waters off Labrador, particularly those deeper than 200 m, the depths most commonly found in the Study Area. The studies described in the Labrador Shelf SEA (Sikumiut 2008) largely concern benthic organisms and communities occurring in inshore waters shallower than 200 m (e.g., Barrie et al. 1980). An extensive literature search revealed no new studies completed in offshore Labrador waters since the Labrador Shelf SEA (Sikumiut 2008) was prepared.

Benthic invertebrate communities can be spatially variable because of physical habitat characteristics such as water depth, substrate type, currents, and sedimentation. The primary factors affecting the structure and function of such communities in high latitude communities are water mass differences, sediment characteristics, and ice scour (Carey 1991). The wide range of these characteristics within the Labrador Shelf area ensures a variety of benthic communities. The structure and metabolism of benthic communities can also be directly affected by the rate of sedimentation of organic detritus in shelf and deeper waters (Desrosiers et al. 2000). The seasonality of phytoplankton can influence production in benthic communities, adding temporal variability to a highly heterogeneous community. The benthic environment in the Study Area can be broken into two distributional zones (Carey 1991):

1. Continental shelf where the biomass is higher at the shelf edge, and
2. Upper Slopes where the biomass begins to decrease.

Stewart et al. (1985) surveyed benthic invertebrates at stations on the continental shelf and slope of southeastern Baffin Island, in Ungava Bay, and on the northern Labrador Shelf. Water depths ranged from 106 to 970 m while bottom temperatures ranged from -0.7 to 4.3°C. Stations deeper than 600 m had fine sand-silt substrate while shallower stations generally had a sand substrate. Stewart et al. (1985) identified 492 species of molluscs, echinoderms, crustaceans, and polychaetes. Many of the species were present in low abundances at a small number of stations. The data indicate that the groupings of the marine benthic organisms were more commonly associated with particular water masses and temperature distribution than with substrate distribution.

Two stations examined by Stewart et al. (1985) were located on the northern Labrador shelf in water depths of 180 m (bottom temp. = 3.0°C; sand substrate) and 621 m (bottom temp. = 4.0ºC; silt and clay substrate). The dominant species, in terms of standing crop and abundance, at the shallower site were *Tachyrhynchus erosus* and *Macoma loveni* for molluscs; *Rhodine gracilior*, *Maldane sarsi,* and *Chaetozone setosa* for polychaetes; *Ophiura robusta* for echinoderms; and *Unciola leucopis* for crustaceans. The deeper site was dominated by *Yoldiella lucida*, *Thyasira gouldi*, and *Dentalium occidentale* for molluscs; *Glycera capitata*, *Ophelina cylindrocaudatus*, *Lumbrineris impatiens*, and an unidentified species for polychaetes; and *Amphipholis squamata* and *Amphiura fragilis* for echinoderms. The dominant crustaceans at the deeper site included *Ischyrocerus megacheir*, *Ampelisca gibba*, *Ampelisca amblyops*, *Haploops tubicola*, and *Byblis crassicornis*. At the shallower site, the water mass was influenced by mixing between the Labrador Current water and deeper, warmer Atlantic Intermediate water. The deeper site occurred under the Irminger Atlantic water mass.

Gilkinson (2013) provides summary data related to DFO research vessel trawl-caught benthos biomass in NAFO Divisions 2J3K between 2006 and 2010. Figure 1 in Gilkinson (2013) indicates that the trawl-caught benthos biomass during this period was dominated by sponges, sea anemones, snow crab, and echinoderms. Sponge catches tended to be higher in 2J compared to 3K while sea anemone catch biomass was greater in 3K.

LGL analysis of DFO research vessel (RV) data for 2007-2011 also indicated that sponges were the benthic group accounting for highest catch weight. Other invertebrate benthos with relatively high catch weights included snow crab, sea anemones, basket stars, corals, basket stars and sea urchins, confirmation of what was reported in Gilkinson (2013). No data were available regarding abundances of benthic invertebrates, corals, and sponges within international waters outside of the Canadian EEZ.

Deep-water Corals and Sponges

A variety of coral groups occur in Newfoundland and Labrador waters. These include scleractinians (solitary stony corals), antipatharians (black wire corals), alcyonaceans (large and small gorgonians, soft corals), and pennatulaceans (sea pens) (Wareham and Edinger 2007; Wareham 2009). Corals are largely distributed along the edge of the continental shelf and slope off Newfoundland and Labrador (Edinger et al. 2007; Wareham and Edinger 2007). Typically, they are found in canyons and along the edges of channels (Breeze et al. 1997), at depths greater than 200 m. Soft corals are distributed in both shallow and deep waters, while horny and stony corals (hard corals) are restricted to deep water in this region. Dense congregations of coral off Labrador are referred to as coral “forests” or “fields”. Others, such as small gorgonians, cup corals, and sea pens, prefer sand or mud substrates (Edinger et al. 2007). The distribution of various corals, based on data collected by fisheries observers, along the northern and southern regions of the Labrador coast (Edinger et al. 2007; Wareham and Edinger 2007) are provided in Figures 4.13 and 4.14 of the Labrador Shelf SEA (Sikumiut 2008). In total, thirty species of corals were documented, including two antipatharians (black wire corals), 13 alcyonaceans (large gorgonians, small gorgonians, and soft corals), four scleractinians (solitary stony corals), and 11 pennatulaceans (sea pens). The authors noted that corals were more widely distributed on the continental edge and slope.

Several recently published reports present information on the ecology of deep cold-water corals of Newfoundland and Labrador waters, including information on biogeography, life history, biochemistry, and relation to fishes (e.g., Gilkinson and Edinger 2009; Kenchington et al. 2010a,b; Baillon et al. 2012; Baker et al. 2012). Wareham (2009) updated deep-sea coral distribution data for the Newfoundland and Labrador and Arctic Regions to partially fill information gaps previously identified by Wareham and Edinger (2007). Their study area encompassed the continental shelf, edge, and slope ranging from Baffin Bay to the Grand Banks, including the Labrador Shelf (NAFO Divisions 2GHJ). Distributional maps were compiled by Wareham (2009) using DFO Newfoundland and Labrador Region Multispecies Surveys (2000 to 2007), DFO Arctic Multispecies Surveys (2006 to 2007), Northern Shrimp Survey (2005), and from Fisheries Observers aboard commercial fishing vessels (2004 to 2007). The maps provided by Wareham (2009) show the distribution of several coral groups occurring along the continental edge and slope from Baffin Bay to the Grand Banks. The groups profiled include antipatharians, alcyonaceans, scleractinians, and pennatulaceans. Six previously undocumented coral species, composed of one alcyonacean, two scleractinians, and three pennatulaceans, were identified in the Newfoundland and Labrador and Arctic Regions (Wareham 2009).

According to distribution maps included in Wareham (2009), there are numerous species of corals occurring within or adjacent to the Study Area. The species identified include large gorgonians (*Primnoa resedaeformis*, *Paragorgia arborea*, and *Paramuricea* spp.), small gorgonians (*Acanthogorgia armata*, *Acanella arbuscula*), and soft corals (*Anthomastus grandiflorus*, *Duva florida*, *Gersemia rubiformis*, and *Nephtheid* spp.). One scleractinian species (*Vaughanella margaritata*) and two pennatulacean species (*Anthoptilum grandiflorum* and unspecified sea pen species) are also noted to occur there. No antipatharian species were noted by Wareham (2009) to occur within this EA's Study Area. The majority of coral species were observed to occur on the continental slope, with the exception of several soft corals (*Gersemia rubiformis* and *Nephtheid* spp.) found distributed on the shelf. Map 1 in Wareham (2009) indicates a continuous coral distribution within the Study Area inside of the 1,000 m isobath, based on DFO RV survey catches. The area beyond 1,000 m was not sampled during the RV surveys. In DFO RV surveys conducted in the Study Area between 2007 and 2011, corals accounted for ~0.2% of the total catch weight (~0.5 mt) (see Table 4.4 in Section 4.3.7). Coral catches during the 2007 to 2011 RV surveys in the Study Area were highest in the northernmost portion of the Study Area (2G) and the western portion of 2H. Corals were caught in areas with water depths ranging between <200 to 1,000 m (see Figure 4.36 in Section 4.3.7).

The patterns of association between deep-sea corals, fish and invertebrate species, based on DFO scientific surveys and remotely operated vehicle (ROV) surveys, are discussed by Edinger et al. (2009). There were no dramatic relationships between corals and abundance of the ten groundfish species studied, probably because few, if any, reef building corals have been located off Newfoundland and Labrador. However, Edinger et al. (2009) did find a weak but statistically significant positive correlation between coral species richness and fish species richness. For various sample segment lengths and depth ranges in the southern Grand Banks, Baker et al. (2012) found significant positive relationships between the presence and/or abundance of roundnose grenadier (*Coryphaenoides* *rupestris*) with that of large skeletal corals and cup corals, of roughhead grenadier (*Macrourus berglax*) with large gorgonians/antipatharians and soft corals, and of marlin-spike grenadier (*Nezumia bairdii*) with small gorgonians. Baillon et al. (2012) determined that several types of coral, particularly sea pens (e.g., *Anthoptilum grandiflorum*) were hosts to eggs and/or larvae of two redfish species (*Sebastes fasciatus* and *S. mentella*), lantern fish (*Benthosema glaciale*), and greater eelpout (*Lycodes esmarkii*) in the Laurentian Channel and southern Grand Banks. This suggests that habitats that support diverse corals may also support diverse assemblages of fishes. Although relationships between corals and groundfish or invertebrates are not obligate and may result from coincidence, conservation areas established for corals may effectively protect populations of groundfish, including some commercial species (Edinger et al. 2009). By increasing the spatial and hydrodynamic complexity of habitats, deep-sea corals may provide important, but probably not critical, habitat for a wide variety of fishes. Effects of deep-sea corals on fish habitat and communities may include higher prey abundance, greater water turbulence, and resting places for a wide variety of fish size classes (Auster et al. 2005 and Costello et al. 2005 *in* Edinger et al. 2009).

Sponges also provide deep-sea habitat, enhance species richness and diversity, and cause clear ecological effects on other local fauna. Sponge grounds and reefs support increased biodiversity compared to structurally-complex abiotic habitats or habitats that do not contain these organisms (Beazley et al. 2013). Kenchington et al. (2013) noted the association of several demersal fish taxa with Geodia-dominated sponge grounds on the Grand Banks and Flemish Cap. Beazley et al. (2013) determined that deep-water sponge grounds in the northwest Atlantic contained a significantly higher biodiversity and abundance of associated megafauna compared to non-sponge habitat.

Morphological forms such as thick encrustations, mounds, and branched, barrel- or fan-like shapes influence near-bottom currents and sedimentation patterns. They provide substrate for other species and offer shelter for associated fauna through the provision of holes, crevices, and spaces. Siliceous hexactinelid sponges can form reefs as their glass spicules fuse together; when the sponge dies, the skeleton remains. This skeleton provides settlement surfaces for other sponges, which in turn form a network that is subsequently filled with sediment (DFO 2010a).

Although some of the siliceous spicules of non-reef-forming species dissolve quickly, there is some accumulation of shed spicules forming a thick sediment-stabilizing mat, which constitutes a special bottom type supporting a rich diversity of species. Organisms commonly associated with sponges and sponge grounds include species of marine worms and bryozoans, as well as higher fauna. Live glass sponge reefs have been shown to provide nursery habitat for juvenile rockfish, and high-complexity reefs are associated with higher species richness and abundance (DFO 2010a).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, sponges accounted for the fifth highest catch weight (~17 mt) (see Table 4.4 in Section 4.3.7). Sponge catches during the 2007 to 2011 RV surveys in the Study Area were highest along the 500 and 1,000 m isobaths, particularly in the most northerly (2G) and the south-central portions of the Study Area (2J3K). Sponges were caught in areas with water depths ranging between <200 to >1,000 m (see Figure 4.35 in Section 4.3.7).

In 2008 and 2009, the North Atlantic Fisheries Organization (NAFO) Scientific Council identified areas of significant coral and sponge concentrations within the NAFO Regulatory Area (DFO 2010a). NAFO Coral/Sponge Closure Area Five was updated in 2012. These areas that are closed to fishing with bottom gear are shown in Section 4.7 on Sensitive Areas.

4.2.2 Fish

For the purposes of this EA, 'fish' includes macroinvertebrates that are targeted in the commercial fisheries and all fishes, targeted in the commercial fisheries or otherwise.

4.2.2.1 Macroinvertebrate and Fish Species Harvested during Commercial Fisheries

This section describes the principal macroinvertebrate and fish species that are typically harvested in the Study Area during commercial fisheries. These include both targeted species (e.g., northern shrimp, snow crab, Greenland halibut or turbot, striped shrimp) and other species caught incidentally.

Four species (northern shrimp, snow crab, Greenland halibut, and striped shrimp) have dominated directed commercial landings data for the Study Area in recent years. Species are discussed in decreasing order of catch weight for the 2005 to 2010 period (see Section 4.3.3). Some of the 'incidental catch' species (e.g., wolffish, Atlantic cod, American plaice) are also discussed in this section.

Northern Shrimp

The primary cold-water shrimp resource in the north Atlantic, the northern shrimp (*Pandalus borealis*), is distributed from Davis Strait to the Gulf of Maine. It usually occupies areas with soft muddy substrates, depths ranging from 150 to 600 m, and water temperatures ranging from 1 to 6°C (DFO 2013a). Larger individuals generally occur in deeper waters (DFO 2013b). During the day, shrimp generally rest and feed on or near the ocean floor. They commence a diel vertical migration at night with large abundances of shrimp moving off the bottom into the water column to feed on zooplankton. Female shrimp also undergo a seasonal migration to shallower areas to spawn (DFO 2013b).

Northern shrimp are protandric hermaphrodites. They first mature as males, mate as males for one to several years and then permanently change to mature females (DFO 2013a). Eggs are typically extruded in the 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 2013b). Northern shrimp are known to live for more than eight years in some areas and are thought to begin recruitment to the fishery as early as age three. Some northern populations exhibit slower rates of growth and maturation but greater longevity that results in larger maximum size (DFO 2013b).

As with most crustaceans, northern shrimp grow by moulting their shells. During this period, the new shell is soft, causing them to be highly vulnerable to predators such as Greenland halibut, cod, Atlantic halibut, skates, wolffishes, and harp seals. Northern shrimp are vulnerable to these predators regardless of whether they have a soft shell or not (DFO 2013a).

In the Study Area commercial fishery conducted between 2005 and 2010, northern shrimp accounted for the highest average annual catch weight (~86,000 mt) (see Table 4.2 in Section 4.3.3.2). Highest catches occurred in NAFO Divisions 2J3K portions of the Study Area and the locations of concentrated harvesting reflected the highest catch areas highlighted for the RV surveys (see Figures 4.11 to 4.13 in Section 4.3.3.5). In updates of northern shrimp assessments for NAFO Division 2G, Hopedale and Cartwright Channels, Hawke Channel and Division 3K, Orr et al. (2011) concluded that the northern shrimp resource appears to be decreasing in the south but increasing in the north.

In DFO RV surveys conducted in the Study Area between 2007 and 2011, northern shrimp accounted for the highest catch weight (~59 mt) (see Table 4.4 in Section 4.3.7). Shrimp were caught during the 2007-2011 RV surveys throughout the portion of the Study Area shallower than 500 m, with the highest catches occurring between the 200 and 500 m isobaths (see Figure 4.31 in Section 4.3.7).

Snow Crab

The snow crab (*Chionoecetes opilio*), a decapod crustacean, occurs over a broad depth range in the northwest Atlantic from Greenland south to the Gulf of Maine (DFO 2013c). Snow crab distribution is widespread and continuous in waters off Newfoundland and southern Labrador. Generally, snow crabs undertake a migration from shallow cold areas with hard substrates to warmer deeper areas with soft substrates as they develop. Large males are most commonly found on mud or mud/sand, while smaller crabs are more common on harder substrates (DFO 2013c).

After spring hatching, snow crabs undergo a multi-stage life cycle including a 12 to 15 week planktonic larval period before settlement. Benthic juveniles of both sexes molt frequently, becoming sexually mature at about 40 mm CW (~4 years of age). Female crabs carry fertilized eggs for about two years (DFO 2013c). Snow crabs are believed to be recruited to the fishery at approximately 10 years of age in warmer areas (e.g., Div. 2J3K) while those in colder areas (e.g., Subdiv. 3LNOPs) are recruited at higher ages owing to less frequent molting in colder temperatures (Dawe et al. 2010 *in* DFO 2013c).

Snow crabs typically feed on fish, clams, benthic worms, brittle stars, shrimps and crustaceans, including smaller snow crabs. Their predators include various groundfish, other snow crabs, and seals (DFO 2013c).

There are two fishery closure areas that occur in the Project Area: (1) Hawke Channel; and (2) Funk Island Deep (see Figure 4.1); both were created to offer protection to snow crab (DFO, pers. comm. 2013). More details on these closure areas are provided in Section 4.7 on Sensitive Areas (also see Figure 4.45).

In the Study Area commercial fishery conducted between 2005 and 2010, snow crab accounted for the second highest average annual catch weight (~7,600 mt) (see Table 4.2 in Section 4.3.3.2). Highest catches occurred in the western NAFO Division 3K portion of the Study Area, followed by the 2J portion in the inshore part of the Cartwright Channel and south of Hamilton Bank in the area of Hawke Channel. Most of the snow crab catches in the Study Area during the six-year period occurred at water depths >200 and <500 m (see Figures 4.16 to 4.18 in Section 4.3.3.5). Snow crab landings in NAFO Div. 2HJ between 2008 and 2012 have decreased by 37% while landings in NAFO Div. 3K (offshore) declined by 52% between 2009 and 2012 (DFO 2013c). Long-term recruitment prospects in these NAFO Divisions are considered unfavourable due to a recent warm oceanic regime (DFO 2013c). Decreases in exploitable snow crab biomass in NAFO Div. 2HJ3K during recent years are also indicated in Mullowney et al. (2013).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, snow crabs accounted for the thirteenth highest catch weight (~2.3 mt) (see Table 4.4 in Section 4.3.7). Snow crab total catch weight during the 2007-2011 RV surveys in the Study Area was relatively low (i.e., ~2.3 mt) and subsequently, was not mapped.

Greenland Halibut (Turbot)

The Greenland halibut (*Reinhardtius hippoglossoides*), often referred to as turbot, is distributed throughout the cold, deep waters of the Labrador-eastern Newfoundland area, inhabiting the continental shelf and slope at depths of 200 to >2,200 m (Smidt 1969; Morgan et al. 2013a). High abundances of the species occur in the Hopedale, Cartwright, and Hawke Channels of mid to southern Labrador (Bowering and Chumakov 1989; Healey 2013). High abundances in shelf channels have been attributed to high concentrations of available prey, namely northern shrimp (Bowering 1983). Greenland halibut feed on a variety of species, including shrimp, small pelagic crustaceans, small fish (e.g., Arctic cod, capelin), larger fish (e.g., redfish, grenadier), and squid (DFO 2008a).

Greenland halibut inhabiting the continental shelf of Labrador are predominately immature (Bowering 1977, 1981, 1983; Zilanov et al. 1976; Bowering and Chumakov 1989). The majority of the adult population is distributed in the deep and warm north Atlantic waters (e.g., Davis Strait, between Greenland and Baffin Island) where spawning typically occurs in winter or early spring (Templeman 1973; Bowering 1983; Bowering and Brodie 1995; Bowering and Nedreaas 2000). Larvae and juveniles are transported south by oceanic currents and colonize the deep channels of the Labrador banks (Bowering 1983; Bowering and Brodie 1995). Greenland halibut are highly mobile and capable of travelling long distances (Boje 2002). In the Labrador Shelf area, halibut move progressively offshore to the deep edges of the continental slope with increasing age and size (Bowering and Brodie 1995; Bowering and Nedreaas 2000). With increasing maturity, most Greenland halibut presumably migrate northward to areas such as Davis Strait to spawn (Templeman 1973; Chumakov 1975; Bowering and Brodie 1995). In addition, movements and changes in distribution of Greenland halibut may be due to fluctuations in oceanic temperatures (Morgan et al. 2013a). Small-scale localized spawning may also occur along the deep slopes of the continental shelf throughout its range (Bowering and Brodie 1995).

Most of the Greenland halibut resource appears to occur in Divisions 2H, 2J and 3K. Survey estimates of stock biomass in these areas have increased during recent years and are near the 1978-2012 time-series average. Estimates of juvenile fish abundances in age groups 1 and 2 captured in the 2012 survey have shown large decreases in these age groups, approximately 65% below average

(Healey 2013). Historically, there was also considerably high abundances of Greenland halibut along the deep slopes of the continental shelf of Div. 2G. However, widespread migration southwards to Div. 3K is believed to have greatly reduced their distributions in this area (Bowering and Power 1995; Healey 2013).

In the Study Area commercial fishery conducted between 2005 and 2010, Greenland halibut accounted for the third highest average annual catch weight (~3,600 mt) (see Table 4.2 in Section 4.3.3.2). Locations with most concentrated commercial harvesting included between the 200 and 500 m isobaths in 2G and 2H, and along the 1,000 m isobaths from 2J to 3K (see Figures 4.21 to 4.23 in Section 4.3.3.5).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, Greenland halibut accounted for the fourth highest catch weight (~31 mt) (see Table 4.4 in Section 4.3.7). Greenland halibut catches during the 2007-2011 RV surveys in the Study Area were highest in the central-west and southwest portions of the Study Area (2HJ3K), particularly between the 200 and 500 m isobaths. Greenland halibut were caught in areas with water depths ranging between <200 to 1,000 m (see Figure 4.34 in Section 4.3.7).

Striped Shrimp

Striped shrimp (*Pandalus montagui*) are distributed from Davis Strait to the Bay of Fundy. As is the case with northern shrimp, the striped shrimp shows preferences for both depth and water temperature. It prefers slightly cooler water (-1 to 2°C) than the northern shrimp and is therefore more commonly distributed at shallower depths (200–500 m). Striped shrimp also appear to prefer harder substrates than northern shrimp (DFO 2013a). Striped shrimp, primarily males and smaller females, migrate into the water column at night. This shrimp is an opportunistic feeder at or near the sea bottom and as well as in the water column. Striped shrimp are thought to live for five to eight years. As is the case with northern shrimp, striped shrimp are an important forage species (DFO 2013a).

Striped shrimp are also protandric hermaphrodites. They first mature as males, mate as males for one to several years, and then permanently change to mature females. Eggs are typically produced once a year in the late summer/fall and remain attached to the female until the following spring when the female migrates to shallow coastal waters where larval hatch occurs. The larvae remain planktonic for three to four months, after which they settle to the bottom and begin the epibenthic portion of their life history (DFO 2013a).

There is some directed fishery for the striped shrimp but most of its harvesting is as a result of by-catch in the northern shrimp fishery (DFO 2011a). In the Study Area commercial fishery conducted between 2005 and 2010, it accounted for the fourth highest average annual catch weight (~1,800 mt) (see Table 4.2 in Section 4.3.3.2). This is only about 2% of the commercial fishery average annual catch weight for northern shrimp in the Study Area during the same period (~86,000 mt). Virtually all striped shrimp catches occurred in the extreme northwestern corner of the Study Area, typically in areas with water depths ranging from 200 to 500 m (see Figures 4.26 to 4.28 in Section 4.3.3.5).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, striped shrimp total catch weight was relatively low (~4 mt) and subsequently was not mapped (see Table 4.4 in Section 4.3.7).

Wolffishes

All three species of wolffish (i.e., northern, spotted and Atlantic) are discussed in Section 4.6 on Species at Risk. Both the northern (*Anarhichas denticulatus*) and spotted (*Anarhichas minor*) wolffishes have *threatened* status under Schedule 1 of *SARA* and under COSEWIC. The Atlantic wolffish (*Anarhichas lupus*) currently has *special concern* status under both Schedule 1 of *SARA* and COSEWIC (DFO 2013d). Wolffishes were also incidentally harvested, but not landed, during directed commercial harvests within the Study Area.

Wolffishes accounted for slightly more than 3.4 mt of total catch weight in DFO RV surveys conducted in the Study Area between 2007 and 2011 (see Table 4.4 in Section 4.3.7). In total, more than 4,200 individual wolffish were caught that five-year period, 79% of which were Atlantic wolfish. In terms of catch weight, northern wolffish and spotted wolffish accounted for about 78% of the total wolffish biomass caught during RV surveys in the Study Area between 2007 and 2011 (see Table 4.4 in Section 4.3.7). However, considering their status under Schedule 1 of *SARA*, their harvest location distributions were mapped (see Figures 4.37 to 4.39 in Section 4.3.7). All three species were caught throughout the portion of Study Area surveyed.

Redfish

The northwest Atlantic redfish consist of a complex of three species identified as Acadian redfish (*S. fasciatus*), golden redfish (*S. marinus*), and deepwater redfish (*S. mentella*) (DFO 2012a). Acadian redfish and deepwater redfish both have *threatened* status under COSEWIC but no status under Schedule 1 of *SARA*. The redfish distribution in the northwest Atlantic ranges from the Gulf of Maine, northwards off Nova Scotia and southern Newfoundland banks, in the Gulf of St. Lawrence, and along the continental slope and deep channels from the southwestern Grand Bank to areas as far north as Baffin Island. Redfish are also present in the area of Flemish Cap and west of Greenland.

Redfish (*Sebastes* spp.) typically inhabit cool waters (3 to 8°C) along the slopes of banks and deep channels in depths of 100 to 700 m (Scott and Scott 1988; DFO 2012a). Although generally found near the bottom, redfish are known to undertake diel vertical migrations, moving off the bottom at night to follow the migration of their prey (DFO 2012a). Redfish are pelagic or bathypelagic feeders, feeding primarily on zooplankton such as copepods, amphipods, and euphausiids. Fishes and crustaceans become more important in the diet of larger redfish (Scott and Scott 1988). Greenland halibut and skate are the primary predators of redfish on the Labrador shelf (DFO 2012a).

The deepwater redfish and Acadian redfish, the two most important commercially-targeted species, are distributed according to a gradient in the northwest Atlantic (DFO 2012a). The deepwater redfish is the dominant species in northern areas, such as Baffin Island and in Labrador waters, whereas Acadian redfish dominates in the Gulf of Maine and the basins and continental slope of the western Scotian Shelf (the latter known collectively as Unit 3). Their distributions overlap in the Gulf of St. Lawrence (Unit

1), the Laurentian Channel (Unit 2), off Newfoundland (3LN, 3M, 3O), and south of the Labrador Sea (2J, 3K). In areas of distributional overlap, deepwater redfish generally occur in deeper water (350 to 500 m) than Acadian redfish (150 to 300 m).

Redfish are generally slow-growing and long-lived fishes (DFO 2012a). Maturation in redfish occurs between 8–10 years of age with Acadian redfish maturing, on average, 1–2 years earlier than deepwater redfish. Males also mature, on average, 1–2 years earlier than females within the same species. The reproductive cycle of redfish is quite different than those of most other fish species. Redfish are ovoviviparous, meaning fertilization is internal and females bear live young. Mating takes place in the fall, most likely between September and December, and females carry the developing embryos until they are extruded as free swimming larvae in spring. Larval extrusion takes place from April to July, the timing being dependent on location and species. Mating and larval extrusion do not necessarily occur in the same locations.

Two biological stocks of *Sebastes* occurs in the Study Area: (1) the northern population of deepwater redfish (SA2+Div.3K); and (2) the Labrador Shelf population of Acadian redfish (SA2+Div.3K) (DFO 2012a). The Div.2J3K portion of the northern population of deepwater redfish stock is believed to be experiencing increased growth while the portion in the rest of SA2 appears to be decreasing. The Labrador Shelf population of Acadian redfish appears to be growing throughout the Study Area (DFO 2012a).

In the Study Area's commercial fishery conducted between 2005 and 2010, redfish accounted for the fifth highest average annual catch weight (~56 mt) (see Table 4.2 in Section 4.3.3.2), an extremely small proportion of the overall total catch weight in the Study Area during that period. Redfish catches were incidental in the commercial fishery.

In DFO RV surveys conducted in the Study Area between 2007 and 2011, deepwater redfish catch weight was second highest (~53 mt) (see Table 4.4 in Section 4.3.7). Deepwater redfish catches during the 2007-2011 RV surveys in the Study Area were highest along the 500 to 1,000 m isobaths (see Figure 4.32 in Section 4.3.7).

Roughhead Grenadier

Although it does not have any status under Schedule 1 of *SARA*, the roughhead grenadier (*Macrourus berglax*) currently has *special concern* status under COSEWIC (COSEWIC 2007).

The roughhead grenadier occurs in deep water along coasts in subarctic to temperate waters on both sides of the north Atlantic. In the northwest Atlantic, this species of grenadier occurs from Davis Strait along the continental slope, off Newfoundland, off Nova Scotia on Banquereau, Sable Island and Browns Bank, and on Georges Bank (Scott and Scott 1988). The range for this species extends beyond Canada's EEZ (COSEWIC 2007). The roughhead grenadier is predominant at depths ranging from 800 to 1,500 m, although they may also occur at lesser and greater depths (i.e., 200–2,000 m) (Murua and De Cardenas 2005 *in* Gonzalez-Costas 2013). Catches tend to be highest at locations where water temperatures range from 2.0 to 3.5ºC (Scott and Scott 1988).

Roughhead grenadier has slow growth rates, late maturation, low fecundity, and low population turnover rates (COSEWIC 2007). Spawning is thought to occur during the winter and early spring. Little is known about its spawning grounds off Newfoundland and Labrador although there is some thought that some spawning occurs on the southern and southeastern slopes of the Grand Banks (Scott and Scott 1988; COSEWIC 2007). Roughhead grenadier eggs are pelagic (Eliassen and Falk-Peterson 1985 *in* COSEWIC 2007). Food for the roughhead grenadier consists of a variety of benthic invertebrates including bivalve molluscs, shrimp, seastars, polychaetes, and some fish. Roughhead grenadier has been found in the stomachs of Atlantic cod.

This grenadier species is quickly becoming an important commercial fish in the northwest Atlantic. Presently its fishery is unregulated since it is usually taken as bycatch in the Greenland halibut fishery (González-Costas 2013). In the Study Area's commercial fishery conducted between 2005 and 2010, roughhead grenadier accounted for the seventh highest average annual catch weight (~27 mt) (see Table 4.2 in Section 4.3.3.2).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, roughhead grenadier catch weight was the ninth highest (~4 mt) (see Table 4.4 in Section 4.3.7). Roughhead grenadier catches during the RV surveys were not mapped in this EA.

American Plaice

The Newfoundland and Labrador population of American plaice (*Hippoglossoides platessoides*) currently has no status under Schedule 1 of *SARA* but it does have *threatened* status under COSEWIC (COSEWIC 2009a; DFO 2012b).

The American plaice is a bottom-dwelling flatfish that resides on both sides of the Atlantic (COSEWIC 2009a). American plaice that reside in the western Atlantic region range from the deep waters off Baffin Island and western Hudson's Bay southward to the Gulf of Maine and Rhode Island (Scott and Scott 1988). In Newfoundland waters, plaice occur both inshore and offshore over a wide variety of bottom types (Morgan 2000) but seem to prefer fine sand and gravel substrates (DFO 2012b). It is tolerant of a wide range of salinities and has been observed in estuaries (Scott and Scott 1988; Jury et al. 1994). Adult and juvenile plaice typically inhabit similar areas at depths ranging from 20 to 700 m but primarily at depths of 100 to 300 m (DFO 2012b). Most commercially harvested plaice are taken at depths of 125 to 200 m. It is a coldwater species, preferring water temperatures of -1.5°C to 13°C, but is most abundant at temperatures ranging from just below zero to -1.5°C (DFO 2012b). Tagging studies in Newfoundland waters suggest that, once settled, juveniles and adults are rather sedentary and do not undertake large scale migrations (DFO 2008b). However, older plaice have been known to travel as far as 160 km (Powles 1965). Migrations have been observed in Canadian waters to deeper offshore waters in the winter, returning to shallower water in the spring (Hebert and Wearing-Wilde 2002 *in* Johnson 2004).

In Newfoundland waters, American plaice spawn during the spring (Scott and Scott 1988). Within the Study Area, there is limited data with respect to the actual spawning times. American plaice in the

Newfoundland Region spawn over the entire area within which they occur (DFO 2008b) with the most intense spawning coincident with areas with the highest abundance of adults (Busby et al. 2007; DFO 2012b). Limited data in southern areas (e.g., Burgeo Bank, St. Pierre Bank and along the slopes of the Laurentian Channel and Hermitage Channel) indicate that spawning does occur in April and possibly other months (Ollerhead et al. 2004). In addition, spawning in southern areas (e.g., St. Pierre Bank) typically occurs in water temperatures of about 2.7°C (Scott and Scott 1988). American plaice are group synchronous, batch spawners that generally release eggs in batches every few days (DFO 2012b). Large quantities of eggs are released and fertilized over a period of days on the seabed (Johnson 2004). Eggs are buoyant and drift into the upper water column where they are widely dispersed. Hatching time is temperature dependant, occurring in 11 to 14 days at temperatures of 5°C (Scott and Scott 1988). Larvae are 4 to 6 mm in length at hatch and subsequent settlement to the seabed occurs when they reach 18 to 34 mm in length and their body flattens (Fahay 1983).

In SA2 + Div. 3K, the American plaice stock declined to very low levels by the early 1990s. Total mortality has been decreasing in recent years but stock biomass remains at only 10% of the values seen in the 1980s (Morgan et al. 2013b)

American plaice catches in the commercial fishery are incidental in other directed fisheries. During 2005-2010, the average annual catch weight for this flatfish was about 12 mt, ranking ninth overall (see Table 4.2 in Section 4.3.3.2).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, American plaice catch weight ranked twelfth (~3 mt) (see Table 4.4 in Section 4.3.7). American plaice catches during the RV surveys were not mapped in this EA.

Atlantic Cod

The Newfoundland and Labrador population of Atlantic cod (*Gadus morhua*) has *endangered* status under COSEWIC but no status under Schedule 1 of *SARA* (COSEWIC 2010a). Cod in the Newfoundland and Labrador population inhabit waters ranging from immediately north of Cape Chidley on the northern tip of Labrador southeast to Grand Bank off eastern Newfoundland. For management purposes, cod in this population are treated as three separate stocks by DFO: (1) northern Labrador cod (NAFO Divisions 2GH), (2) "northern cod" i.e., those found off southeastern Labrador, the northeast Newfoundland Shelf, and the northern half of Grand Bank (NAFO Divisions 2J3KL, and (3) southern Grand Bank cod (NAFO Divisions 3NO). Cod in the Study Area are considered to be those of the northern Labrador (2GH) cod stock and the 'northern cod' (2J3KL). Cod in NAFO Subdiv. 0AB are part of the Arctic population and are also likely to occur in the Study Area. The following paragraphs provide an overall summary of the life history and ecology of Atlantic cod in Canadian waters, regardless of cod population or stock (Brattey et al. 2011).

The Atlantic cod is a demersal fish that inhabits cold waters in coastal areas and in offshore waters overlying the continental shelf throughout the Atlantic Ocean (COSEWIC 2010a). The species is found contiguously along the east coast of Canada from Baffin Island to Georges Bank. During the first few weeks of life, cod eggs and larvae are found in the upper 50 m of the water column. As juveniles, cod are settled on the bottom and tend to occur in nearshore habitats with vertical structure such as eelgrass (*Zostera marina*) and macroalgae. As adults, the habitat requirements of cod are increasingly diverse.

Atlantic cod typically spawn over a period of less than three months in water that may vary in depth from tens to hundreds of metres (COSEWIC 2010a). Cod are described as batch spawners because only a small percentage (5 to 25%) of the female's egg total is released at any given time during a three to six week period. After hatching, larvae obtain nourishment from a yolk sac until they have reached a length of 1.5 to 2.0 mm. During the larval stage, the young feed on phytoplankton and small zooplankton in the upper 10 to 50 m of the water column. After the larval stage, the juveniles settle to the bottom where they appear to remain for a period of 1 to 4 years. These settlement areas are known to range from very shallow (<10 to 30 m) coastal waters to moderately deep (50 to 150 m) waters on offshore banks. After this settlement period, it is believed that the fish begin to undertake seasonal movements and migrations characteristic of adults.

Dispersal in Atlantic cod appears to be limited to the egg and larval phases of life, during which surface and near-surface water currents and turbulence are the primary determinants of horizontal and vertical displacement in the water column (COSEWIC 2010a). For some cod populations, eggs and larvae are capable of dispersing very long distances. For example, cod eggs spawned off southeastern Labrador (NAFO Division 2J) may possibly disperse as far south as Grand Bank. By contrast, eggs spawned by cod in inshore, coastal waters, especially at the heads of large bays, may experience dispersal distances of a few kilometres or less.

Long-term movements by cod take the form of seasonal migrations (COSEWIC 2010a). These migrations can be attributed to geographical and seasonal differences in water temperature, food supply, and possibly spawning grounds. At one extreme, some inshore populations are suspected to have extremely short migrations, possibly limited to tens of kilometres or less. In contrast, cod in other populations are known to move hundreds of kilometres during their seasonal migrations.

Since the early 1970s, the northern Labrador cod stock (2GH) has been managed separately from southern Labrador cod (2J) because of differing characteristics (e.g., growth rates) of the stocks (ICNAF 1973). In addition, stock separation was influenced by over-fishing experienced in the 1960s, which affected the cod stock more in northern Labrador than in southern areas (Pinhorn 1976; DFO 2013e). According to COSEWIC (2010a), cod abundance in the inshore and offshore waters of Labrador and northeastern Newfoundland has declined by 97–99% since the 1960s and is currently at historical lows. Virtually no recovery of either abundance or age structure of offshore cod has been observed since the moratoria were imposed in the early 1990s, and threats to persistence include fishing, predation by fish and seals, and natural and fishing-induced ecosystem changes. There is currently no directed fishery for cod in the Study Area, and only a relatively small quantity of cod by-catch is allowed. The stock remains at a low level (DFO 2013e).

Overall, the status of the 2J3KL cod stock has improved, particularly during 2004-2008. However, the improvements are limited to areas adjacent to the 3KL border and the central portion of the inshore. The stock has not increased across much of the historical geographic range (Brattey et al. 2011)

There are two fishery closure areas that occur in the Project Area: (1) Hawke Channel; and (2) Funk Island Deep (see Figure 4.1 in Section 4.2.1.1); both were created to offer protection to Atlantic cod (DFO, pers. comm. 2013). More details on these closure areas are provided in Section 4.7 on Sensitive Areas (also see Figure 4.45).

Atlantic cod catches in the commercial fishery are incidental in other directed fisheries. During 2005-2010, the average annual catch weight for this flatfish was about 1 mt, twelfth overall (see Table 4.2 in Section 4.3.3.2).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, Atlantic cod catch weight ranked seventh (~4.4 mt) (see Table 4.4 in Section 4.3.7). Atlantic cod catches during the RV surveys were not mapped in this EA.

Roundnose Grenadier

Although it does not have any status under Schedule 1 of *SARA*, roundnose grenadier (*Coryphaenoides rupestris*) currently has *endangered* status under COSEWIC. This designation is based on declines of roundnose grenadier in both DFO RV fall bottom trawl surveys in NAFO Divisions 2J3KL and in commercial catch rates. Populations of roundnose grenadier have declined by more than 95% since 2000 (COSEWIC 2008a).

Distributed in the northwest Atlantic from Cape Hatteras to Greenland, the roundnose grenadier is a deepwater, demersal fish found in continental slope areas at depths of 180 to 2,600 m, but primarily occurs between 400 to 1,200 m (DFO 2010b). DFO RV surveys indicate catches are concentrated along the perimeter of the continental slope in NAFO Divisions 2HJ3KLNO. This species is thought to undergo seasonal migrations with individuals in northeast Newfoundland and Labrador waters occupying deeper water in winter and shallower water in late summer, possibly due to prey availability and/or temperature differences (DFO 2010b). Roundnose grenadier prefer a temperature range of 3.5 to 4.5°C and will form dense aggregations in areas where warm water lies directly above the seabed. It appears to prefer areas with weak currents and tend to aggregate in troughs, gorges, terraces, and lower parts of the slope (DFO 2010b). Diurnal vertical migrations also occur that may carry them more than 1,000 m off the bottom (COSEWIC 2008a). The long-lived, late-maturing, slow-growing species has a low fecundity and is potentially vulnerable to overfishing (Devine and Haedrich 2008). The roundnose grenadier harvest has been under a moratorium in Canadian waters in NAFO Subareas 2 and 3 since the 1990s, and is currently under moratorium in NAFO Subarea 0 as well. Roundnose grenadier is harvested as bycatch in other fisheries (e.g., Greenland halibut fishery) inside and outside the 200 mile limit (Power 1999, DFO 2010b). Population models indicate that current bycatch levels appear to be sustainable but reductions in bycatch of roundnose grenadier could aid in recovery of stocks (DFO 2010b).

This species is known as a batch spawner, releasing eggs in more than one spawning event per spawning season (DFO 2010b). Roundnose grenadier spawning grounds are largely unknown but suspected to be in waters deeper than 850 m. Spawning is believed to occur either in different areas throughout the northwest Atlantic (COSEWIC 2008a) or predominately in Icelandic waters from which eggs and larvae are carried to other areas in the northwest Atlantic by currents (Scott and Scott 1988). The spawning time is uncertain but believed to be throughout the year with more intense spawning during particular periods (Atkinson 1995). The roundnose grenadier feeds on a variety of small crustaceans and euphasiids, squid, and small fishes. According to Kearley (2012), its main predators include at least two species of redfish and blue ling (*Molva dypterygia*).

Despite large declines in the roundnose grenadier resource from the 1990s, recent trends in abundance in Div. 2J3K from 1995-2009 suggest that catch rates are potentially increasing (DFO 2010b).

In DFO RV surveys conducted in the Study Area between 2007 and 2011, roundnose grenadier catch weight ranked sixteenth (~2 mt) (see Table 4.4 in Section 4.3.7). Roundnose grenadier catches during the RV surveys were not mapped in this EA.

Atlantic Salmon

Various populations of Atlantic salmon (*Salmo salar*), all of which potentially pass through the Study Area during migration, have various status listings under COSEWIC, including *endangered*, *threatened* and *special concern*. In particular, the south Newfoundland population was designated *threatened* by COSEWIC in 2010 due to a significant 42.4% decline in abundance of Atlantic salmon over the last three generations (1996-2010) (COSEWIC 2010b). No Atlantic salmon populations have status under Schedule 1 of *SARA*.

The Atlantic salmon is an anadromous fish that lives in fresh water for one to eight years before migrating to sea for one to four years, after which time it returns to freshwater to spawn (COSEWIC 2010b). Unlike Pacific salmon (*Onchorhynchus* spp.), Atlantic salmon can spawn repeatedly (Schaffer 1974 *in* O'Connell et al. 2006; Flemming and Reynolds 2004 *in* O'Connell et al. 2006). The range of Atlantic salmon distribution in Canadian waters extends northward from the St. Croix River to the outer Ungava Bay and eastern Hudson Bay in Quebec. Approximately 700 Canadian rivers have supported Atlantic salmon populations in the past (COSEWIC 2010b).

Atlantic salmon return to their natal rivers or tributaries for spawning in freshwater through a process called homing. Both post-smolt (juvenile) and adult salmon migrate from northeastern North America in the spring and summer to waters off Labrador and Greenland to overwinter. During these migrations, Atlantic salmon appear to transit the Study Area in early to mid-summer and late summer to fall (Reddin 2006). While at sea, adult salmon spend a considerable amount of time in the upper portion of the water column (Reddin 2006). Tagging studies of post-smolts indicate that they spend most of their time near the surface but at times dive deeply, likely in search of prey (Reddin et al. 2006).

Adults at sea consume euphausiids, amphipods and fishes such as herring, capelin, small mackerel, sand lance and small cod. When salmon return to fresh water to spawn, they likely do not eat (Scott and Scott 1988). The causes of at-sea mortality of salmon are poorly understood (Reddin 2006) but it is known that they are prey for seals, sharks, pollock, and tuna (Scott and Scott 1988). In general, low marine survival appears to be the main attributable factor which is presently limiting the abundance of Newfoundland and Labrador salmon. Some factors which may influence marine survival include illegal fisheries, mixed-stock marine fisheries and by-catch, ecological and genetic interactions with escaped domestic Atlantic salmon, and changes in marine ecosystems (DFO 2013f).

Commercial salmon harvesting ceased in insular Newfoundland in 1992, the Straits area of Labrador in 1997, and the remainder of Labrador in 1998. Recreational angling in freshwater and an Aboriginal subsistence fishery nearshore still occur (Reddin et al. 2006, DFO 2012c). The latter, which has seen landings increase from 16 mt in 2000 to 32 mt in 2005 and 2006, is undertaken by three groups consisting of the Nunatsiavut Government (formerly the Labrador Inuit Association or LIA), the Nunatukavut Community Council (NCC; formerly the Labrador Métis Nation), and the Innu Nation (Reddin et al. 2006). According to DFO (2012c), recent numbers of small and large salmon in Labrador were above the previous six year average but below levels achieved prior to the moratorium. In 2011, returns of small and large salmon were some of the highest on record, and all four assessed rivers reached their conservation egg requirements (DFO 2012c).

Cusk

Although it does not have status under Schedule 1 of *SARA*, cusk (*Brosme brosme*) was designated as *threatened* by COSEWIC in May 2003. Recently the status of cusk was re-examined and designated *endangered* in November 2012 (COSEWIC 2012a).

Cusk are sedentary, slow-swimming groundfish inhabiting subarctic and boreal shelf waters on both sides of the north Atlantic. They are generally solitary but will form small schools (Kearley 2012). In Canadian waters, this species is most common in the Gulf of Maine and the southwestern Scotian Shelf (Scott and Scott 1988; COSEWIC 2012a). While cusk also occur in the Study Area along the edge of the continental shelf off Newfoundland and Labrador, they are rare in these deep waters (COSEWIC 2012a).

Although most common within a depth range of 150 to 450 m, some individuals have been caught as deep as 1,185 m during recent survey work along the edge of the continental shelf off of Nova Scotia (COSEWIC 2012a). Cusk display preference for water temperatures in the range of 6 to 10°C and prefer bottom habitats containing hard, rough, and rocky substrate; they are not often captured on soft, sandy bottoms (COSEWIC 2012a). The diet of cusk is not well documented because their stomachs usually evert when they are brought to the surface. Studies have shown that in European waters, cusk feed on crab, molluscs, krill, cod, and halibut. Their diet is presumed to be the same in Canadian waters (Scott and Scott 1988). Predators of cusk include winter skate, spiny dogfish, Atlantic cod, white hake, Atlantic halibut, monkfish and possibly grey seals (COSEWIC 2012a).

Spawning on the Scotian Shelf occurs from May to August, typically peaking in June (COSEWIC 2012a). Specific spawning sites for cusk have yet to be identified. Fertilized eggs float at or near the surface and the hatching larvae remain in the water column to feed until settlement to the sea bottom (Kearley 2012).

American Eel

The American eel (*Anguilla rostrata*) does not have status under Schedule 1 of *SARA* but was designated *special concern* under COSEWIC in April 2006. Recently the status of the American eel was re-examined and designated *threatened* in May 2012 (COSEWIC 2012b). Large declines in abundance of eels over its distribution as well as continuing habitat degradation due to dams, pollution, and existing fisheries are factors which have led COSEWIC to place the American eel in a higher risk category.

The American eel is the west Atlantic representative of the worldwide genus *Anguilla* whose members spawn in ocean waters, migrate to coastal and inland continental waters to grow, and then return to ocean spawning grounds to reproduce and die (Cairns et al. 2008). The historic Canadian range encompassed all accessible fresh water, estuaries and coastal marine waters connected to the Atlantic Ocean as far north as the mid-Labrador coast. Continental shelves are used by juvenile eels arriving from spawning grounds, and by silver eels, after several years in fresh water, returning to the spawning grounds. Eels at his stage are primarily benthic and will use any available resources for protection and cover including rocky, sandy, or muddy substrate, woody debris, and submerged vegetation such as eelgrass. Spawning takes place in the Sargasso Sea, located south of Bermuda and east of the Bahamas (COSEWIC 2012b).

Hatched larvae develop a leaf-like shape and are termed leptocephali (COSEWIC 2012b). American eel leptocephali drift westward towards the continental shelf where they metamorphose into small, transparent glass eels with the serpentine shape of the adult form. As glass eels move into inshore waters, they develop pigmentation and become elvers. Elver arrival generally occurs in May and early June on the Atlantic coast of Canada. Some elvers remain in shallow protected salt water, some move into estuaries, and some move into fresh water. Elvers become yellow eels which have a dark back and a yellowish belly. Sexual differentiation occurs during the yellow phase and appears to be controlled by environmental factors. When yellow eels reach a certain size, their bellies turn silver and they prepare for the spawning migration. Eels that occupy brackish and salt water tend to grow more rapidly than those in fresh water and thus return to spawning grounds at a younger age. Yellow eels in fresh water may continue to migrate for many years before returning to the spawning ground. Newfoundland and Labrador is the most data-deficient area of the American eel's Canadian range.

Arctic Cod

In Canadian waters, the Arctic cod (*Boreogadus saida*), is found in the Beaufort Sea, the Arctic Archipelago, Hudson Bay, Baffin Bay, along the Labrador coast, eastern Newfoundland coast, the northern and eastern Grand Banks, and very rarely in the Gulf of St. Lawrence (Kearley 2012; DFO 2013g). Arctic cod are a pelagic species that occur at a variety of water depths ranging from a few metres to >900 m (DFO 2013g; Hop and Gjøsæter 2013). Off northern Labrador, exploratory fishing revealed that the best otter trawl catches were made at depths of 100 to 250 m with bottom water temperatures ranging from -1.4 to 0.6°C (DFO 2013g). Off southern Labrador and northern Newfoundland, catches were smaller and mainly at depths ranging from 200 to 300 m with bottom water temperatures of -1.2 to 3.6°C. During autumn, fish have been observed congregating in large numbers and moving into coastal waters (Welsh et al. 1993, Benoit et al. 2008 *in* Hop and Gjøsæter 2013).

Temperatures ranging from 0 to 4°C are believed to be optimal for Arctic cod survival although the species has been found in waters <0°C and frequently near drifting ice (DFO 2013g).

The stock structure of Arctic cod in the northwest Atlantic is not known but it is assumed that most of the adult stock(s) may reside on the northern Labrador shelf or even further north (Lilly et al. 1994). In northern Canadian waters, spawning is believed to occur in late autumn and winter under ice cover (DFO 2013g). Larvae are pelagic and may be transported with the Labrador Current south to the southern Labrador and northeast Newfoundland shelves where mainly one and two year old Arctic cod are found (Lilly et al. 1994). Larvae feed on eggs, nauplii, and juvenile stage of copepods (Ponomarenko 1967 *in* Hop and Gjøsæter 2013). Drifting sea ice provides a refuge for one and two year old cod, and they become part of the pelagic stock when the ice melts (Hop et al. 1997 *in* Hop and Gjøsæter 2013)

The Arctic cod is generally of low commercial interest to Canadian fishermen because of its small size and relatively low abundance (Scott and Scott 1988; DFO 2013g); however, large numbers have been obtained off Labrador by Soviet trawlers as bycatch in the offshore capelin fishery (DFO 2013g). The Arctic cod is an extremely important component of the Arctic food web (Lear 1983) and plays a key role as a forage fish species for predators such as marine mammals (e.g., narwhals, belugas, ringed seals), seabirds, and fishes (e.g., Atlantic cod, Arctic char, Greenland halibut, and Atlantic salmon) that inhabit the area (Scott and Scott 1988; Kearley 2012). In turn, Arctic cod are the main consumers of plankton in the Arctic seas. Depending on age and body size, Arctic cod are known to feed on various stages of copepods and amphipods in addition to euphausiids, arrow worms (chaetognaths), and smaller members of their own kind (DFO 2013g).

Sand Lance

Sand lance (*Ammodytes* spp.) is a small planktivorous fish found on sandy seabeds. It is a pelagic species that forms dense schools feeding throughout the water column, and also spends a portion of each day buried in the seabed. It is found in the north Atlantic from Greenland to the Gulf of St. Lawrence and is typically found at depths less than 100 m (Scott and Scott 1988) along the coast or the tops of offshore banks, on sand or light-gravel bottom substrate (DFO 2013h). The species of sand lance present in the Labrador Shelf Area is the northern sand lance (*A. dubius*). However, there is speculation about whether there are one or two species of sand lance in the area covered by the Study Area (DFO 2013h). It is generally accepted that the offshore, northern species is *A. dubius* and the inshore species *A. americanus* (= *A. hexapterus*), but the characteristics of the two species are quite similar (DFO 2013h). It co-occurs over much of its range with the American sand lance (*A. americanus*) (Scott and Scott 1988). Sandlance do not undertake large scale migrations. They are limited to daily trips between burrowing areas and feeding grounds where they move out to deeper waters during the day to feed, primarily on copepods (Kearley 2012).

There is no available information specific to the timing of spawning in the Study Area, but sand lance generally spawn demersally during late fall and winter in shallow waters and the eggs adhere to grains of sand and gravel (Kearley 2012; DFO 2013h). Larvae hatch after 9 to 10 weeks and drift upwards to the surface waters where they remain for several weeks (Kearley 2012). The larvae of sandlance are actually the most abundant and widespread of any fish larvae in the northwest Atlantic in the early months of the year. Once they reach approximately 20 mm in length, they descend to the bottom as juveniles and begin to burrow in the substrates (Kearley 2012).

This species is not commercially fished but may represent one of the major unexploited fish resources of the northwest Atlantic (DFO 2013h). Despite its lack of commercial value, it remains an important part of the marine food web, serving as prey for marine mammals, seabirds, and several fish species, including cod.

Arctic Char

Arctic char (*Salvelinus alpinus*) has a circumpolar distribution in the northern hemisphere and is found throughout the Canadian Arctic. In Atlantic Canada, it spawns in rivers and lakes on the north coast of Labrador (Kearley 2012). This species is categorized as either anadromous or a resident freshwater fish. There is a predominance of resident freshwater char in its southern distribution while anadromous populations are most common in its northern distribution.

Seaward migration for northern Labrador Arctic char commences with spring runoff and ice break-up in coastal rivers. Migrations consist of both first-time and repeat migrants with first time migrants being between two to seven years and 10 to 20 cm in length. Prior to migrating to sea, they inhabit brackish, estuarine waters to increase their tolerance to the salinity of ocean waters, and then enter nearshore marine waters to spend five to eight weeks of the summer feeding (Kearley 2012). Seaward migration for Arctic char is short and irregular, with both juveniles and adults spending only one to four months at sea before returning to fresh water. Ocean migrations are also spatially limited, with few Arctic char moving less than 100 km from home rivers, mostly along shore. The return migrations occur from July to September, with large, mature char returning first, followed by non-mature adults then juveniles (Kearley 2012).

Northern Labrador Arctic char mature at younger ages and smaller sizes than other char stocks from northern Canada (DFO 2001). Anadramous char first spawn between four to ten years of age while resident freshwater char spawn between two to five years of age. Spawning takes place in the fall, commencing by mid-October, and occurs in either lakes or streams commonly over gravel beds. In Labrador, females begin to mature at approximately six years, with most individuals spawning at least once by the age of nine. After spawning, char will either migrate back to estuaries or the ocean if they are in a river that freezes, or they will overwinter in freshwater if the river is deep enough to remain relatively unfrozen (Kearley 2012).

Arctic char are opportunistic predators while at sea, with diet varying over spatial areas. Sand lance, capelin, sculpins and hyperiid amphipods are the four main species of prey for Arctic char within Labrador Shelf waters (DFO 2001).

4.2.2.2 Macroinvertebrate and Fish Reproduction in the Study Area

Temporal and spatial reproduction specifics for macroinvertebrates and fishes that occur in the Study Area are provided in Table 4.1.

Table 4.1 Reproduction Specifics of Key Macroinvertebrate and Fish Species Known or Likely to Reproduce within or near the Study Area.

Species	Locations of Reproductive Events	Times of Reproductive Events	Duration of Planktonic Stages
Northern shrimp	On banks and in channels over the extent of its distribution	Spawning in late summer/fall Fertilized eggs carried by female for 8 to 10 months and larvae hatch in the spring	12 to 16 weeks
Snow crab	On banks and possibly along some upper slope regions over the extent of its distribution	Mating in early spring Fertilized eggs carried by female for 2 years and larvae hatch in late spring/early summer	12 to 15 weeks
Greenland halibut	Spawning grounds extend from Davis Strait (south of 67°N) to south of Flemish Pass between 800 m and 2,000 m depth	Winter months	Uncertain
Redfish	Primarily along edge of shelf and banks, in slope waters, and in deep channels	Mating in late winter and release of young between April and July (peak in April)	No planktonic stage
Atlantic cod	Spawn along outer slopes of the shelf in depths from tens to hundreds of metres	March to June	10 to 12 weeks
Skates	Uncertain	Year-round	N/A
American plaice	Spawning generally occurs throughout the range the population inhabits.	April to May	12 to 16 weeks
Cusk	Uncertain	May to August	Presumed to be 4 to 16 weeks
Porbeagle shark	Very little known about the location of the pupping grounds	Mating in late summer and pupping during the winter	N/A
Wolffishes	Likely along the slope regions	September to November	Uncertain
Roundnose grenadier	Uncertain	Uncertain	Uncertain
Roughhead grenadier	Uncertain	Winter/early spring	Uncertain
Sand lance	Shallow waters	Late Fall to winter	Uncertain
Capelin	Spawning generally on beaches or in deeper waters	Late June to early July	Several weeks
Atlantic salmon	Spawn in freshwater	October to November	Several weeks in freshwater
Arctic char	Spawn in freshwater	October to November	Several weeks in freshwater

4.3 Fisheries

This section provides a description of the fisheries within the Study Area. Most of this section describes the commercial fishery in the Study Area between 2005 and 2012. Figure 4.1 shows the Study and Project areas in relation to regional fisheries management areas. As the figure indicates, the Study Area comprises portions of NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, and 3K. Two fishery closure areas are also identified in Figure 4.1. The Hawke Channel fishery closure area occurs entirely within the southwestern part of the Project Area (within NAFO Division 2J), while the Funk Island Deep fishery closure area is partially located within the far southwestern portion of the Project and Study areas. Both closure areas are described further in Section 4.7 on Sensitive Areas.

This section also briefly describes any recreational fisheries, traditional fisheries, aquaculture activity, and DFO's recent research vessel surveys in the Study Area. The biological characteristics and status of the principal commercial and other marine species, including prey for commercial species, were described in the preceding Section 4.2.

4.3.1 Information Sources

NAFO catch weight data are used to describe both domestic and foreign fisheries beyond the 200 nmi EEZ. Approximately one third of the Study Area is located outside of the 200 nmi limit. The NAFO data are derived from the STATLANT 21 data set for 2005 to 2012. The STATLANT reporting system of questionnaires is a long-standing standardized statistical inquiry for submission of national catch data to international fisheries agencies by national reporting offices. Rather than being georeferenced, these STATLANT data are geographically resolved at the NAFO Division level only. Thus the analysis of these data quantifies harvesting for portions of NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, and 3K (see Figure 4.1).

The fisheries data analyses use DFO Newfoundland Region (Newfoundland and Labrador), Maritimes Region (New Brunswick and Nova Scotia Atlantic coasts), Gulf Region (Prince Edward Island, and New Brunswick and Nova Scotia Gulf coasts), and Quebec Region (Gulf and St. Lawrence River) georeferenced catch and effort datasets for the 2005 to 2010 time period. DFO catch data for 2011 and 2012 were provided in a format different than that for years prior to 2011. The 2011 and 2012 catch data were provided as ranges of catch weight and catch value within 6 min x 6 min cells (latitude x longitude). Figures based on these 2011 and 2012 commercial fishery databases are included in the EA. The DFO datasets record domestic harvest and foreign harvest landed in Canada.

The 2005 to 2010 DFO data are georeferenced in two ways: by latitude and longitude (degrees and minutes) of the gear set location, and by the Unit Area in which the catch was harvested. Georeferencing by latitude and longitude allows the mapping of specific harvesting locations. Areas farther from shore, fished generally by larger boats, tend to have a greater proportion of their catch georeferenced, while those closer to shore have less. Also, certain inshore species (e.g., lobster) are not georeferenced, while the GPS coordinates of the harvesting locations of deep water species (e.g., snow crab) are usually reported. While much of the harvest carries the latitude and longitude information, virtually all the data carry a Unit Area (UA) designation. The UA designation allows all the harvesting data to be tabulated according to these fisheries management sub-zones. It is important to note that some of the UAs occur only partially within the boundaries of the Study Area. For these UAs, the harvesting locations occurring outside of the Study Area were excluded from analysis for the detailed overview of the 2005 to 2010 fishing seasons.

The maps in the sections that follow show harvesting locations for 2005 to 2010, based on the latitude and longitude (lat/long) data, as dark points. (The data coordinates given are those recorded in the vessel's fishing log, and are reported in the DFO datasets by degree and minute of latitude and longitude; thus the positions should be accurate within approximately 925 m (0.5 nm) of the reported coordinates. The points are not "weighted" by quantity of harvest, but show where fishing effort was recorded. Such location data have been groundtruthed with fishers in many consultations for past assessments and for fisheries planning. They have proven to be particularly useful for Operators in understanding the likely location of gear concentrations and timing of fisheries in order to eliminate or minimize potential mutual interference. DFO catch data for 2011 and 2012, based on 6 min x 6 min cells, are displayed as uniformly coloured grid cells representing cells within which harvesting was reported. Samples of fishery harvest location maps were presented during consultations.

The data primarily used to characterize the fisheries in this EA are harvest catch weights. Catch value is used to demonstrate that some species have lower ranked catch weights but are highly ranked in terms of value. Catch values are important in the case of a gear damage incident, and would be carefully evaluated at that time, based on then-current numbers, to calculate compensation (e.g., to be used as an impact mitigation during a seismic project).

The following groups were involved in consultations that included the most discussion related to fisheries.

- Cartwright Fishers Committee;
- Labrador Fishermen's Union Shrimp Company;
- Torngat Secretariat;
- Torngat Fish Producers Cooperative;
- Nunatsiavut Government: Department of Lands and Natural Resources and the Department of Education and Economic Development;
- Hopedale Inuit Community Government;
- Makkovik Inuit Community Government;
- Sivunivut Inuit Community Corporation;
- Nunatsiavut Government Department of Lands and Natural Resources;
- Fisheries and Oceans Canada;
- Newfoundland and Labrador Department of Fisheries and Aquaculture;
- Nature Newfoundland and Labrador;
- Fish Food and Allied Workers and One Ocean;
- Newfoundland Association of Seafood Producers;
- Ocean Choice International;

- Gulf Shrimp Limited and Quinlan Brothers;
- St. Anthony Port Authority; and
- St. Anthony Basin Resources Inc.

Part of the purpose of the consultations was to gather information about area fisheries and to determine any issues or concerns to be considered in the EA, as well as to discuss communications, mitigations and other solutions aimed at eliminating or minimizing potential impacts on the fisheries (see Consultation Report, Appendix 1).

Other sources consulted for this assessment include DFO species management plans, stock status reports, previous EAs (e.g., LGL and GXT 2013), and the C-NLOPB SEA reports (e.g., Labrador Shelf SEA [Sikumiut 2008]).

4.3.2 Regional NAFO Fisheries

As noted previously, approximately one third of the Study Area occurs outside of Canada's 200 nmi EEZ. The Study Area overlaps portions of NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, and 3K (see Figure 4.1). NAFO manages 19 stocks comprised of 11 species: Atlantic cod (3L, 3M, 3NO stocks), redfish (3LN, 3M, 3O, Sub-area 2 and Div. 1F+3K stocks), American plaice (3LNO, 3M stocks), witch flounder (3L, 3NO stocks), yellowtail flounder (3LNO stocks), Greenland halibut (3LMNO stock), white hake (3NO stock), skates (3LNO stock), capelin (3NO stock), squid (Sub-areas 3+4 stock), and shrimp (3L and 3NO stocks). Of the 19 stocks managed by NAFO, 16 straddle the EEZ; only the 3M cod, redfish and American plaice stocks occur entirely outside of the EEZ. Most fishing for relevant species in the NAFO Convention Regulatory Area is conducted using bottom trawlers.

During the 2005 to 2012 period, commercial harvesting beyond the 200 nmi EEZ, in terms of catch weight, was dominated by northern shrimp (51% of total catch weight; primarily in NAFO Division 3K), pink (Pandalid) shrimp (10%; primarily in 2H and 2J), snow crab (8%; primarily in 3K), Greenland halibut (turbot) (6%; primarily in 0B), capelin (6%; primarily in 3K), and Atlantic mackerel (6%; primarily in 3K). The highest catch weights during the eight-year period were taken in NAFO Divisions 3K (47%) and 2J (19%), followed by 2H, 2G, 1F, 0B and 1E. Canadian vessels accounted for 88% of the commercial catch weight reported for this area during 2005 to 2012. Only in Divisions 1E and 1F did the foreign vessels dominate catches (100% and >99% of total catch weight in these Divisions, respectively). Catches in 1E were dominated by northern shrimp, Atlantic cod, and lumpfish. Catches in 1F were dominated by Atlantic cod, Atlantic redfishes, deepwater redfish, and northern shrimp.

4.3.3 Domestic Fisheries

This section provides an overview of the commercial fisheries within and/or adjacent to the Project Area and Study Area. The first part provides the historical context. The second part of this overview provides similar recent information for the georeferenced (latitude/longitude) data specifically recorded within the Study Area and Project Area for 2005 to 2010, and maps the locations of these fisheries for that period along with 2011 and 2012. This section also provides more detailed information on the principal regional fisheries.

4.3.3.1 Historical Fisheries

Commercial fish harvesting in many parts of Newfoundland and Labrador has changed considerably over the last two decades, shifting from a groundfish-based industry to primarily crustacean harvesting. In the early 1990s, a harvesting moratorium was imposed on several commercially important groundfish species and directed fisheries for Atlantic cod and other groundfish were no longer permitted in most areas.

The Study Area fisheries were not exceptions to this trend (Sikumiut 2008; LGL 2010; LGL and GXT 2013). After large groundfish catches in NAFO Divisions 2GHJ and 3K in the 1970s and 1980s, the fishery was considerably reduced in the early 1990s at the time of the moratorium. Since then, much lower quotas have been allowed, varying over the years based in scientific advice and other considerations. Overall, the Study Area groundfish fishery has become greatly reduced while the invertebrate fisheries have grown substantially in importance. Invertebrate catches, most notably northern shrimp, have become increasingly important within the Study Area, particularly since the mid-1990s. In the late 1980s, the fisheries largely targeted northern shrimp, Atlantic cod, and Greenland halibut (turbot). Northern shrimp and Greenland halibut remain important target species in 2010; however, snow crab has replaced Atlantic cod as a principal species. Today, there is no directed fishery for Atlantic cod, and only a modest by-catch is allowed.

4.3.3.2 Study Area 2005 to 2010 Catch Analysis

The 2005 to 2010 domestic harvests recorded from within the Study Area are shown in Table 4.2. As indicated, the principal fisheries (by quantity of harvest) within the Study Area are for northern shrimp (86.7%), snow crab (7.7%), and Greenland halibut (turbot) (3.6%), combining for 98% of the average annual catch. The total annual commercial fisheries catch weights of all species during May to November, 2005 to 2010 combined are indicated in Figure 4.2.

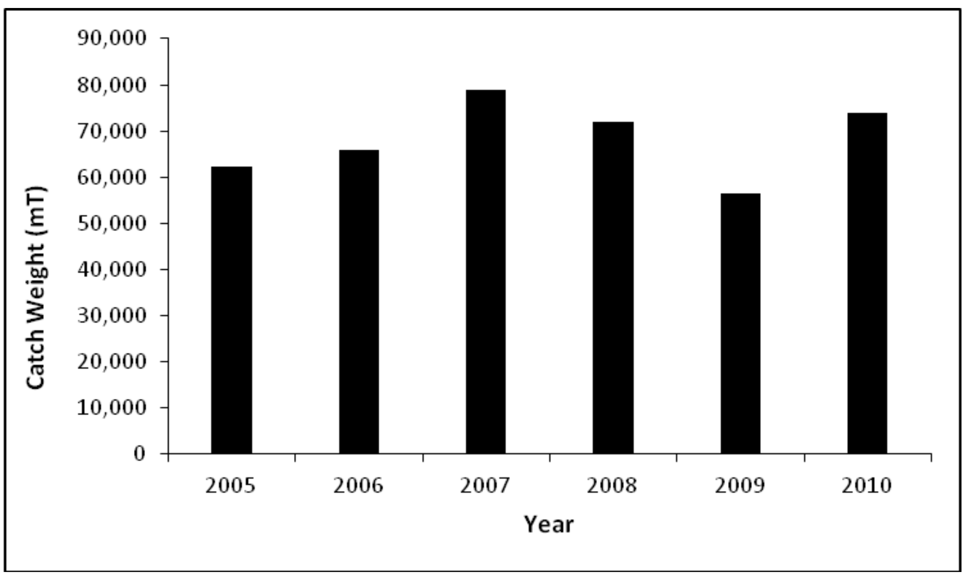
Harvesting Locations

Figures 4.3 to 4.5 indicate georeferenced harvesting locations in relation to the Study and Project Areas for all species, May to November, 2005 to 2012. As Figures 4.3 to 4.5 indicate, most of the fish harvesting occurs in the southwestern part of the Study and Project areas. A comparison with fisheries maps in the Labrador Shelf SEA and EA (Sikumiut 2008; LGL and GXT 2013) indicates that most of these locations are highly consistent from year to year.

Table 4.2 Average Annual Study Area Catch Weight and Catch Value by Species, 2005 to 2010.

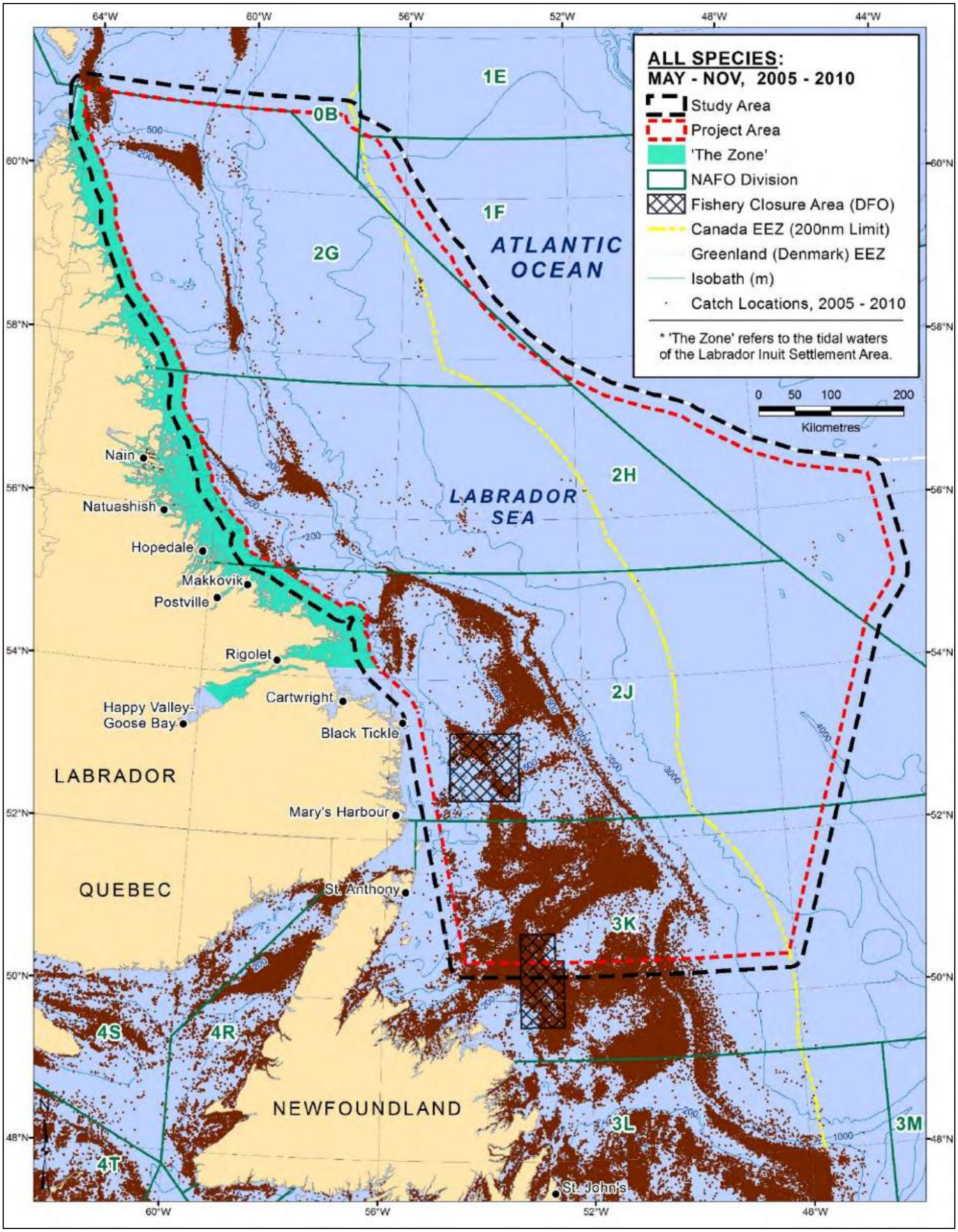
Species	Quantity (mt)	% of Total	Value ($)	% of Total
Northern Shrimp	86,051	86.7	144,619,996	80.3
Snow Crab	7,613	7.7	23,251,057	12.9
Greenland Halibut (Turbot)	3,603	3.6	8,617,951	4.8
Striped Shrimp	1,803	1.8	3,590,319	2.0
Redfish	56	0.1	28,053	<0.1
Mackerel	49	<0.1	16,047	<0.1
Roughhead Grenadier	27	<0.1	10,075	<0.1
Witch Flounder	22	<0.1	12,701	<0.1
American Plaice	12	<0.1	8,107	<0.1
Skate	5	<0.1	1,400	<0.1
Capelin	5	<0.1	558	<0.1
Atlantic Cod	1	<0.1	715	<0.1
White Hake	0.3	<0.1	208	<0.1
Haddock	0.2	<0.1	159	<0.1
Atlantic Halibut	0.2	<0.1	1,020	<0.1
Icelandic Scallops	0.2	<0.1	211	<0.1
Flounder sp.	0.1	<0.1	148	<0.1
Yellowtail Flounder	<0.1	<0.1	14	<0.1
Monkfish	<0.1	<0.1	5	<0.1
Totals	**99,247**	**100.0**	**180,158,743**	**100.0**

Source: DFO commercial landings database (2005 to 2010).



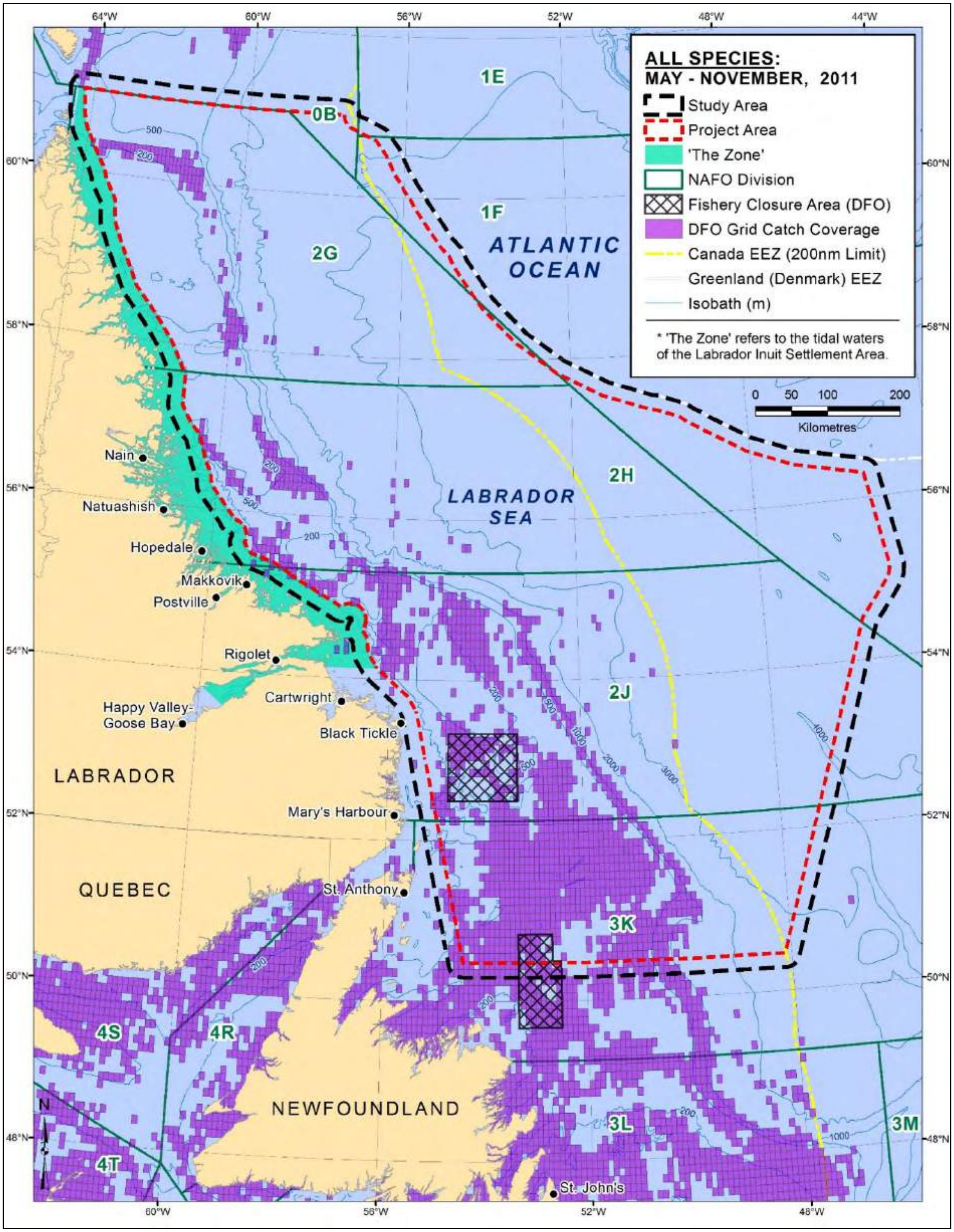
Source: DFO commercial landings database (2005 to 2010).

Figure 4.2 Annual Total Catch Weights of All Species within the Study Area, May to November 2005 to 2010.



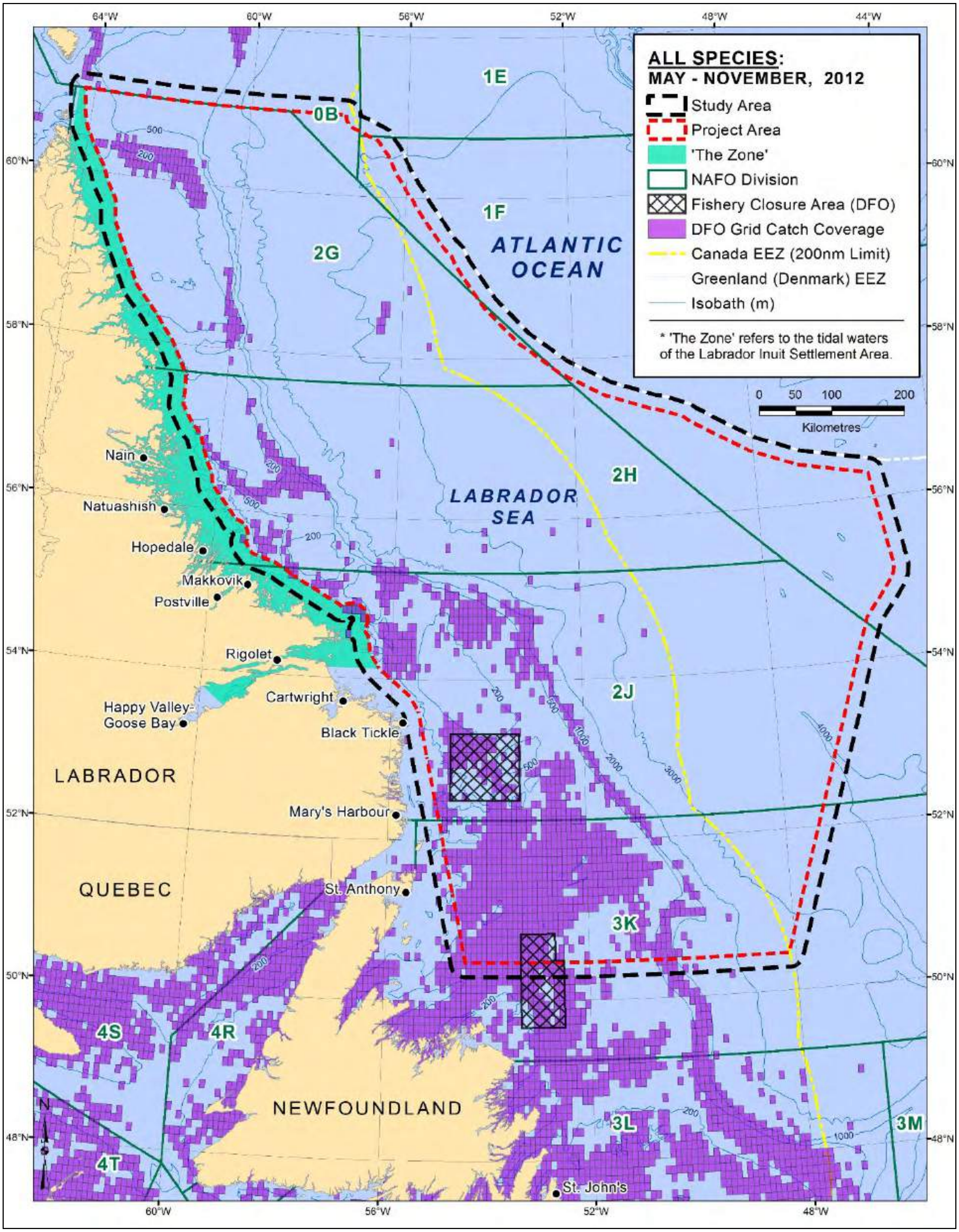
Source: DFO commercial landings database (2005 to 2010).

Figure 4.3 Harvest Location Distribution of All Species within the Study Area, May to November, 2005 to 2010.



Source: DFO commercial landings database (2011)

Figure 4.4 Harvest Location Distribution of All Species within the Study Area, May to November, 2011 (grid cells are 6 min x 6 min in size).



Source: DFO commercial landings database (2012)

Figure 4.5 Harvest Location Distribution of All Species within the Study Area, May to November, 2012 (grid cells are 6 min x 6 min in size).

For the most part, the fishing gear used in the Study Area in 2005 to 2010 reflects the species being exploited (Table 4.3). Shrimp trawls target northern shrimp, crab pots target snow crab, and gillnets harvest Greenland halibut. Shrimp trawl, a mobile gear, accounted for slightly more than 85% of the total catch weight of all species in the Study Area, between May and November, 2005 to 2010. The fixed gears (pots/traps, gillnets, and longlines) accounted for 13% of the total catch weight in this period. Fishing gear descriptions are provided in Section 4.10.2.3 of the Labrador Shelf SEA (Sikumiut 2008).

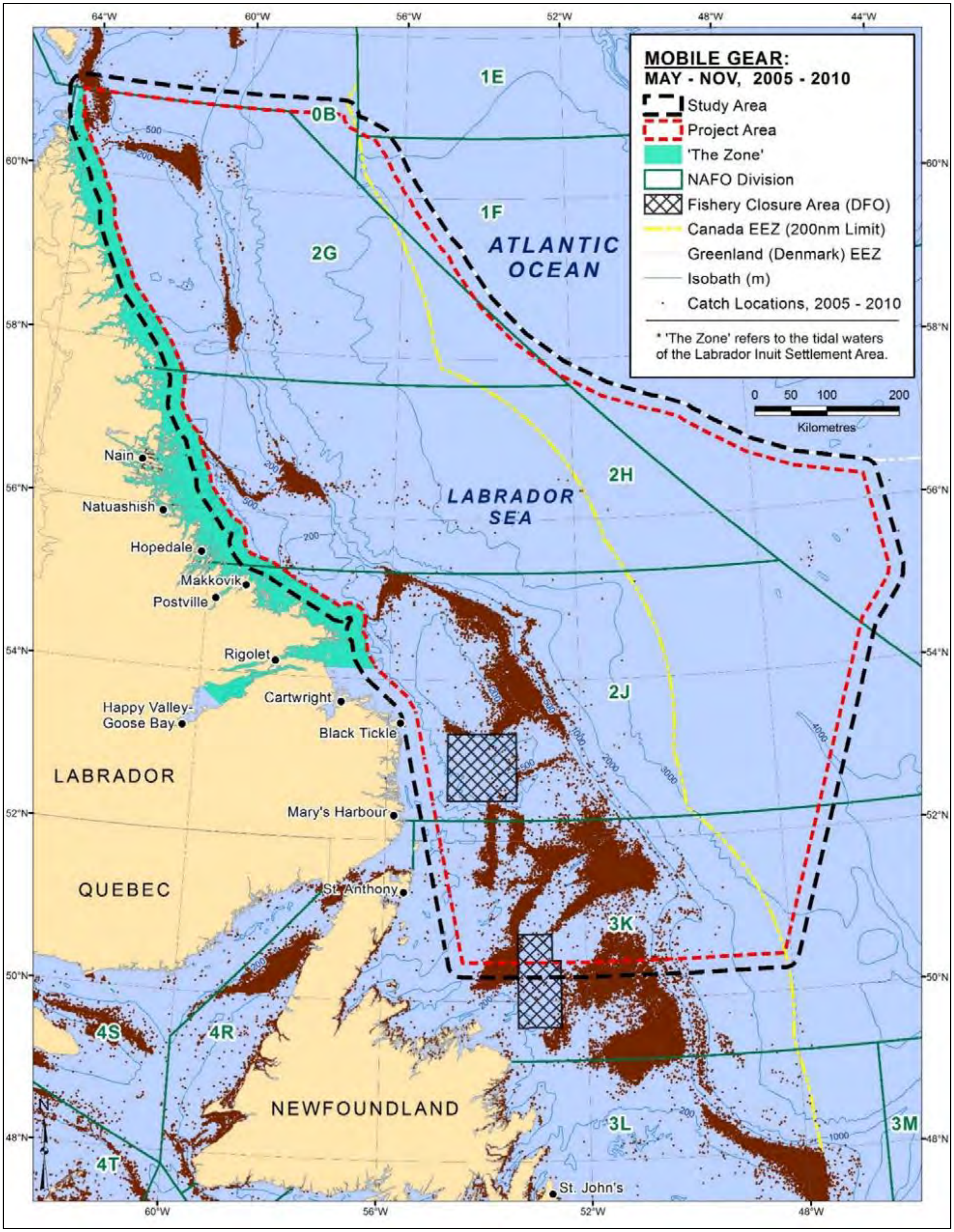
Table 4.3 Average Annual Study Area Catch Weight by Gear Type, May to November, 2005 to 2010.

Species	Fixed Gear (mt)	% of Total Fixed	Mobile Gear (mt)	% of Total Mobile
Northern Shrimp	0	0	56,869	96.0
Snow Crab	7,295	82.4	0	0
Greenland Halibut (Turbot)	1,517	17.1	853	1.4
Shrimp	0	0	1,418	2.4
Redfish	6	0.1	42	0.1
Mackerel	0	0	49	0.1
Roughhead Grenadier	24	0.3	1	<0.1
Witch Flounder	2	<0.1	2	<0.1
American Plaice	1	<0.1	1	<0.1
Skate	5	0.1	0.1	<0.1
Capelin	0	0	5	<0.1
Atlantic Cod	0.1	<0.1	1	<0.1
White Hake	0.3	<0.1	0	0
Haddock	0.2	<0.1	0	0
Atlantic Halibut	0.1	<0.1	0.1	<0.1
Icelandic Scallops	0	0	0.3	<0.1
Flounder sp.	0	0	0	0
Yellowtail Flounder	<0.1	<0.1	0	0
Monkfish	<0.1	<0.1	0	0
Totals	**8,850**	**100.0**	**59,241**	**100.0**

Source: DFO commercial landings database (2005 to 2010).

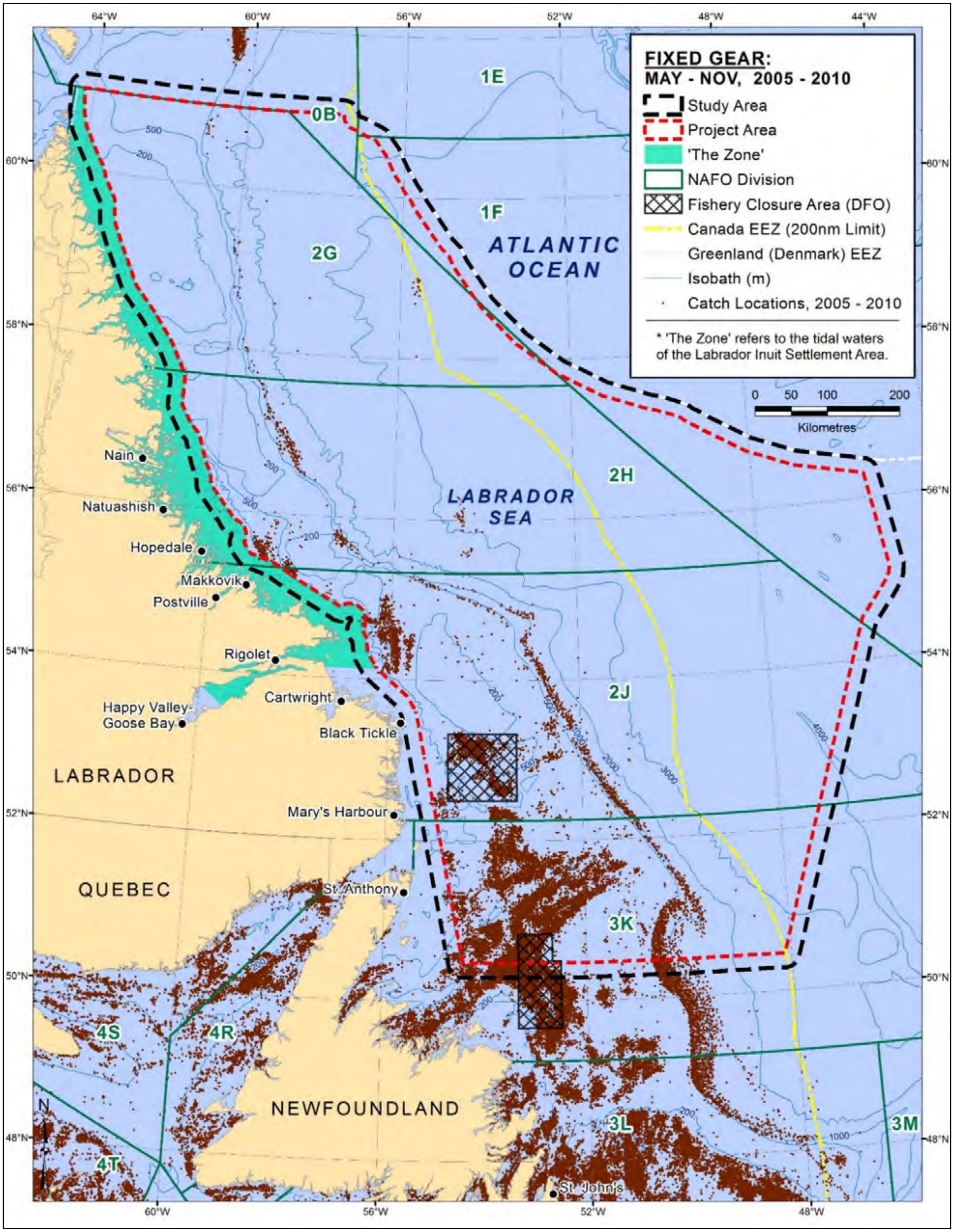
In general, the fixed gears have greater potential for interacting with Project activities than mobile gears, because they use submerged lines attached to buoys at the ocean surface, which can be easily snagged by towed seismic gear, causing damage to both the fishing gear and to the seismic streamer. They are often placed in one location for several days, are difficult to detect and may be set out over long distances in the water.

Figures 4.6 and 4.7 show locations of mobile and fix gear harvesting locations during May to November, 2005 to 2010 combined.



Source: DFO commercial landings database (2005 to 2010).

Figure 4.6 Mobile Gear Harvesting Location Distribution within the Study Area, May to November, 2005 to 2010.

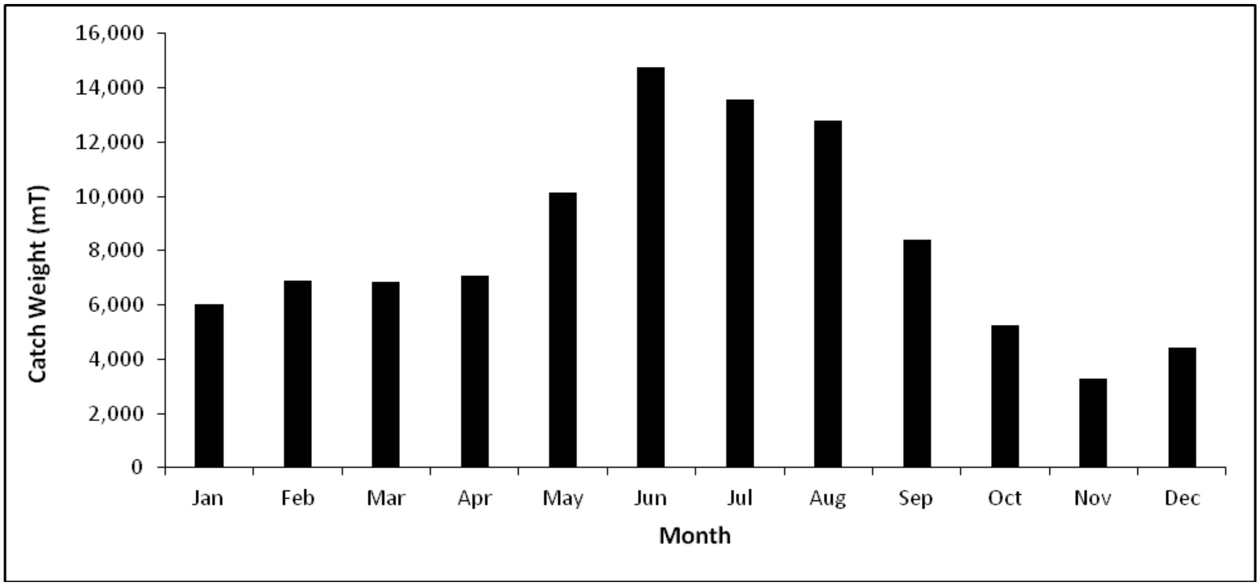


Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.7 Fixed Gear Harvesting Location Distribution within the Study Area, May-November, 2005 to 2010.

Harvest Timing

Monthly timing of commercial harvesting of all species within the Study Area for 2005 to 2010 is indicated in Figure 4.8. Overall catch weight was highest May to September and lowest during late fall and winter. However, the timing of the harvests can vary from year to year with resource availability, fisheries management plans, and enterprise harvesting strategies



Source: DFO commercial landings database (2005 to 2010).

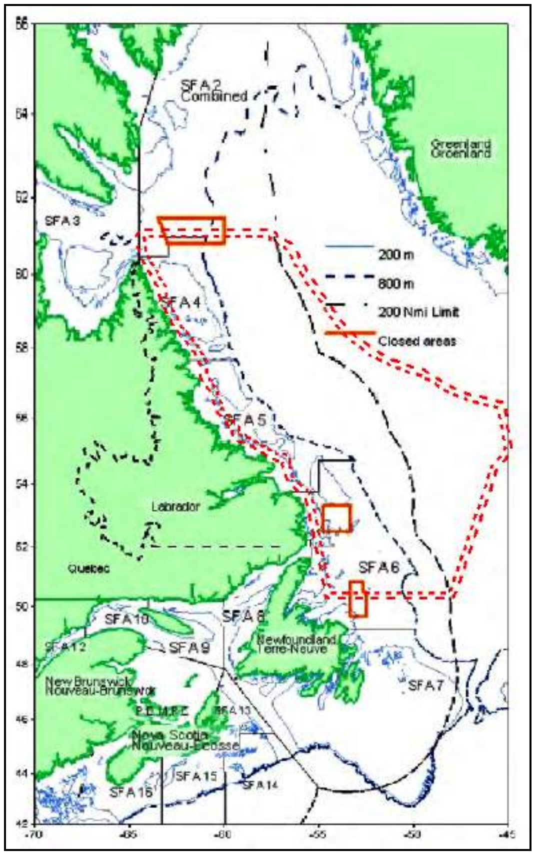
Figure 4.8 Average Monthly Catch Weight of All Species within the Study Area, 2005 to 2010.

Principal Species

The following section provides information on the principal Study Area fisheries as identified through the DFO commercial landings database, previous EAs (LGL 2010; Stantec 2010; LGL and GXT 2013), and the Labrador Shelf SEA (Sikumiut 2008).

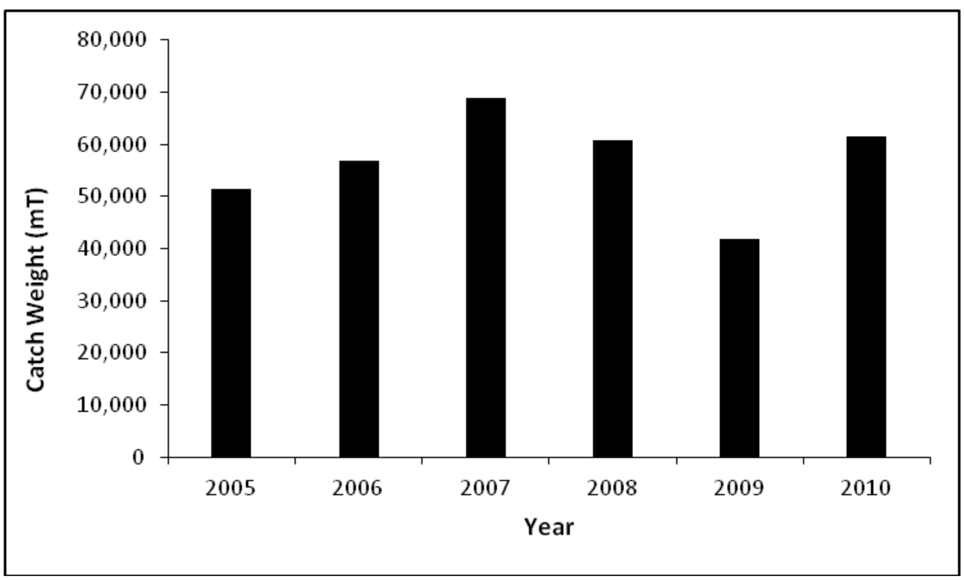
Northern Shrimp

The fishery for northern shrimp off the coast of Labrador began in the mid-1970s, primarily in the Hopedale and Cartwright Channels, before expanding north and south through the 1980s (DFO 2013a). Hopedale and Cartwright Channels occur in Shrimp Fishing Area (SFA) 5 (DFO 2013a); the Study Area includes all of SFA 4 and 5 and most of SFA 6 (Figure 4.9). Northern shrimp has been the major fishery in the Project and Study Areas over the last two decades, by both quantity and value. Total annual catch weights for northern shrimp in the Study Area between May and November, 2005 to 2010 are indicated in Figure 4.10, averaging at about 86,000 mt per year. Figure 4.11 shows the northern shrimp harvesting locations for May to November, 2005 to 2010, combined. Figures 4.12 and 4.13 show harvesting locations for 2011 and 2012, respectively. The average northern shrimp harvests by month for the 2005 to 2010 period for the Study Area are shown in Figure 4.14. It indicates that June to September was the period during which the highest catches were made.



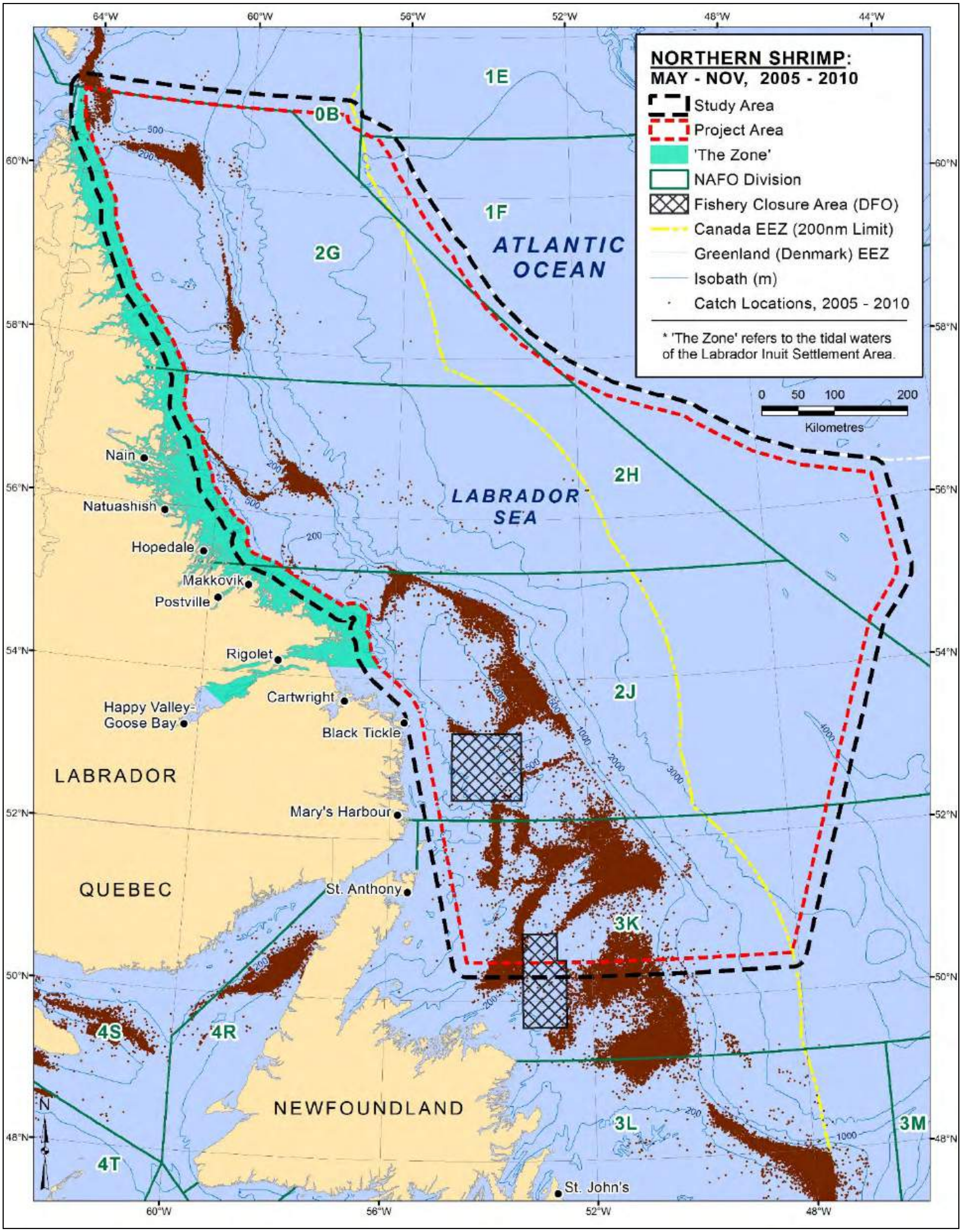
Source: DFO 2013i

Figure 4.9 Shrimp Fishing Areas (SFAs) in Relation to the Project and Study Areas.



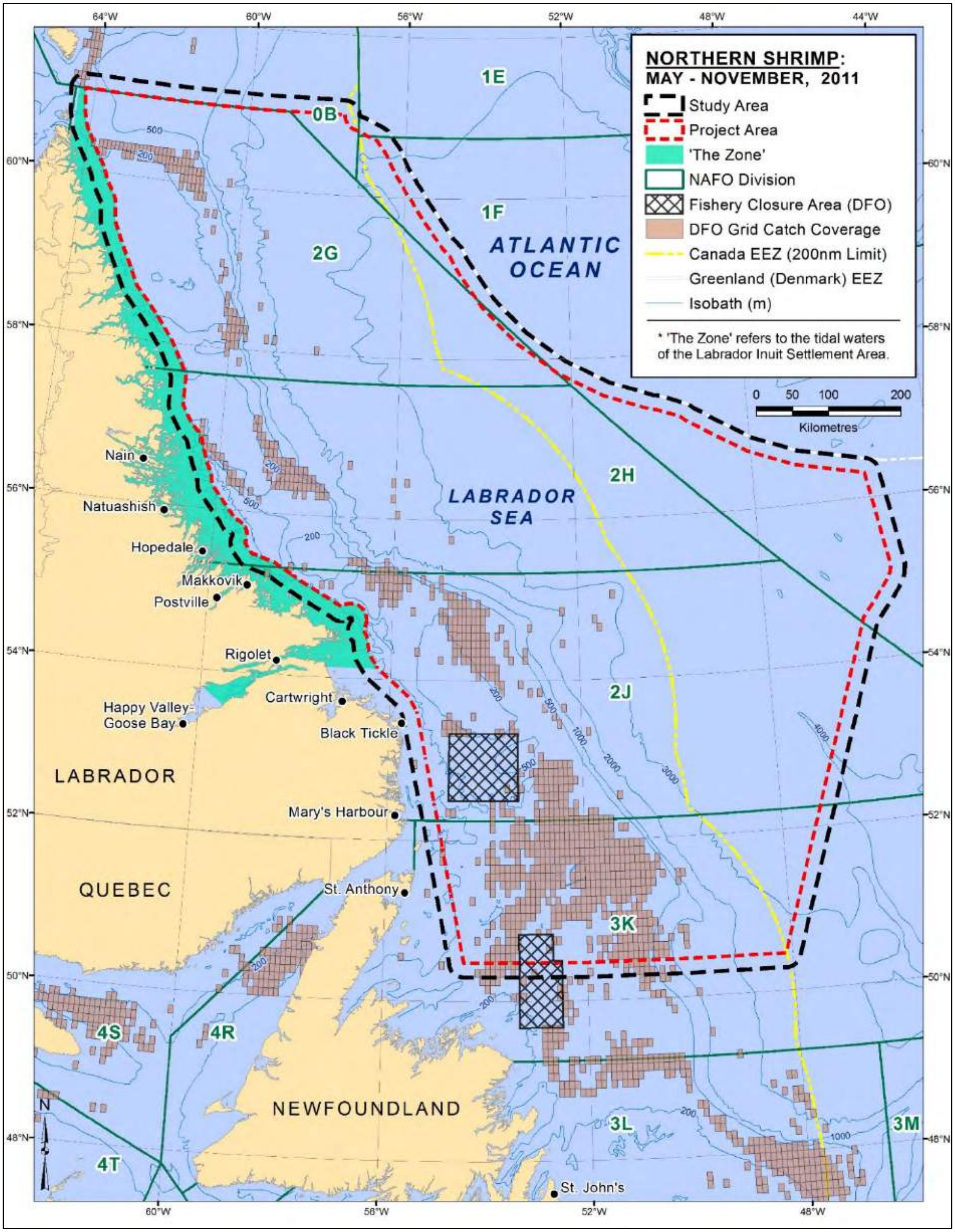
Source: DFO commercial landings database, All Atlantic Regions, 2005 to 2010.

Figure 4.10 Total Annual Catch Weights for Northern Shrimp within the Study Area, May to November, 2005 to 2010.



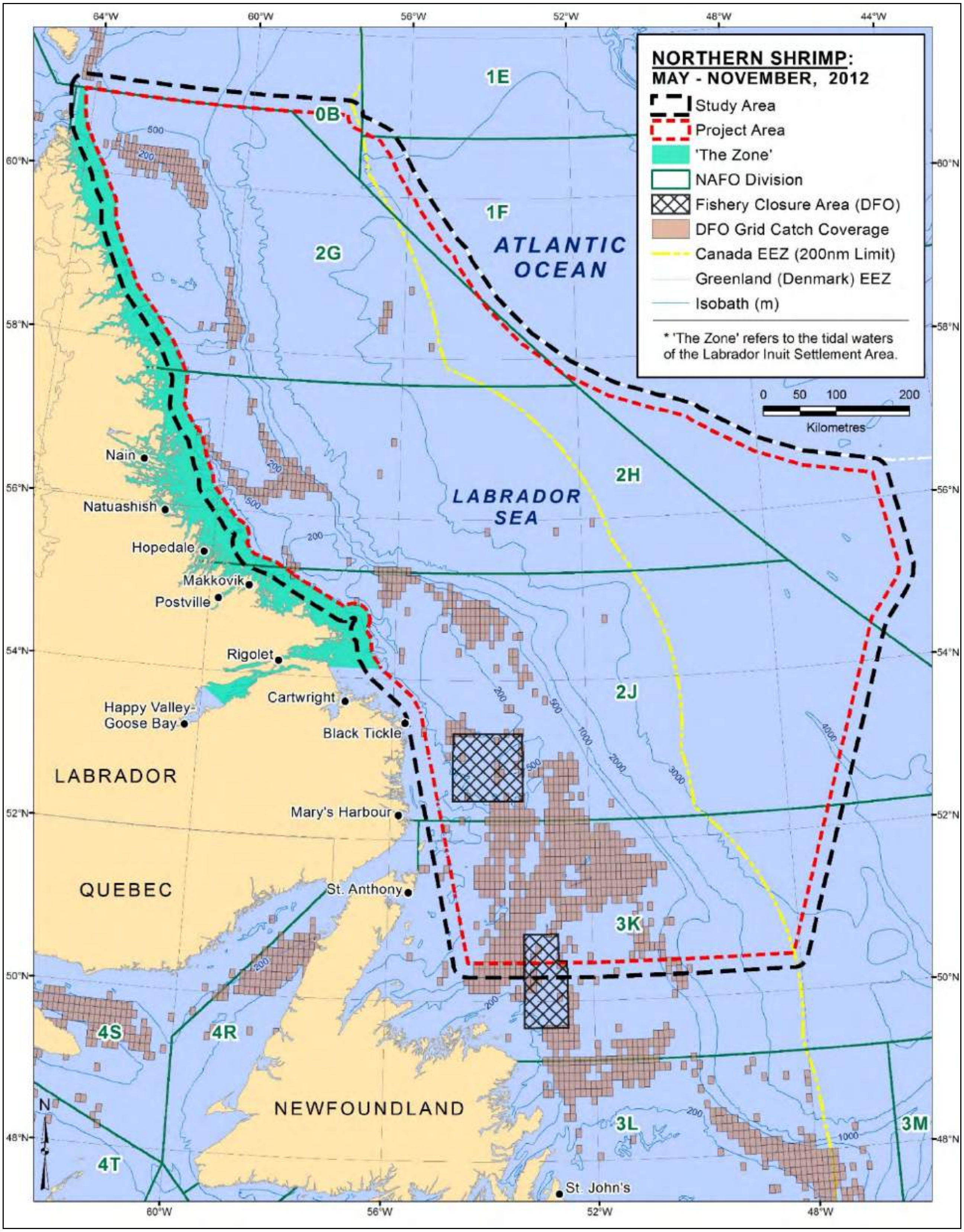
Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.11 Harvest Location Distribution of Northern Shrimp within the Study Area, May to November, 2005 to 2010.



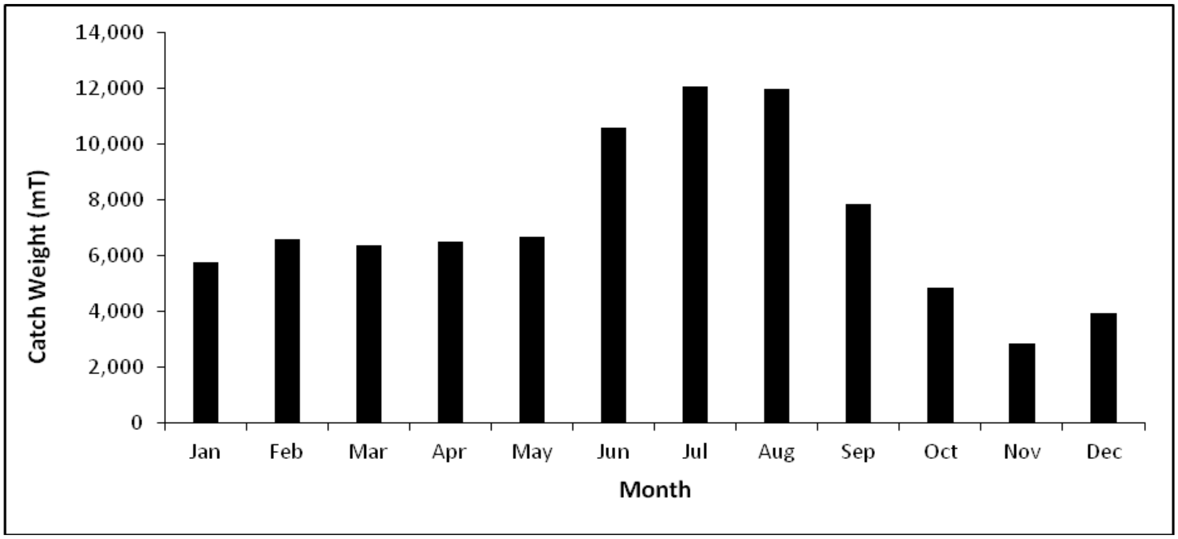
Source: DFO commercial landings database, All Atlantic Regions (2011).

Figure 4.12 Harvest Location Distribution of Northern Shrimp within the Study Area, May to November, 2011 (grid cells are 6 min x 6 min in size).



Source: DFO commercial landings database, All Atlantic Regions (2012).

Figure 4.13 Harvest Location Distribution of Northern Shrimp within the Study Area, May to November, 2012 (grid cells are 6 min x 6 min in size).

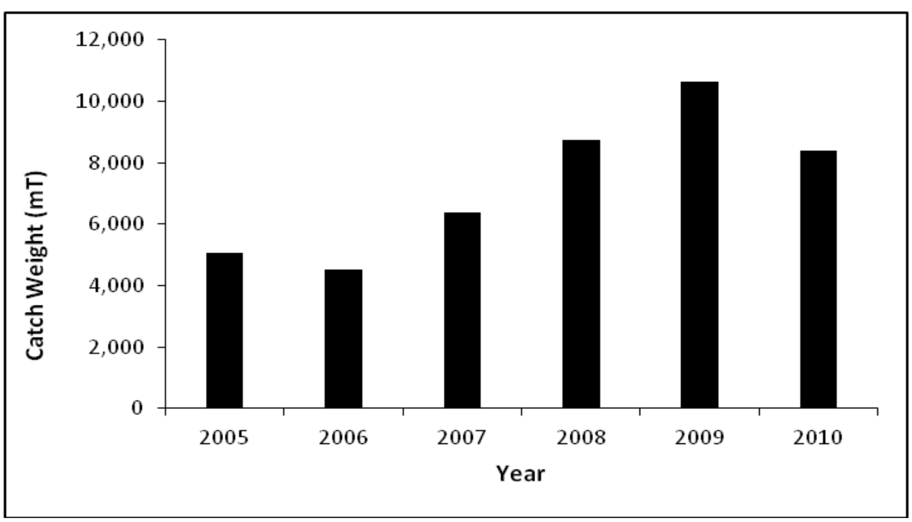


Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.14 Average Monthly Catch Weights for Northern Shrimp in the Study Area, 2005 to 2010.

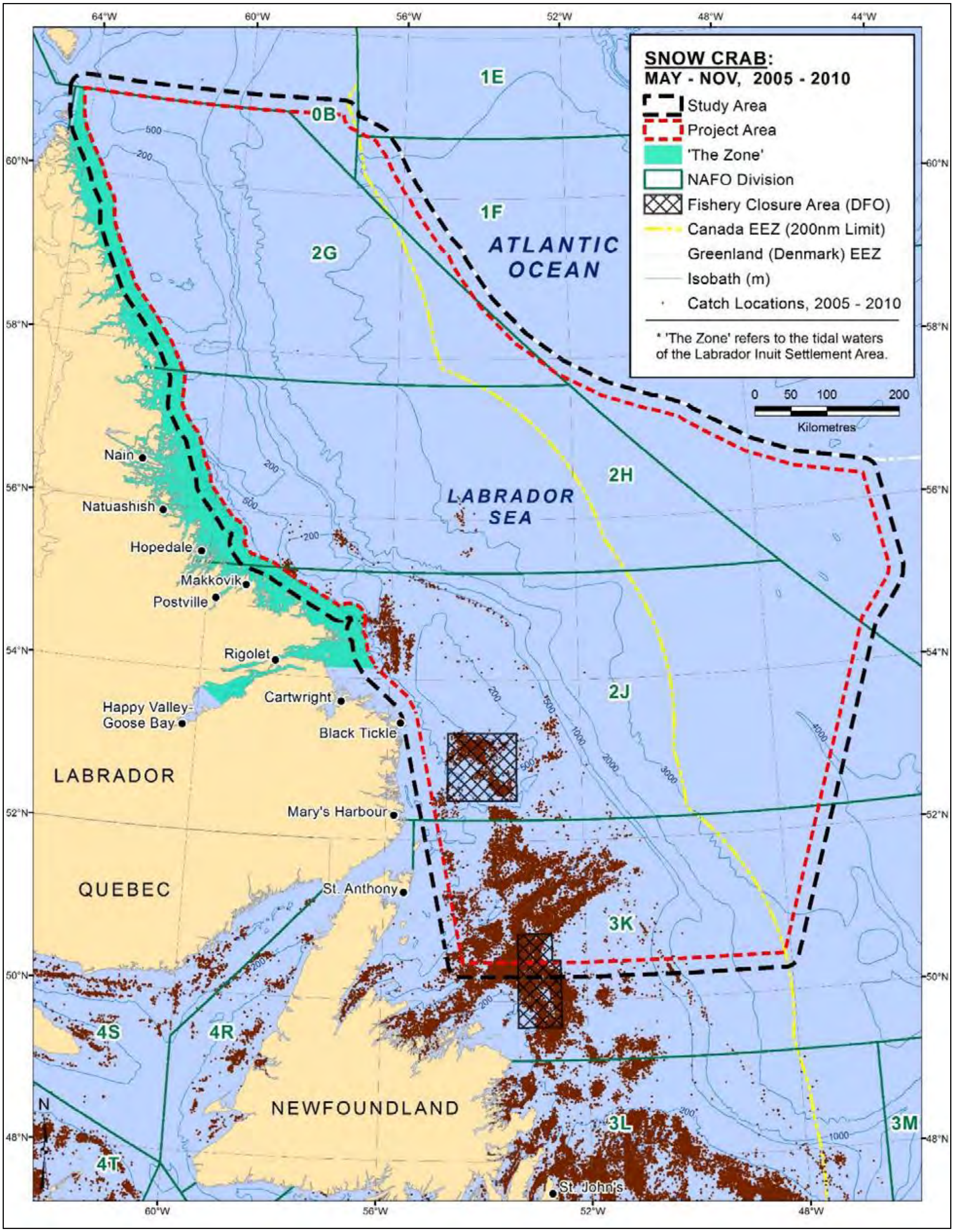
Snow Crab

Snow crab is the second most important commercial species in the Study Area by both quantity and value. Total annual catch weights for snow crab in the Study Area between May and November, 2005 to 2010 are indicated in Figure 4.15. Figure 4.16 shows the snow crab harvesting locations for May to November, 2005-2010. Figures 4.17 and 4.18 show harvesting locations for May to November, 2011 and 2012, respectively. The average snow crab harvests by month for the 2005 to 2010 period in the Study Area are shown in Figure 4.19. May and June were the two months during which most of the snow crab was caught.



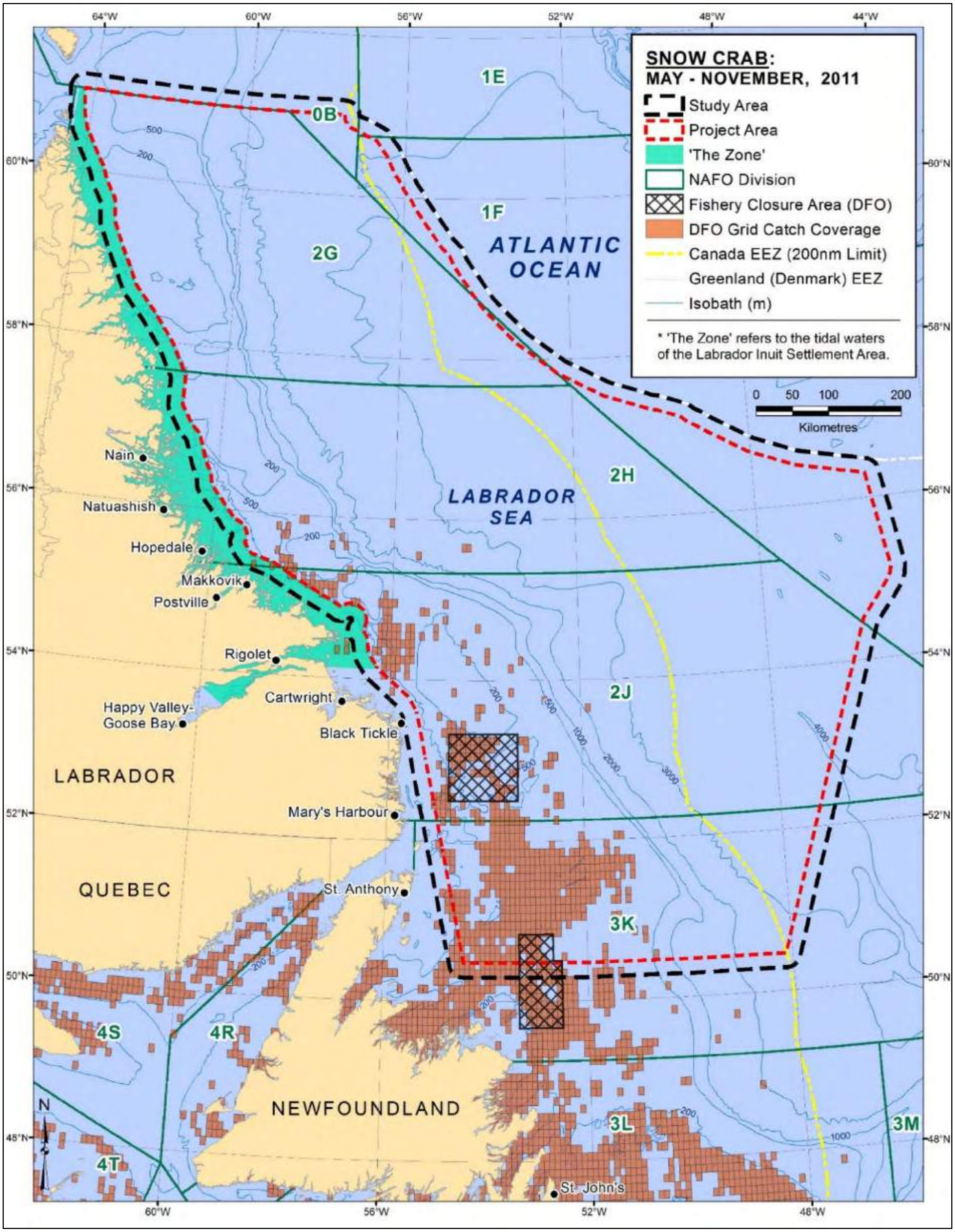
Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.15 Total Annual Catch Weights for Snow Crab within the Study Area, May to November, 2005 to 2010.



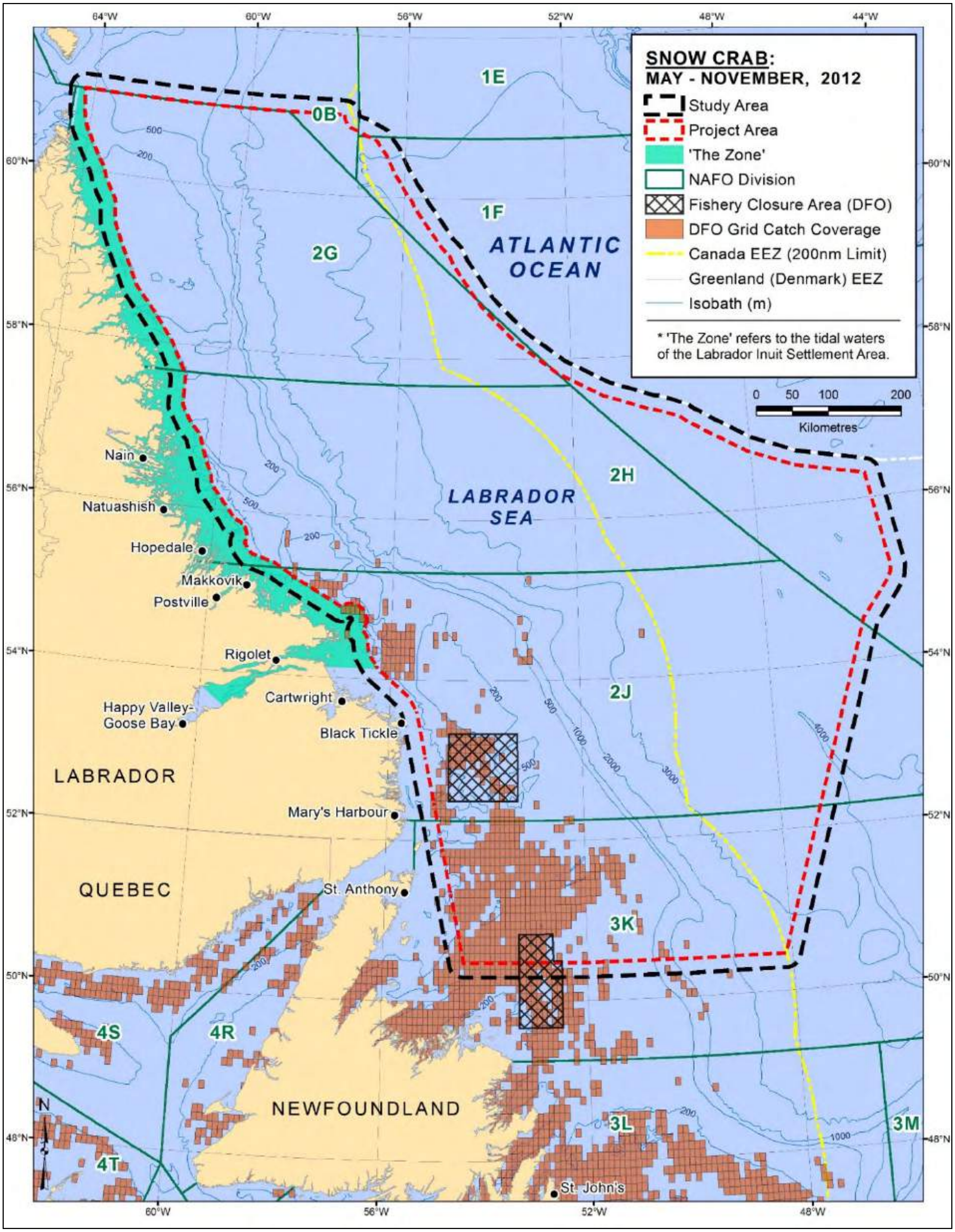
Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.16 Harvest Location Distribution of Snow Crab within the Study Area, May to November, 2005 to 2010.



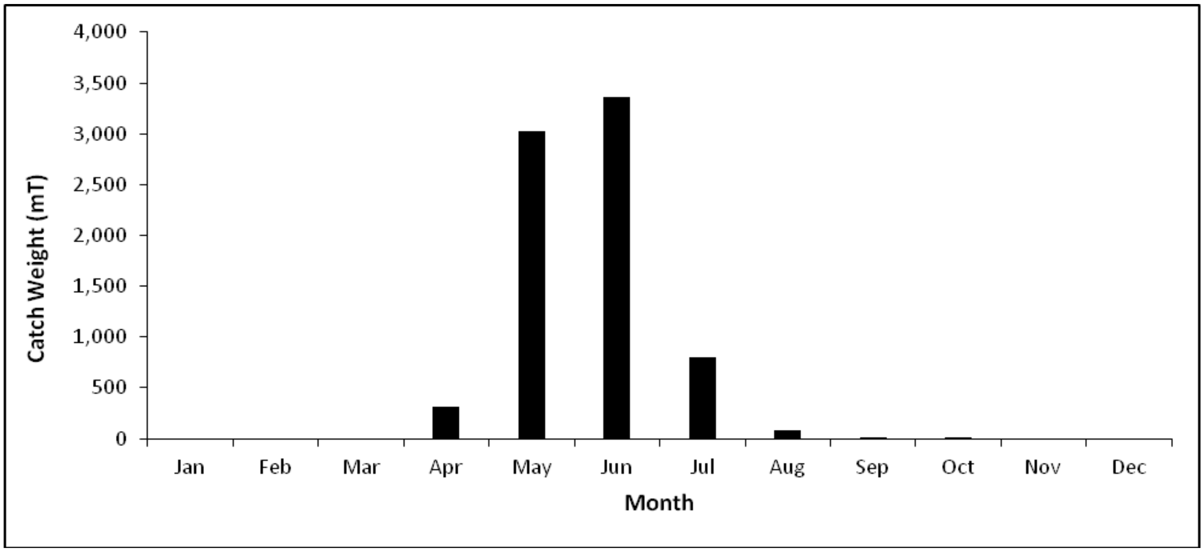
Source: DFO commercial landings database, All Atlantic Regions (2011).

Figure 4.17 Harvest Location Distribution of Snow Crab within the Study Area, May to November, 2011 (grid cells are 6 min x 6 min in size).



Source: DFO commercial landings database, All Atlantic Regions (2012).

Figure 4.18 Harvest Location Distribution of Snow Crab within the Study Area, May to November, 2012 (grid cells are 6 min x 6 min in size).

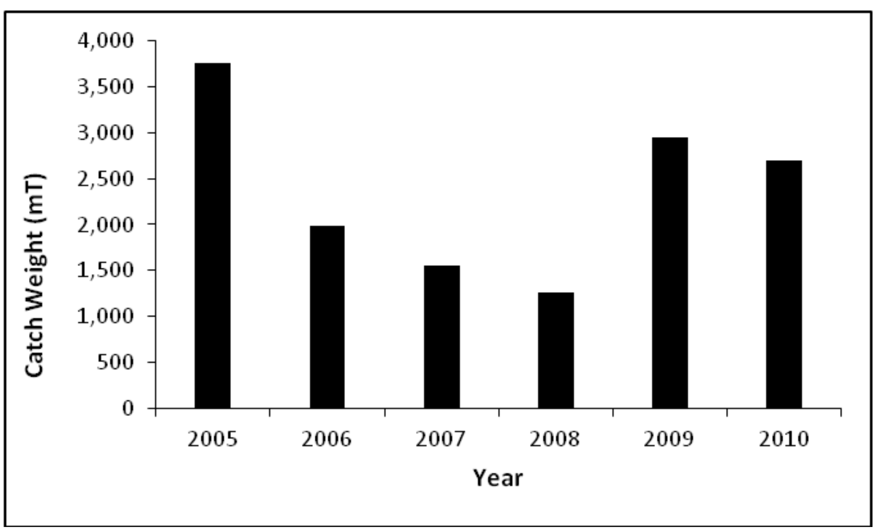


Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.19 Average Monthly Catch Weights for Snow Crab within the Study Area, 2005 to 2010.

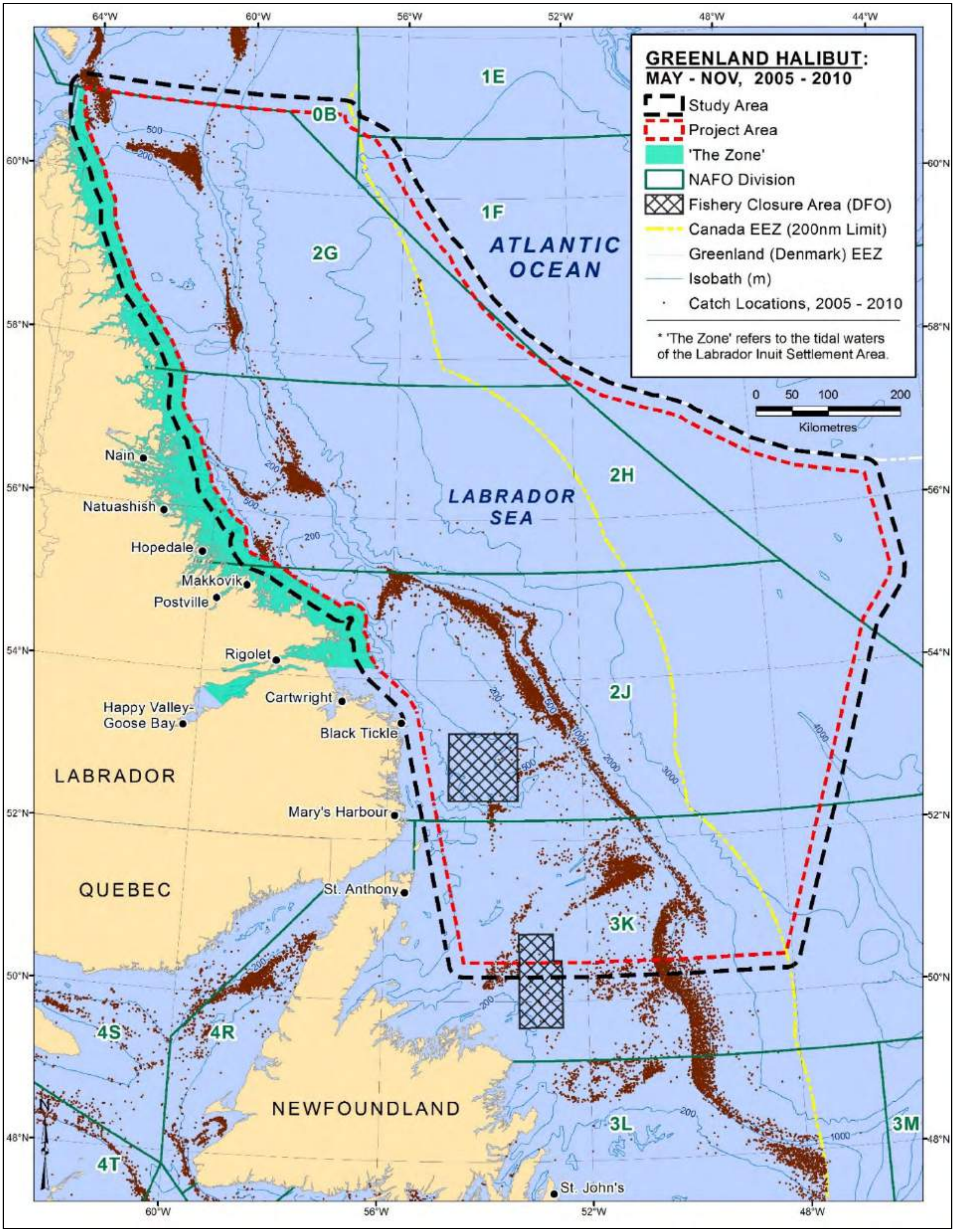
Greenland Halibut (Turbot)

Although its total catch weight is small, Greenland halibut (turbot) made up the largest part of groundfish catches in the Study Area from 2005 to 2010. Total annual catch weights for Greenland halibut in the Study Area between May and November, 2005 to 2010 are indicated in Figure 4.20. Figure 4.21 shows the Greenland halibut harvesting locations for 2005 to 2010 combined. Figures 4.22 and 4.23 show harvesting locations for 2011 and 2012, respectively. The average Greenland halibut harvests by month for the 2005 to 2010 period in the Study Area are shown in Figure 4.24. June and July were the two months during which most of the Greenland halibut was caught.



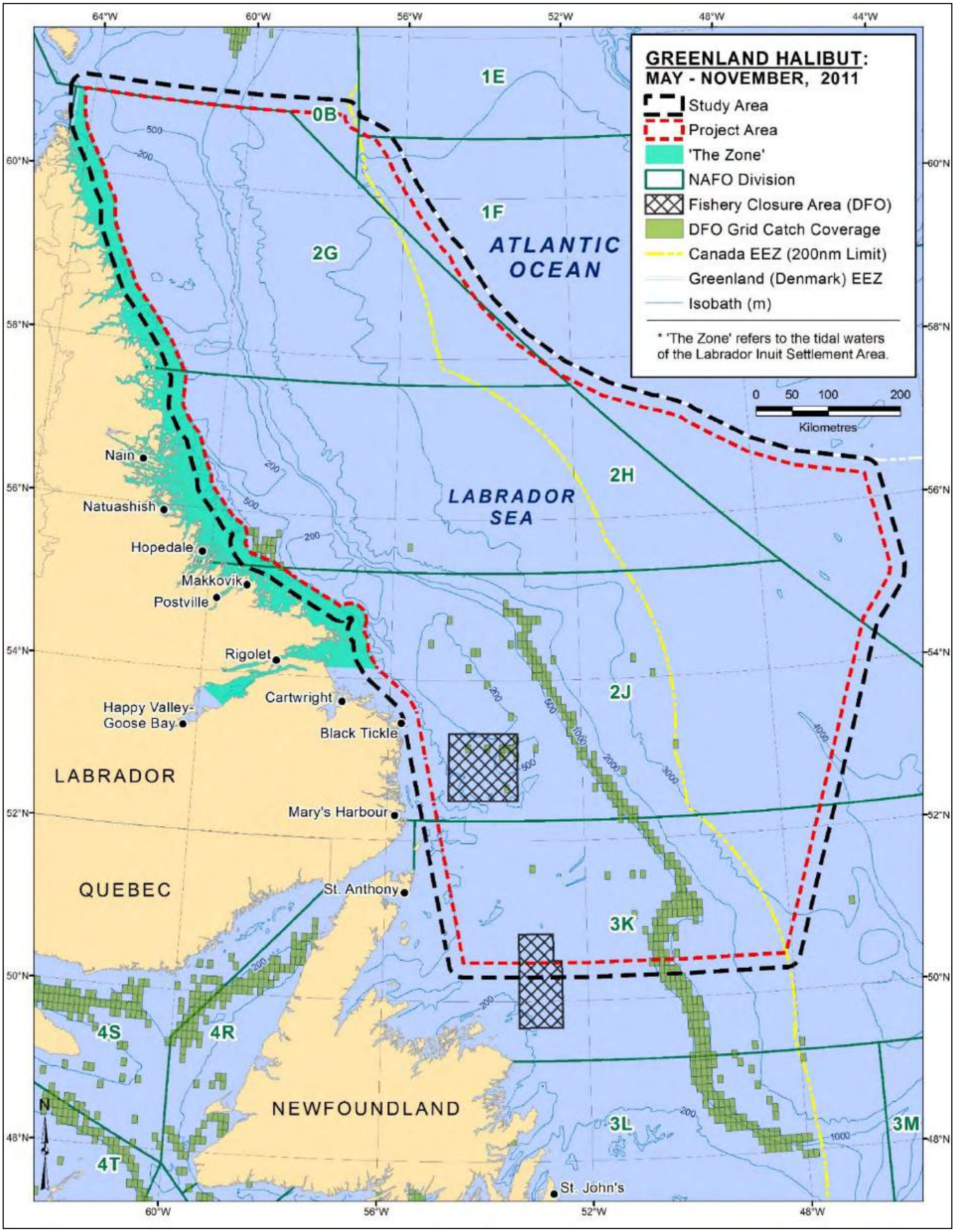
Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.20 Total Annual Catch Weights for Greenland Halibut within the Study Area, May to November, 2005 to 2010.



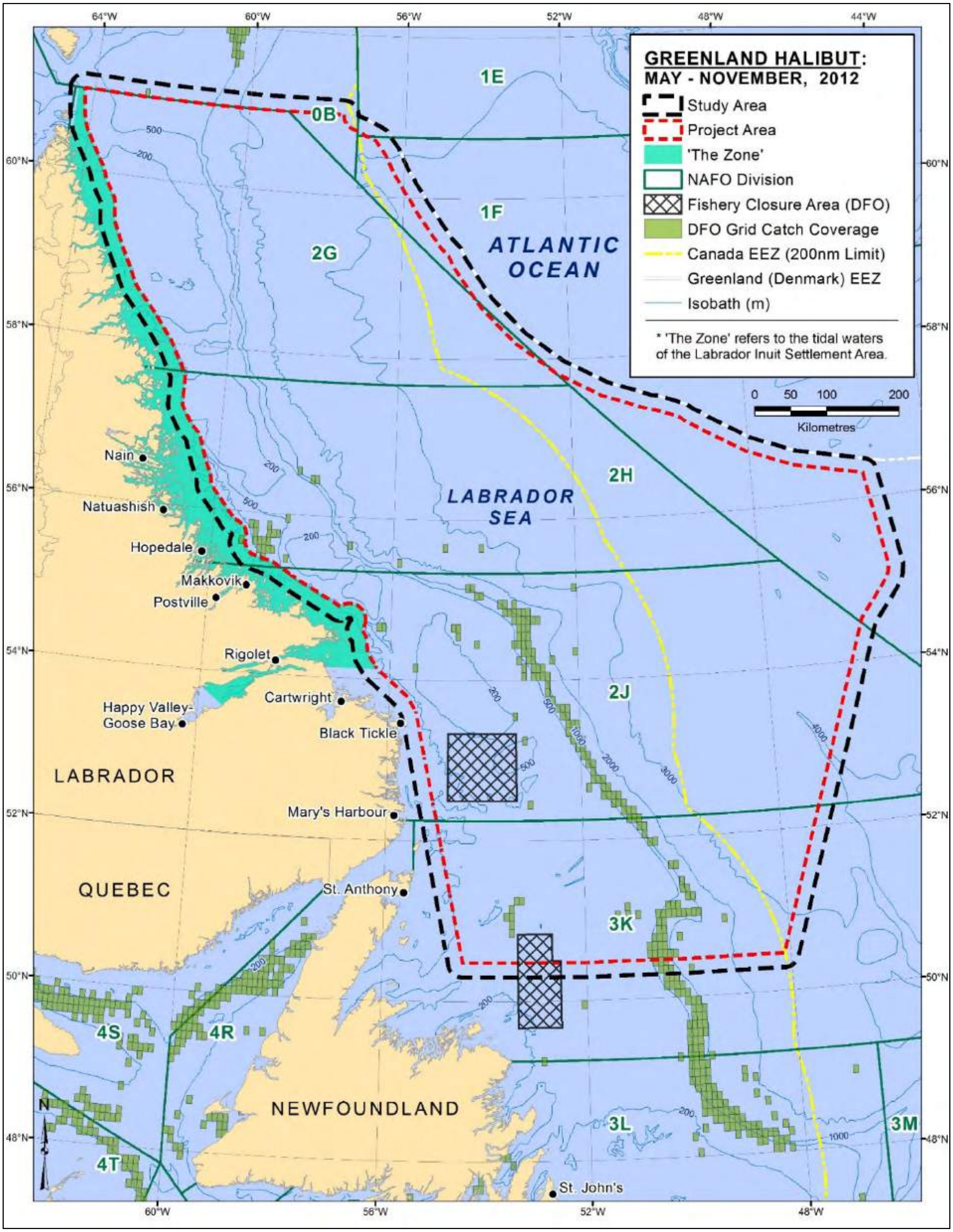
Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.21 Harvest Location Distribution of Greenland Halibut within the Study Area, May to November, 2005 to 2010.



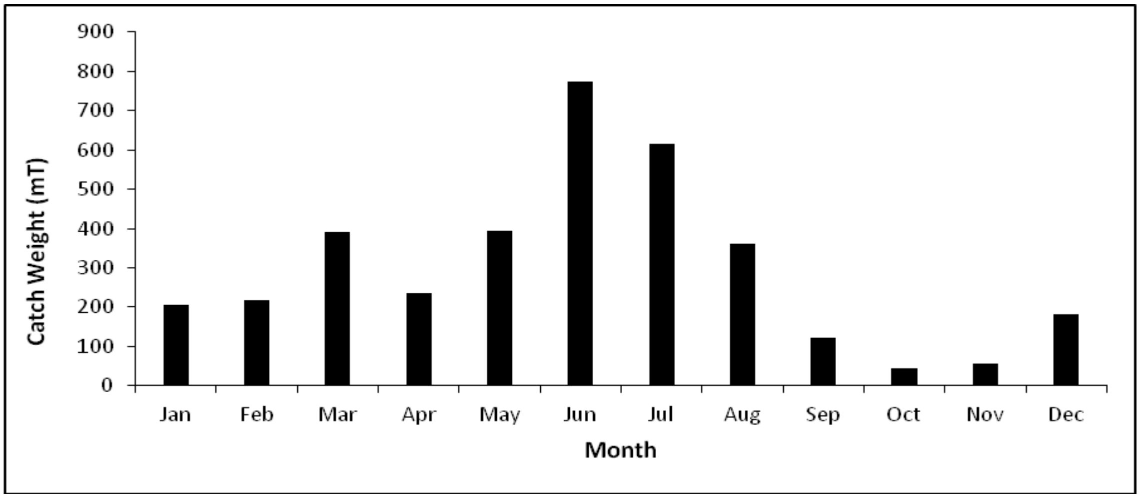
Source: DFO commercial landings database, All Atlantic Regions (2011).

Figure 4.22 Harvest Location Distribution of Greenland Halibut within the Study Area, May to November, 2011 (grid cells are 6 min x 6 min in size).



Source: DFO commercial landings database, All Atlantic Regions (2012).

Figure 4.23 Harvest Location Distribution of Greenland Halibut within the Study Area, May to November, 2012 (grid cells are 6 min x 6 min in size).

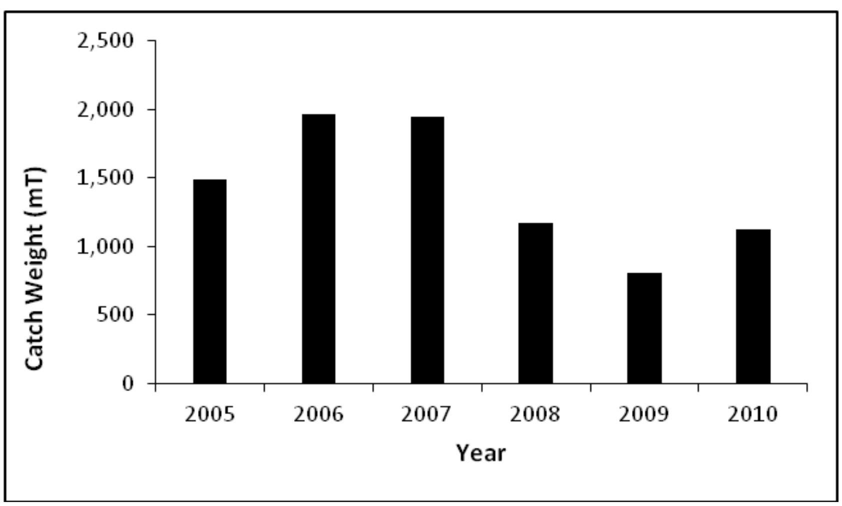


Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.24 Average Monthly Catch Weights for Greenland Halibut within the Study Area, 2005 to 2010.

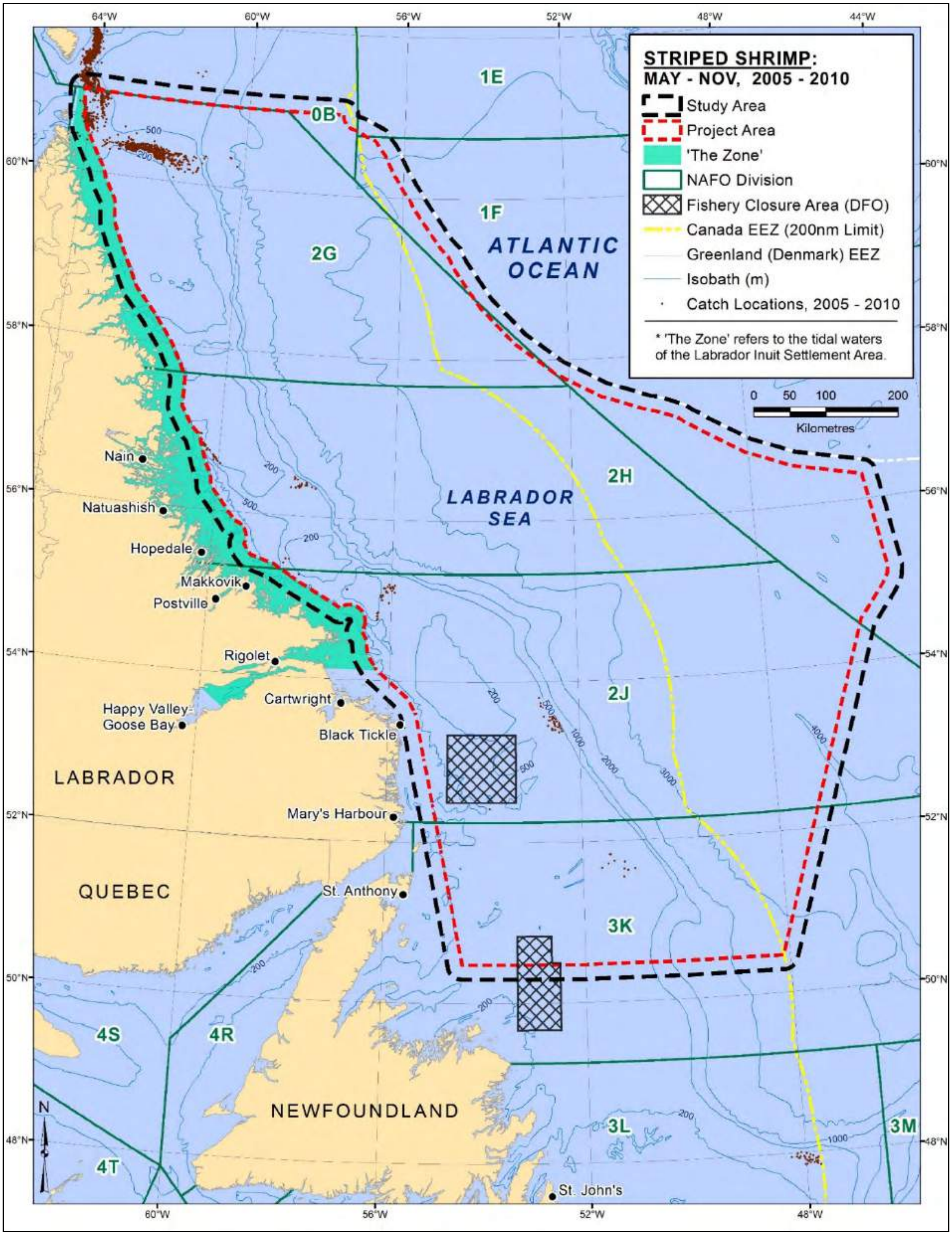
Striped Shrimp

Despite its relatively small average annual catch weight in the Study Area between 2005 and 2010, striped shrimp catch was valued at $2 million over that time. Although there is some directed fishery for this shrimp, most is harvested as by-catch in the northern shrimp fishery (DFO 2013b). Total annual catch weights for striped shrimp in the Study Area between May and November, 2005 to 2010 are indicated in Figure 4.25. As the graph illustrates, there was considerable variability in total catch weight during that time. As Figures 4.26 to 4.28 show catches were primarily in the most northwestern part of the Study Area. The average striped shrimp harvests by month for the 2005 to 2010 period in the Study Area are shown in Figure 4.29. As illustrated by the graph, August to December was the primary harvesting period for this species during the six-year period.



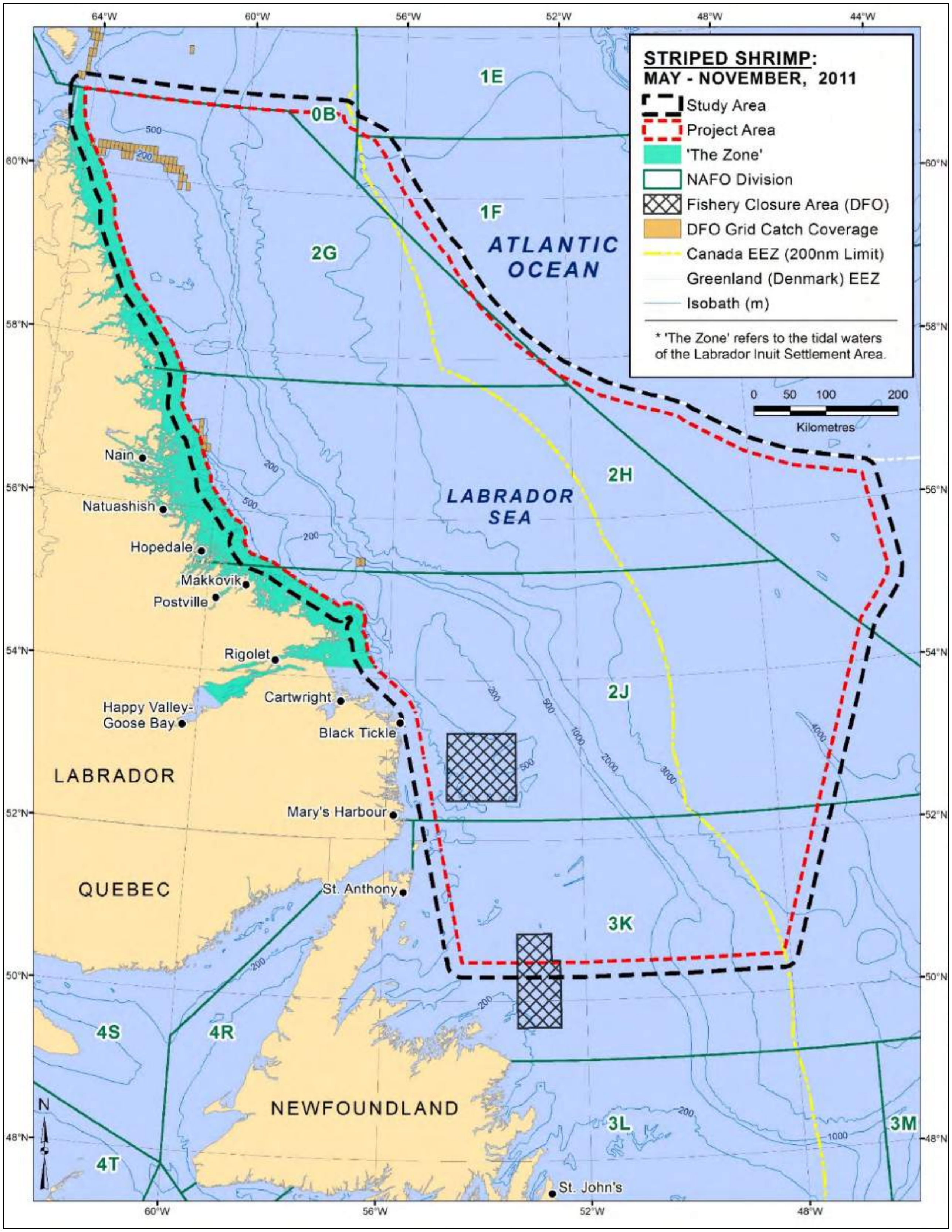
Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.25 Total Annual Catch Weights for Striped Shrimp, May to November, 2005 to 2010.



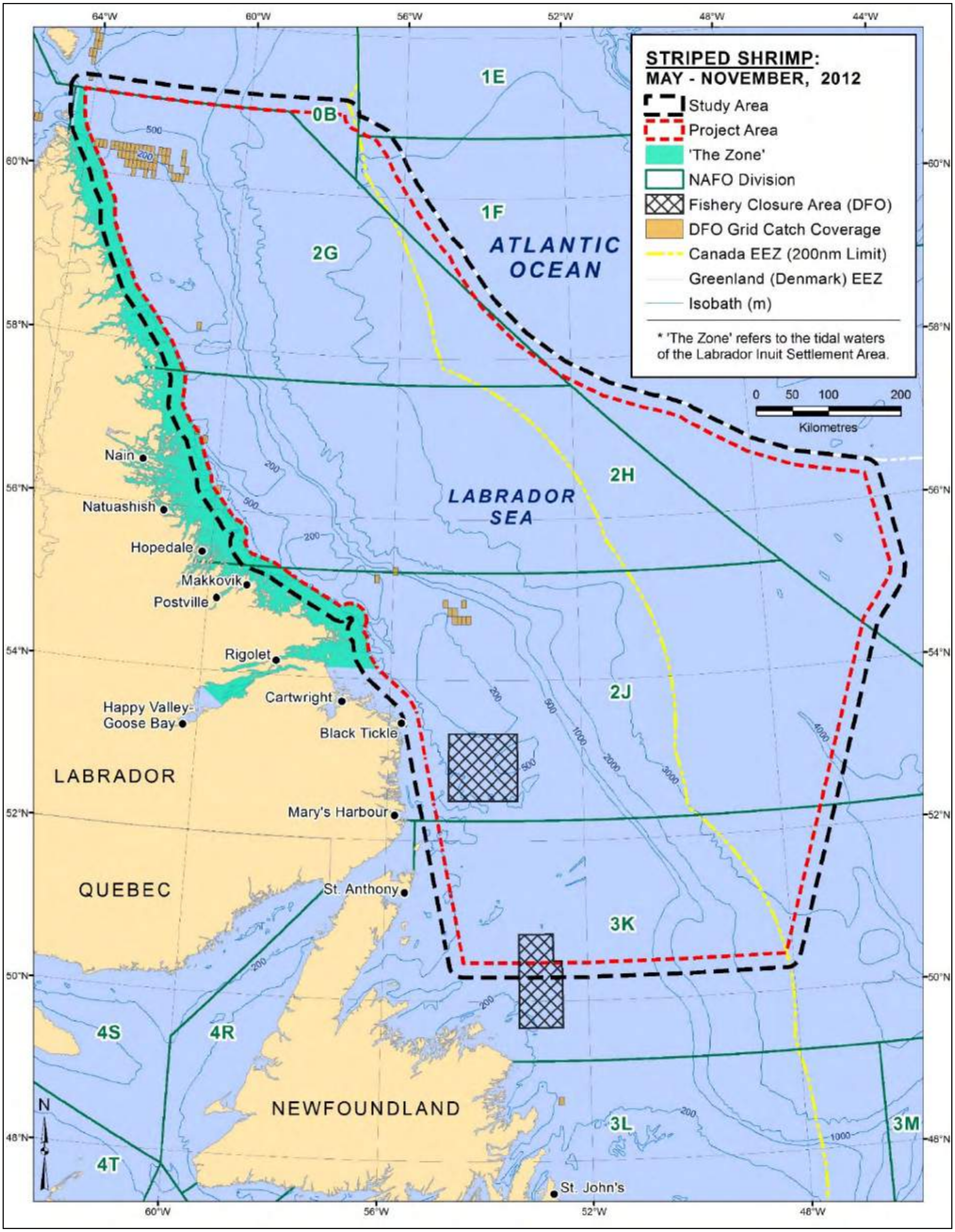
Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.26 Harvest Location Distribution of Striped Shrimp within the Study Area, May to November, 2005 to 2010.



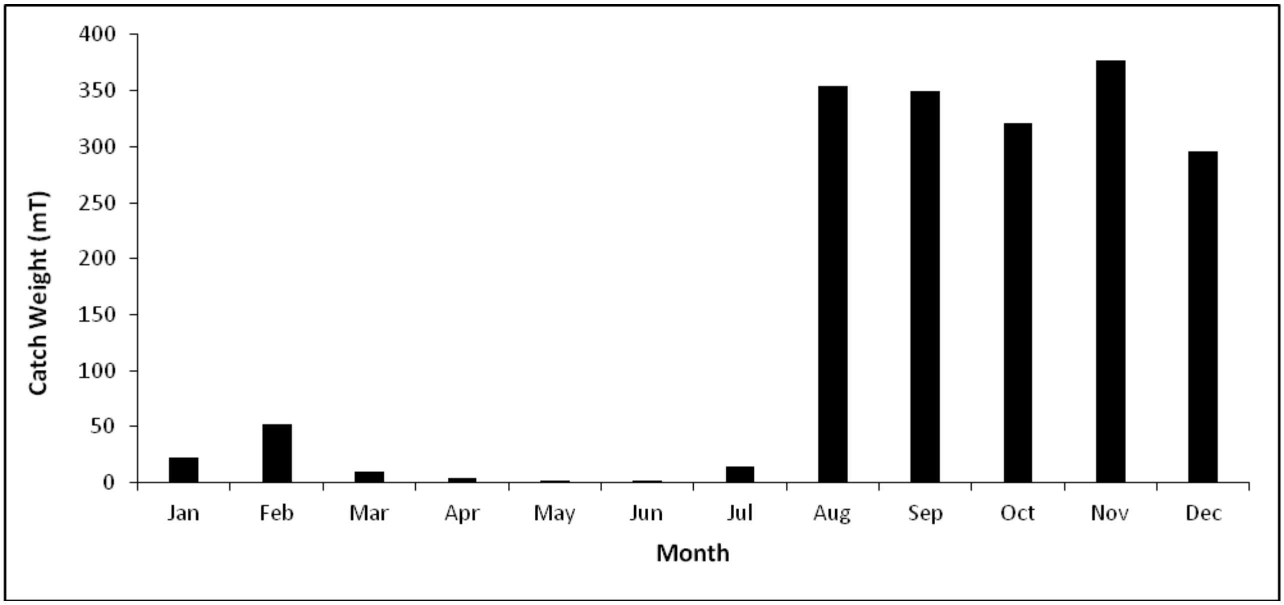
Source: DFO commercial landings database, All Atlantic Regions (2011).

Figure 4.27 Harvest Location Distribution of Striped Shrimp within the Study Area, May to November, 2011 (grid cells are 6 min x 6 min in size).



Source: DFO commercial landings database, All Atlantic Regions (2012).

Figure 4.28 Harvest Location Distribution of Striped Shrimp within the Study Area, May to November, 2012 (grid cells are 6 min x 6 min in size).



Source: DFO commercial landings database, All Atlantic Regions (2005 to 2010).

Figure 4.29 Average Monthly Catch Weights for Striped Shrimp within the Study Area, 2005 to 2010.

4.3.4 Traditional and Aboriginal Fisheries

According to the Labrador Shelf SEA (Sikumiut 2008), Labrador waters are used extensively by local aboriginal peoples for traditional hunting and fishing. The activities are spread widely throughout the region and vary by season. The aboriginal people consider these activities as part of their culture and history, and concerns were expressed in the public consultation sessions during the completion of the SEA report and through the process of collecting traditional knowledge over the impact that operations and/or accidental events may have on them. Some of the activities and issues that were highlighted for the SEA Area are:

- Fishing: the area is used extensively for fishing. Species noted were crab, rock cod (= Greenland cod), Atlantic cod, Arctic char, sculpin, mussels, clams, wrinkles, and sea urchins;
- Traditional uses such as egging and berry picking are conducted on the islands in coastal areas;
- Harlequin Duck, a *threatened* species migrates through the area;
- Ducks and geese are also hunted in the area; and,
- Traditional activities are well dispersed throughout the Labrador Shelf Area.

Though not specified by the Labrador Shelf SEA (Sikumiut 2008), it is likely that most of these activities occur in inshore waters landward of the Project and Study Areas.

The traditional, or country food, harvesting activities occurring in the Labrador Shelf SEA Area are described in Section 4.10.6 of the Labrador Shelf SEA (Sikumiut 2008) and include the harvest of invertebrate and fish (marine and anadromous) species and the hunting of seabirds, waterfowl, and marine mammals, particularly seals.

Inuit have the right to harvest fish, wildlife, and plants throughout the Labrador Inuit Settlement Area at all times of the year up to their full level of needs for food, social and ceremonial (FSC) purposes (Nunatsiavut 2009). Inuit are able to take as many fish as they need for their FSC purposes unless a total allowable harvest is established by the federal Minister of Fisheries for conservation purposes.

If a total allowable harvest is set for a species or stock of fish, the Nunatsiavut Government will recommend an Inuit domestic harvest level for that species or stock (Nunatsiavut 2009). The domestic harvest level will be the amount that Inuit need for their FSC purposes, and will come from information that is being collected from Inuit about their fishing, hunting and gathering activities. The Nunatsiavut Government's recommendation must be accepted by the federal Minister of Fisheries unless it cannot be supported by information.

When an Inuit domestic harvest level is established for a species or stock of fish, Inuit will be able to harvest up to the Inuit domestic harvest level for that species or stock (Nunatsiavut 2009). If necessary, the Inuit domestic harvest level will be divided amongst individuals or families by the Nunatsiavut Government. The FSC species harvested are not listed by Nunatsiavut (2009); however, the Labrador Métis Nation, which has similar rights for FSC purposes, provides the harvesting regulations for several species on their website (LMN 2009). Species harvested for FSC purposes include Atlantic salmon, Arctic char, trout, herring, smelt, scallop, and whelk. Several seal species are hunted and include harp, grey, ringed, bearded, and hooded. Some examples of the birds harvested include geese, eiders, and gull eggs. Various regulations exist for the harvest of different species for FSC use. Smelt, for example, can only be harvested by angling and harvest limits are restricted to the amount required for FSC purposes. The species can be harvested year-round in tidal waters from Hamilton Inlet to Battle Harbour.

FSC or subsistence fisheries for Atlantic salmon and Arctic char occurring in Labrador waters are described by Reddin et al. (2008). From 1999 to 2005, a FSC or subsistence fishery of 10 mt was available for members of the Labrador Inuit Association (now known as the Nunatsiavut Government) in the north as well as the Lake Melville area, both located in SFA 1. The Innu Nation also fish for salmon in Lake Melville from the community of Sheshatshiu and on the north coast from the community of Natuashish. They generally restrict themselves to harvests of around 3 mt. Beginning in 2000 and continuing into 2005, residents of Labrador were able to fish in the sea for brook trout and Arctic char with a permitted bycatch of four salmon. In 2004 to 2005, members of the Labrador Métis Nation (LMN) on the south coast of Labrador negotiated a subsistence fishery of 10 mt with DFO in the area between Fish Cove Point and Cape St. Charles, located in SFA 2. The total landings in the four fisheries for FSC or subsistence purposes, including the bycatch of salmon in the resident trout fishery, were 26 mt in 2007, which was a slight decline from the 2006 landings. Landings for 2008 subsistence harvest were unavailable when DFO (2009) was prepared. The Arctic char food fishery has a higher harvest than the Atlantic salmon food fishery harvest (DFO 2009); however, the total number of char (and trout) landed in Labrador is unknown because there is no reporting system for fish caught either through the ice in the winter and spring or by recreational fishing in the summer (Reddin et al. 2008). The total landings of Arctic char were also unavailable (DFO 2009). The recreational groundfish fishery for NAFO Div. 2J3KL has allocated a quota for FSC purposes for the Labrador Metis Nation and Innu in recent years. In 2008, the FSC quota was 10 mt.

The harvesting of country food can take many forms and today has incorporated many modern methods according to the Labrador Shelf SEA. The use of traditional ecological knowledge derived from generations of harvesting helps to identify the locale and timing of harvest activities that are tied to a particular target species' migrations and resource use. A variety of nets, traps and jigs are used to harvest fish, typically from inshore motor boats. Marine mammals are hunted with the assistance of boats and snowmobiles. Birds are hunted with rifles from land and water with the use of snowmobiles and boats.

Traditionally, the outer edge of the landfast ice, the "sina", was usually the most productive zone accessible to Inuit hunters. In the Nain and Hopedale areas, coastal islands shield the landfast ice from environmental impacts and the ice is subsequently locked in place, providing an extension of hunting and trapping areas up to 30 km from the coast (VBNC 1997 *in* the Labrador Shelf SEA [Sikumiut 2008]). For residents of Postville, smelt and capelin were caught only during spawning time. Smelt are only caught near the head of the bays. Bay capelin spawn on inside beaches, while outside capelin spawn on the beaches along the coast (Brice-Bennett 1977 *in* the Labrador Shelf SEA [Sikumiut 2008]). Salmon arrived on the coast in late June/early July and are caught using traps, nets, or jigged. The importance of cod varied along the coast (Brice-Bennett 1977 *in* the Labrador Shelf SEA [Sikumiut 2008]).

Ringed seals are hunted near their breathing holes or in open water. After the break-up of ice in mid-June, harp seals are hunted or netted as they enter the bays (VBNC 1997 *in* the Labrador Shelf SEA [Sikumiut 2008]). Traditionally, char were speared as they migrated up the rivers. Char and salmon were also caught by net along the coast. In the spring, ice fishing camps can be found at the heads of bays (e.g., Anaktalak Bay).

Information on country harvesting in Labrador was collected by traditional knowledge interviews, during public consultation meetings, and from literature sources for the Labrador Shelf SEA. Using this information, the authors identified important country food and harvest areas. None of the areas identified occurred in offshore waters, including those within the Study Area. Rather, the areas identified for many of the species discussed (capelin, various seal species, harbour porpoise, Atlantic white-sided dolphins, polar bears, and migratory birds) highlighted the importance of coastal waters (e.g., "The Zone" see Section 4.7) for traditional harvesting in Labrador. The seismic survey activities will not enter this area.

4.3.5 Recreational Fisheries

Arctic char and Atlantic salmon were suggested to be important non-commercial species targeted by recreational fisheries in the Labrador Shelf Area (see the Labrador Shelf SEA [Sikumiut 2008]). Recreational fisheries directed at brook trout (*Salvelinus fontinalis*) also occur in Labrador waters. These three anadromous species are typically harvested in freshwater or coastal marine waters, outside of the Study Area. Subsistence fisheries also occur for Atlantic salmon and Arctic char in Labrador waters.

Small recreational fisheries for Atlantic cod occur in Labrador Shelf waters with the majority of catches occurring within NAFO Division 2J, August to September, according to the Labrador Shelf SEA (Sikumiut 2008).

4.3.6 Aquaculture

Currently there are no approved aquaculture sites within the Study Area.

4.3.7 Macroinvertebrates and Fishes Collected during DFO Research Vessel Surveys

DFO RV data collected during annual multi-species trawl surveys provide distributional information for species not discussed in the commercial fisheries as well as added information for commercial species.

Data collected during 2007 to 2011 spring and fall DFO RV surveys in the Study Area were analyzed, and catch weights and catch numbers of species/groups are presented in Table 4.4.

Table 4.4 Catch Weights and Numbers of Macroinvertebrates and Fish Species Collected during DFO RV Surveys within the Study Area, 2007 to 2011.

Species	Catch Weight (kg)	Catch Number
Northern Shrimp (*Pandalus borealis*)	59,024	13,304,694
Deepwater Redfish (*Sebastes mentella*)	52,649	452,305
Shrimp (Natantia)	36,216	n/d
Greenland Halibut (*Reinhardtius hippoglossoides*)	31,352	153,795
Sponges (Porifera)	17,017	n/d
Capelin (*Mallotus villosus*)	8,449	473,912
Atlantic Cod (*Gadus morhua*)	4,413	6,766
Striped Shrimp (*Pandalus montagui*)	3,931	890,199
Roughhead Grenadier (*Macrourus berglax*)	3,703	9,461
Blue Hake (*Antimora rostrata*)	3,184	20,697
Arctic Cod (*Boreogadus saida*)	2,862	155,867
American Plaice (*Hippoglossoides platessoides*)	2,860	16,054
Snow Crab (*Chionoecetes opilio*)	2,264	12,193
Scyphozoa (Jellyfish)	2,171	80
Sea Anemones	2,053	12,631
Roundnose Grenadier (*Coryphaenoides rupestris*)	1,816	15,815
Thorny Skate (*Raja radiata*)	1,769	6,324
Northern Wolffish (*Anarhichas denticulatus*)	1,677	381
Invertebrates	1,641	n/d
Basket Star (Gorgonocephalidae)	1,606	225
Longnose Eel (*Synaphobranchus kaupi*)	1,187	15,094
Shrimp (*Argis dentata*)	1,104	219,806
Spotted Wolffish (*Anarhichas minor*)	1,031	524

Species	Catch Weight (kg)	Catch Number
Lanternfishes (Myctophidae)	841	104,971
Atlantic (Striped) Wolffish (*Anarhichas lupus*)	764	3,336
Witch Flounder (*Glyptocephalus cynoglossus*)	724	2,110
Marlin Spike (*Nezumia bairdi*)	630	6,534
Shanny (*Lumpenus maculatus*)	562	97,221
Corals	546	n/d
Eelpout (*Lycodes* sp.)	529	14,612
Black Herring (*Bathytroctes* sp.)	521	363
Spinytail Skate (*Raja* [*Bathyraja*] *spinicauda*)	516	95
Vahl's Eelpout (*Lycodes vahlii*)	516	13,334
Common Lumpfish (*Cyclopterus lumpus*)	481	297
Snake Blenny (*Lumpenus lumpretaeformis*)	464	29,233
Sea Urchin (Echinoidea)	416	12,125
Eelpout (Zoarcidae)	408	13,506
Greenland Shark (*Somniosus microcephalus*)	400	1
Basket Star (*Gorgonocephalus arcticus*)	387	84
Mailed Sculpin (*Triglops* sp.)	303	28,171
Northern Alligatorfish (*Agonus decagonus*)	289	27,073
Large Scale Tapirfish (*Notacanthus nasus*)	267	349
Golden Redfish (*Sebastes marinus*)	241	341
Arctic Eelpout (*Lycodes reticulatus*)	210	1,117
Rigid Cushion Star (*Heppasteria phygiana*)	189	878
Shrimp (*Eualus gaimardii belcheri*)	182	71,125
Black Dogfish (*Centroscyllium fabricii*)	180	142
Jensen's Skate (*Raja jenseni*)	171	52
Shrimp (*Eualus macilentus*)	158	153,621
Shrimp (*Pasiphaea* sp.)	155	17,649
Moustache Sculpin (*Triglops murrayi*)	155	13,847
Shrimp (*Sabinea septemcarinata*)	154	43,697
Sea Urchin (Strongylocentrotidae)	150	13,938
Shrimp (*Pasiphaea multidentata*)	131	13,778
Deepsea Cat Shark (*Apristurus profundorum*)	130	75
Sea Star (*Ctenodiscus* sp.)	127	8,796
Shrimp (*Pasiphaea tarda*)	114	11,644
Shrimp (*Lebeus groenlandicus*)	112	23,994
Threebeard Rockling (*Gaidropsarus* sp.)	110	1,039
Sea Urchin (*Strongylocentrotus droebachiensis*)	109	4,355
Threebeard Rockling (*Gaidropsarus ensis*)	107	1,084
Atlantic Halibut (*Hippoglossus hippoglossus*)	106	3
Octopus (Octopodidae)	101	241
Cusk (*Brosme brosme*)	7	9
Spiny Dogfish (*Squalus acanthias*)	2	2
Total	**256,644**	-

Source: DFO RV Survey Data (2007-2011). Note: n/d denotes data unavailable.

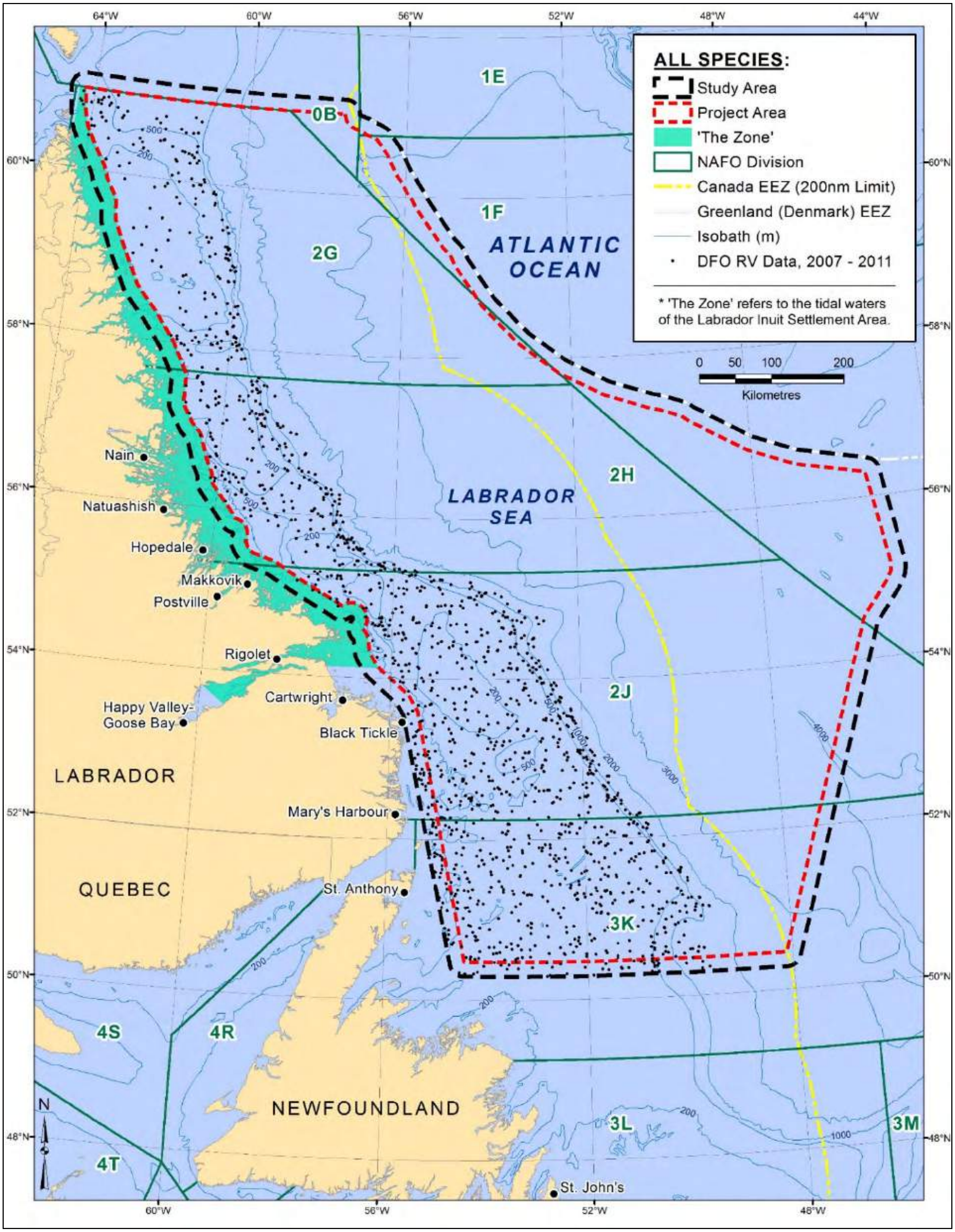
Northern shrimp accounted for 22.7% of the total 2007 to 2011 catch weight, followed by deepwater redfish (20.2%), shrimp (Natantia) (13.9%), Greenland halibut (turbot) (12.0%), sponges (6.5%), capelin (3.2%), Atlantic cod (1.7%), striped shrimp (1.5%), roughhead grenadier (1.4%), blue hake (1.2%), Arctic cod (1.1%), and American plaice (1.1%). All other species/groups accounted for less than 1% of the total 2007-2011 catch weight in the Study Area. The distribution of geo-referenced catch locations reported during the 2007 to 2011 DFO RV surveys within the Study Area are shown in Figure 4.30. Across all species caught during the 2007 to 2011 DFO RV surveys in the Study Area, total catch weight ranged from 44,499 kg in 2007 to 63,236 kg in 2008.

Spring surveys accounted for <15% of the total catch weight. The average mean depths of catch during spring and fall surveys between 2007 and 2011 were 281 m (min: 80 m; max: 657 m) and 467 m (min: 89 m; max: 1,526 m), respectively. In descending order, the top five species/groups in terms of catch weight during the 2007-2011 spring surveys were northern shrimp, deepwater redfish, sponges, striped shrimp, and invertebrates. In descending order, the top five species/groups in terms of catch weight during the 2007-2011 fall surveys were deepwater redfish, northern shrimp, shrimp (Natantia), Greenland halibut, and sponges.

Species/groups that were caught predominantly during the spring RV surveys included various shrimps (i.e., *Euphausia* sp., *Pontophilus norvegicus*, *Eualus gaimardii belcheri*), barndoor skate (*Raja laevis*), spiny crab (Lithodidae), spiny lumpsucker (*Eumicrotremus spinosus variabilis*), snubnose eel (Simenchelyidae), cephalopods (*Rossia* sp.), invertebrates, soft eelpout (*Melanostigma atlanticum*), hagfishes (Myxiniformes), and corals. Species/groups that were caught in essentially equal amounts during both surveys included various shrimps (i.e., *Argis dentata*, *Spirontocaris spinus*, *Eualus macilentus*, *Sabinea septemcarinata*), sea cucumbers (Holothuroidea), spiny crab (*Lithodes maja*), skates (*Raja* sp.), wolf eel (*Lycenchelys* sp.), spoonarm octopus (*Bathypolypus arcticus*), and seasnails (Liparidae). Most species/groups were caught predominantly during the fall RV surveys. The survey depth differences between spring and fall surveys likely account for some of the seasonal differences.

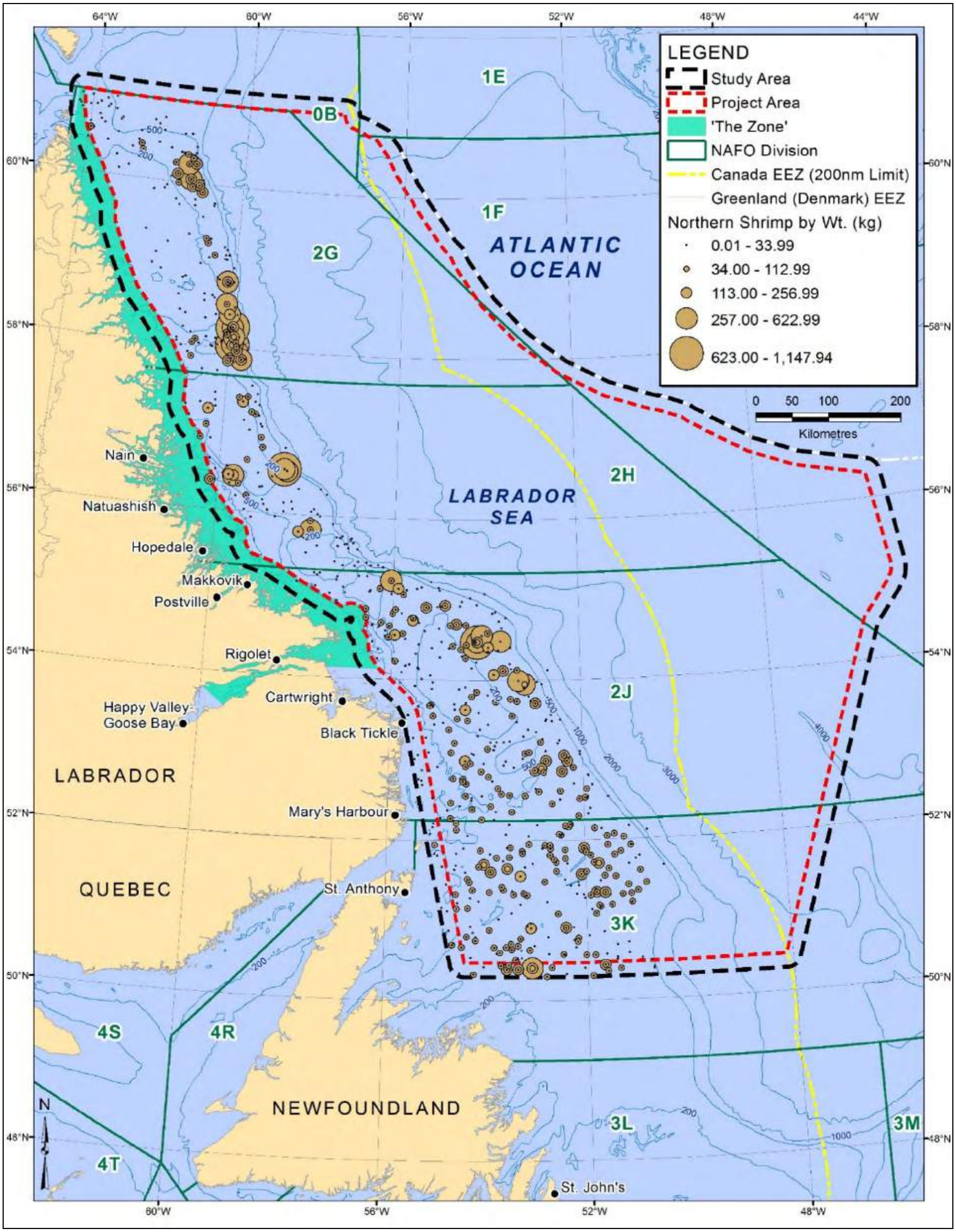
Figures 4.31 to 4.39 indicate DFO RV survey catch locations for northern shrimp, redfish, shrimp (Natantia), Greenland halibut, sponges, corals, and wolffishes during 2007 to 2011. The sizes of the circular symbols used in these figures are proportional to the catch weight range they represent for each species.

Catches at various mean depth ranges are also examined in this section. Table 4.5 presents total catch weights and predominant species caught within each mean depth range in the Study Area during the 2007 to 2011 period. Northern shrimp was caught primarily at depths ranging from 200 to 400 m, deepwater redfish at depths ranging from 300 to 500 m, shrimp (Natantia) at depths ranging from 100 to 500 m and greater than 1,000 m, Greenland halibut at depths ranging from 200 to 500 m and greater than 1,000 m, and sponges at depths ranging from 200 to 600 m.



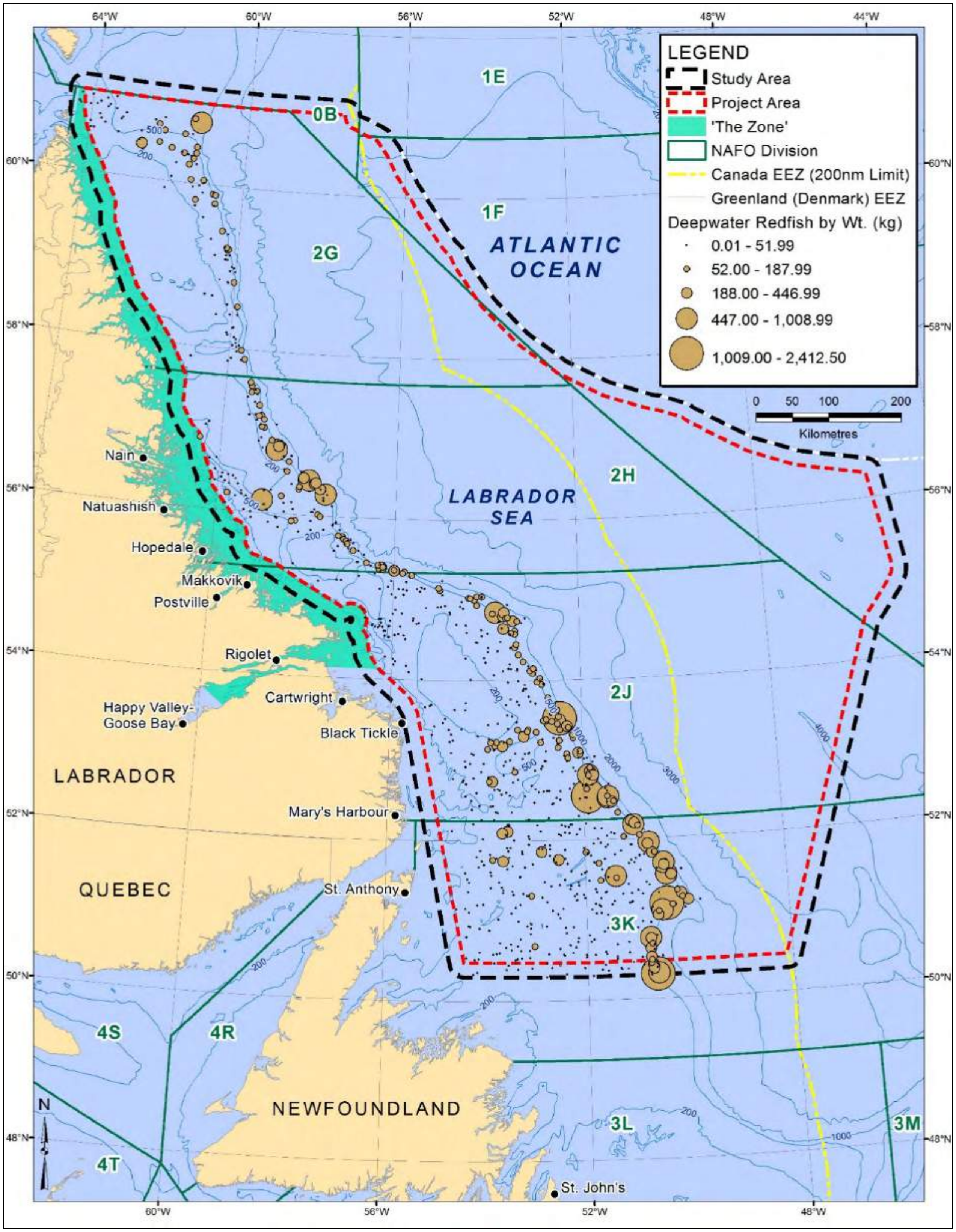
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.30 Distribution of DFO RV Survey Catch Locations for All Species within the Study Area, 2007 to 2011.



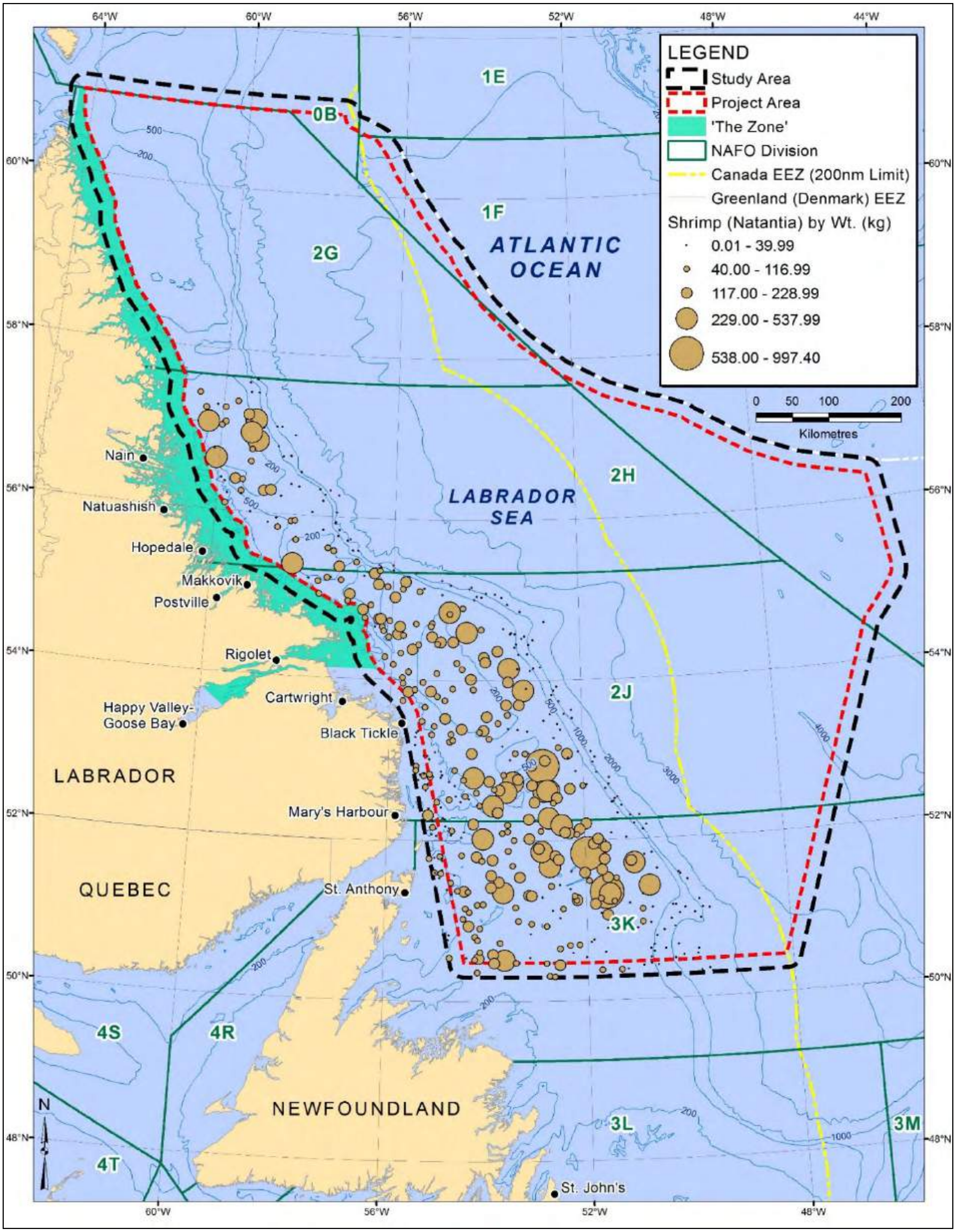
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.31 Distribution of DFO RV Survey Northern Shrimp Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



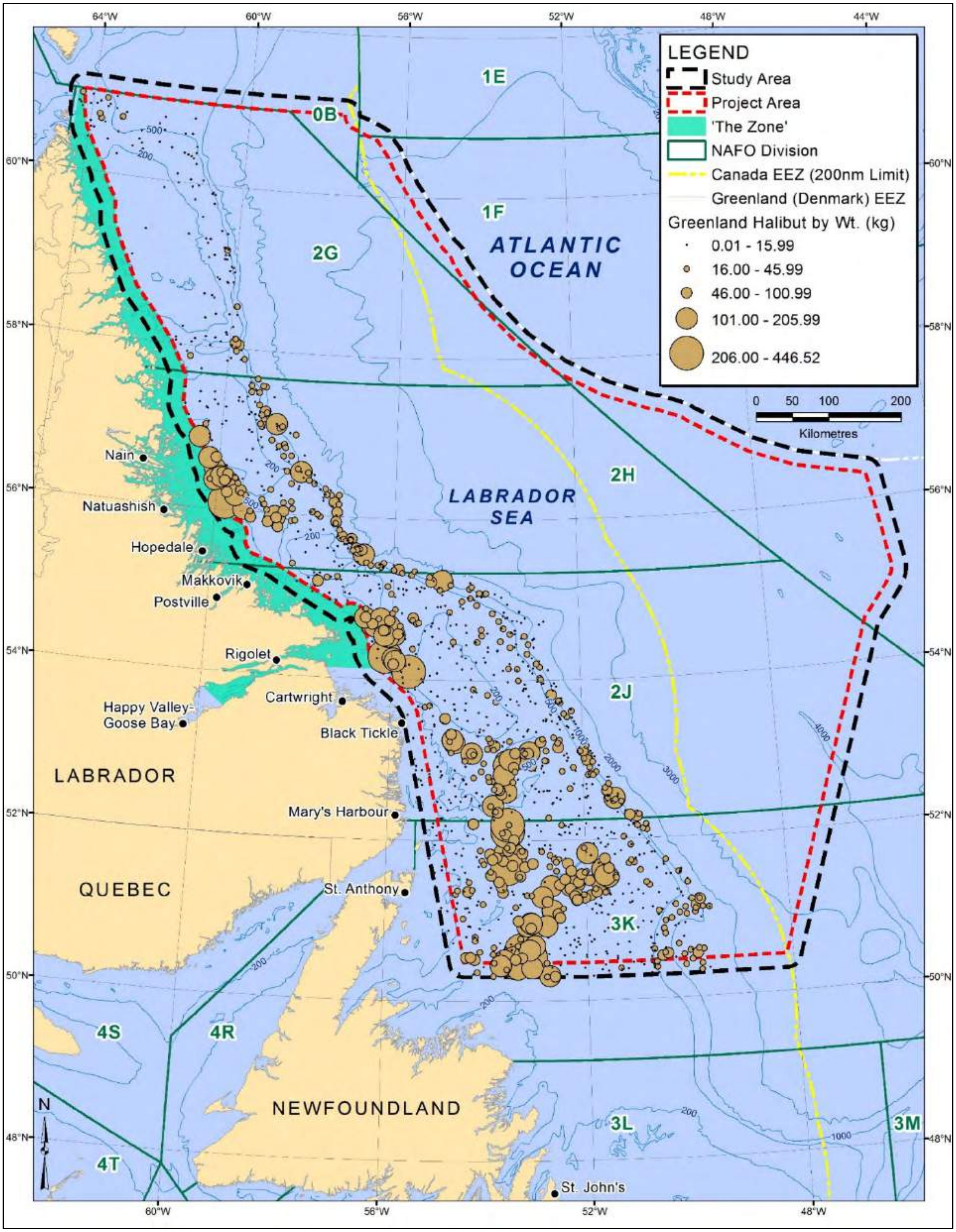
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.32 Distribution of DFO RV Survey Deepwater Redfish Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



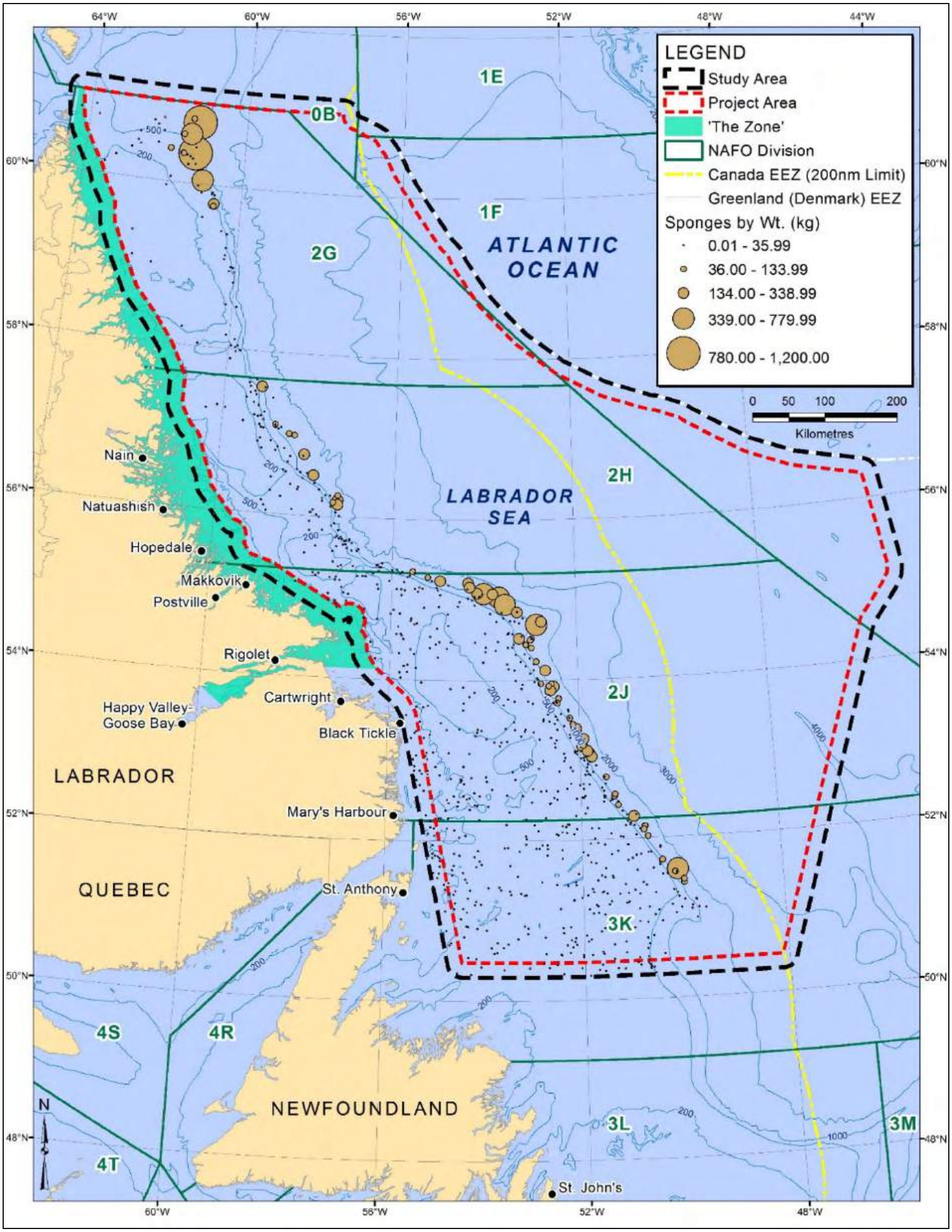
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.33 Distribution of DFO RV Survey Shrimp (Natantia) Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



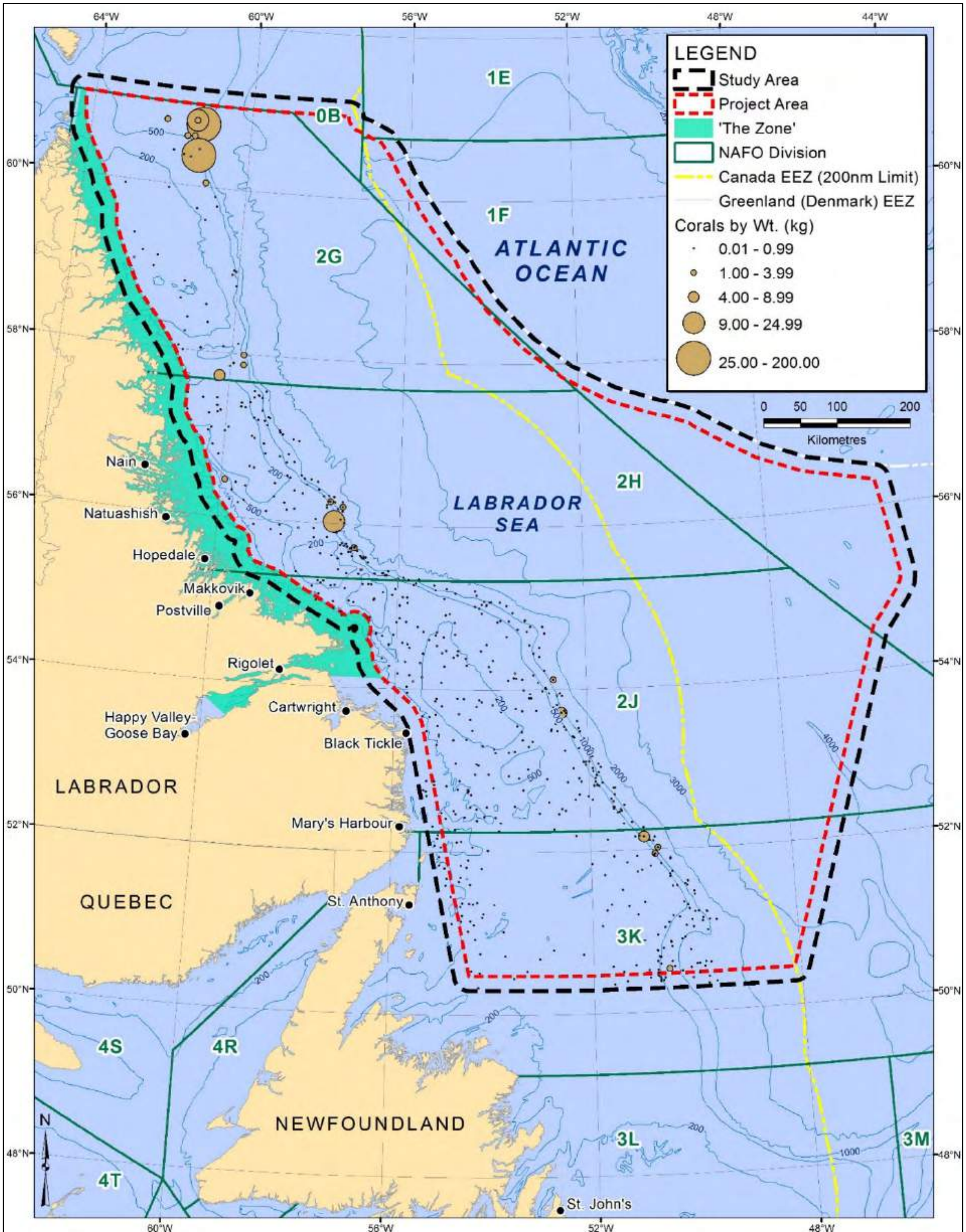
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.34 Distribution of DFO RV Survey Greenland Halibut Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



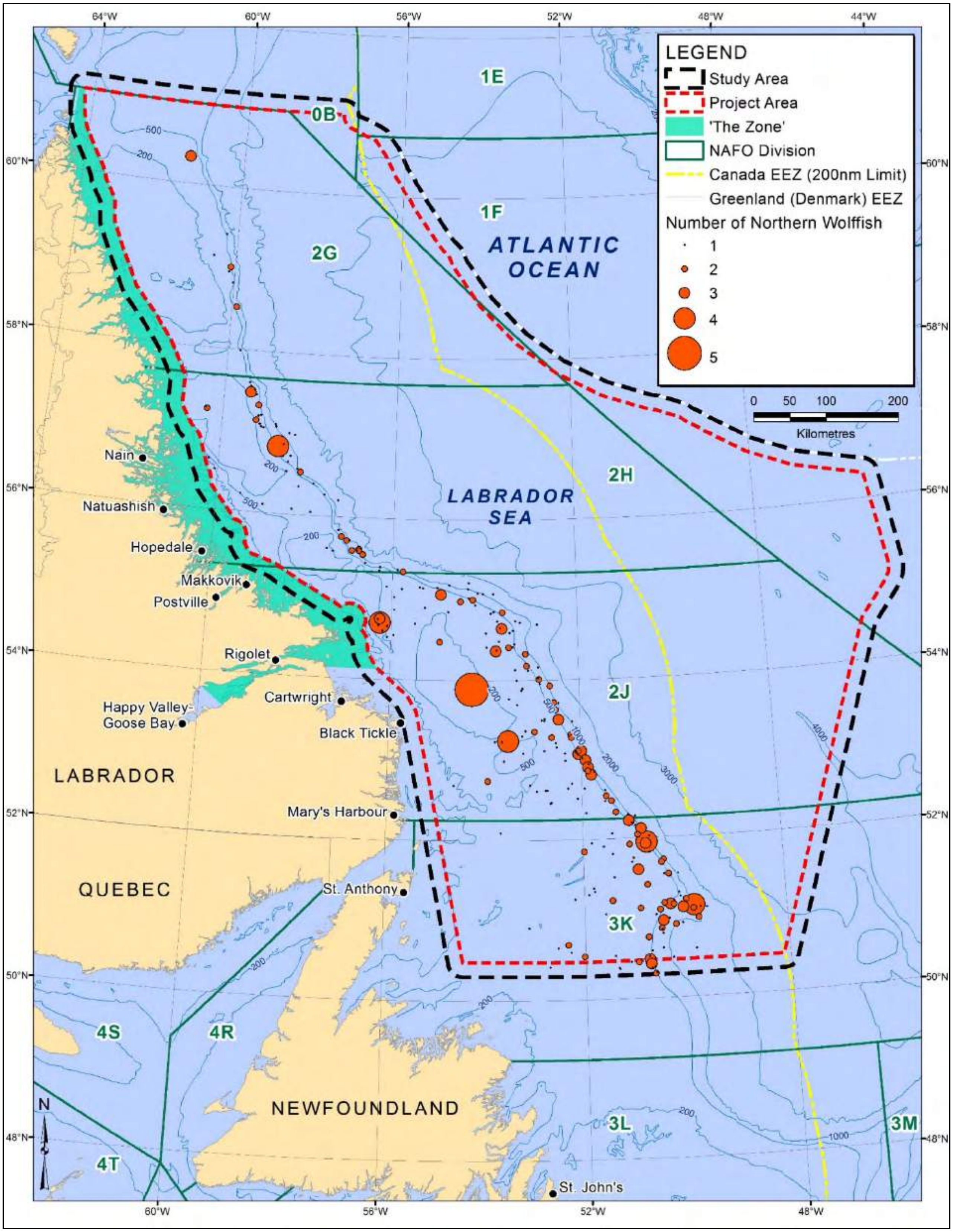
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.35 Distribution of DFO RV Survey Sponge Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



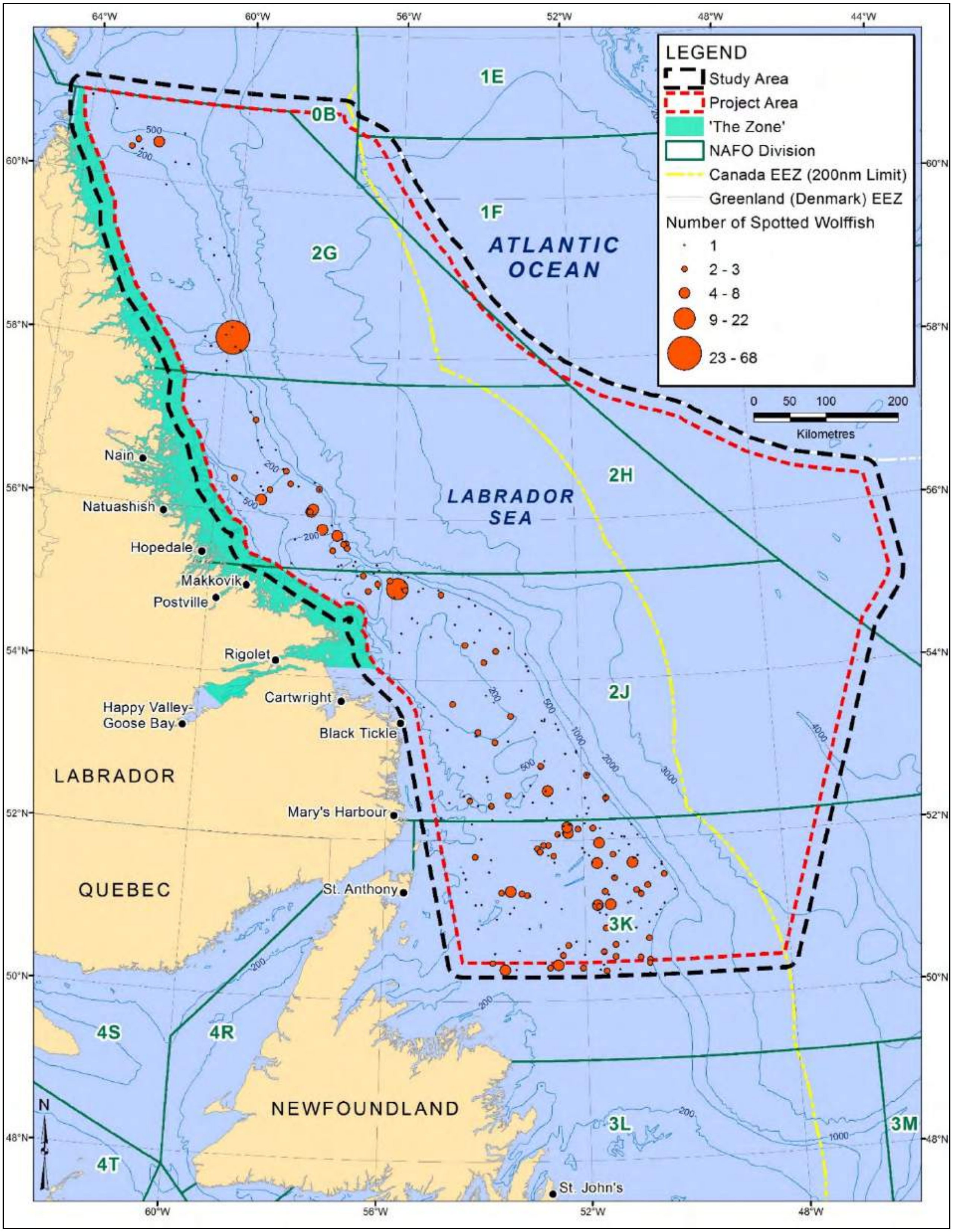
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.36 Distribution of DFO RV Survey Coral Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



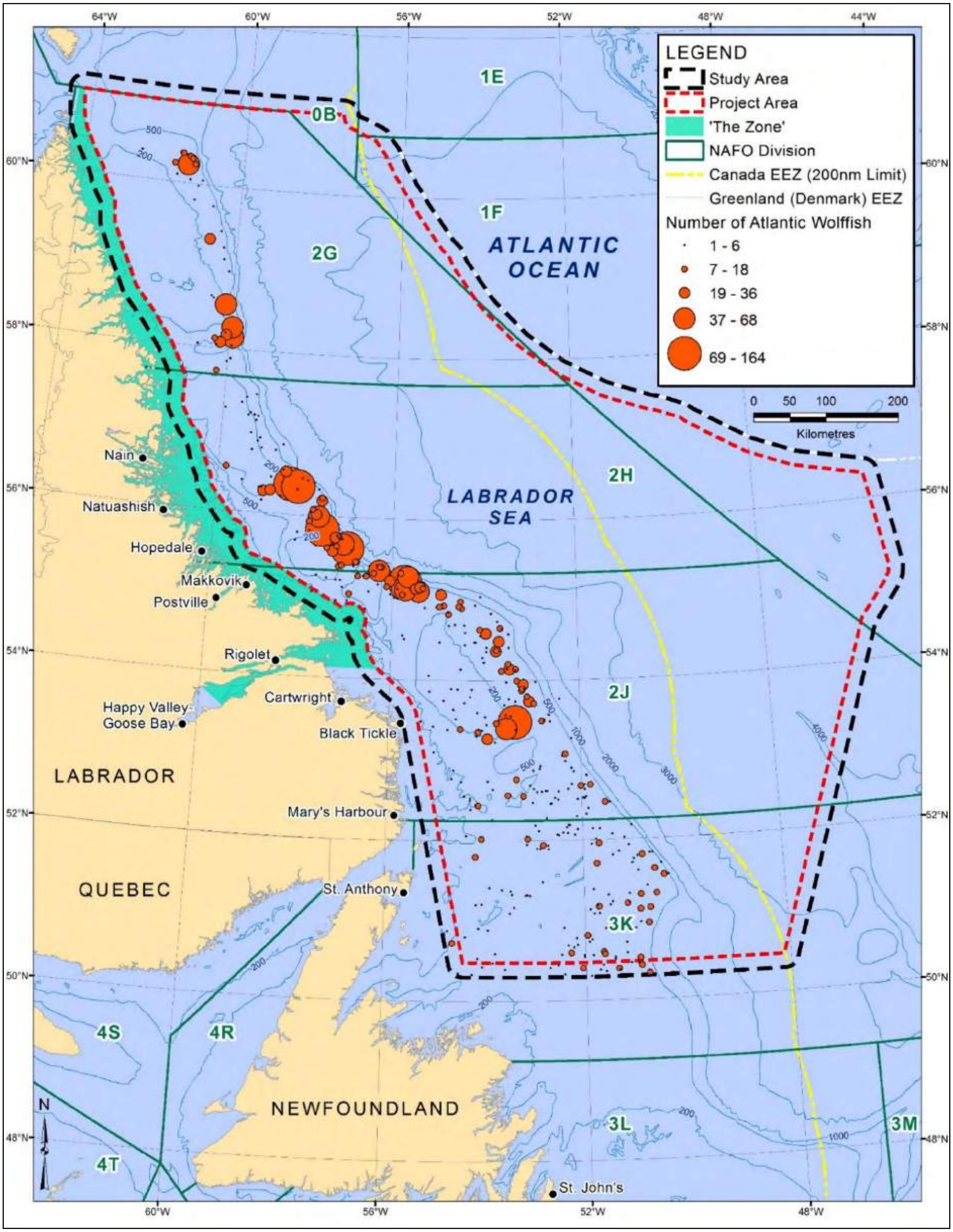
Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.37 Distribution of DFO RV Survey Northern Wolffish Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.38 Distribution of DFO RV Survey Spotted Wolffish Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).



Source: DFO Research Vessel Survey Database (2007-2011).

Figure 4.39 Distribution of DFO RV Survey Atlantic (striped) Wolffish Catch Locations within the Study Area, 2007 to 2011 (symbol size range represents proportional catch weights).

Table 4.5 DFO RV Survey Total Catch Weights and Predominant Species Caught at Various Mean Catch Depth Ranges, 2007 to 2011.

Mean Catch Depth Range	Total Catch Weight (kg)	Predominant Species
<100	-	-
≥100 - <200	1,421	Shrimp (*Argis dentate*; 78%) Shorthorn Sculpin (5%) Spiny Lumpfish (5%)
≥200 - <300	55,329	Northern Shrimp (49%) Capelin (15%) Atlantic Cod (8%) Arctic Cod (5%)
≥300 - <400	94,563	Deepwater Redfish (56%) Northern Shrimp (35%)
≥ 400 - <500	98,500	Shrimp (Natantia; 37%) Greenland Halibut (32%) Sponges (17%)
≥500 - <600	2,017	Broadhead Wolffish (83%) Sea Star (Asteroidea; 4%)
≥600 - <700	8,070	Roughhead Grenadier (46%) Scyphozoans (27%) Lanternfishes (10%)
≥700 - <800	381	Octopus (51%) Shrimp (*Pasiphaea tarda*; 30%)
≥800 - <900	1,819	Longnose Eel (65%) Spinytail Skate (28%)
≥900 - <1,000	5,743	Blue Hake (55%) Roundnose Grenadier (32%)
≥1,000	1,589	Black Herring (33%) Jensen's Skate (11%) Deepsea Cat Shark (8%) Shortnose Snipe Eel (6%) Deepwater Chimaera (6%) Goitre Blacksmelt (6%) Shrimp (*Acanthephyra pelagica*; 5%)

Source: DFO Research Vessel Survey Database (2007-2011).

Other Information

- RV Data (2007-2011):
  - On average (based on catch weight): Fish (49.9%), Invertebrates (49.9%), Corals (0.2%)
    - Greatest catch in 2008; driven by higher northern shrimp catch than other survey years
  - Percent Total (based on catch weight): Summer (14.8%), Fall (85.2%)
  - Coral Average Mean Catch Depth: Summer (349 m), Fall (645 m)
  - Sponge Average Mean Catch Depth: Summer (306 m), Fall (458 m)

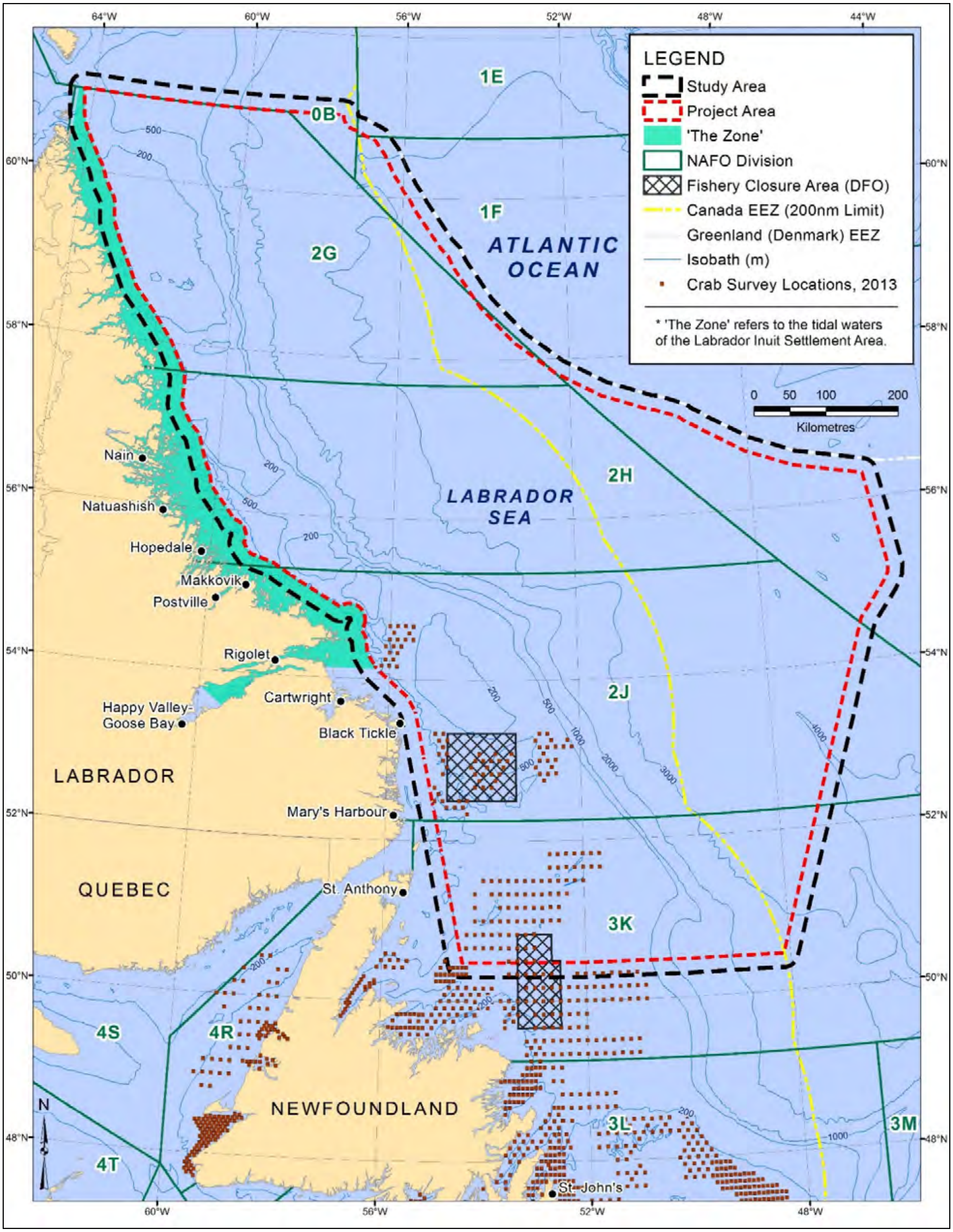
4.3.8 Industry and DFO Science Surveys

Fisheries research surveys conducted by DFO, and sometimes by the fishing industry, are important to the commercial fisheries to determine stock status, as well as for scientific investigation. In any year, there may be overlap between the Study Area and DFO research surveys in NAFO Divisions 0B, 1EF, 2GHJ and 3K, depending on the timing in a particular year.

The Groundfish Enterprise Allocation Council (GEAC) has been involved in conducting fisheries research, including multispecies surveys (target Atlantic cod, American plaice, witch flounder and haddock), and redfish surveys. All survey locations have been south of Newfoundland, well outside of the Study Area. Survey locations are generally consistent between survey years and are not anticipated to expand northward to the Study Area.

The 2014/2015 schedule for DFO RV surveys in the Study Area was not finalized at the time of writing; however, spring surveys are currently not set to begin until the last week in March 2014 (G. Sheppard, DFO, pers. comm., 2014). Based on recent years, DFO fall research surveys are likely to occur in the Study area for most of October, a portion of November, and perhaps in early December (e.g., see Table 4.7 in LGL and GXT 2013).

Members of the FFAW have been involved in an industry survey for crab in various offshore harvesting locations over the past few years, such as the snow crab DFO-industry collaborative post-season trap survey; this survey is conducted every year. It starts on September 1 and may continue until November before it is completed. The set locations are determined by DFO and do not change from year to year. Many of the northern stations fall within the Study Area. Research station locations in relation to the Project Area and Study Area are shown in Figure 4.40.



Source: DFO (2013).

Figure 4.40 Locations of DFO-Industry Collaborative Post-Season Snow Crab Trap Survey Stations in Relation to the Project and Study Areas.

4.4 Seabirds and Migratory Birds

The Labrador Sea is rich in breeding and migratory seabirds. There are over 30 species of marine birds occurring regularly on the Labrador coast and the north coast of Newfoundland (Table 4.6). Among the countless islands along these coastlines, some provide suitable nesting conditions for colonies of various gull species, Arctic and Common Tern, Common Eider, and auks (Razorbill, Thick-billed Murre, Common Murre, Atlantic Puffin and Black Guillemot). There are five main concentrations of nesting auks, along these coastlines: (1) offshore islands south east of Nain, (2) Quaker Hat Island near Cape Harrison, (3) Gannet Islands and Bird Island in Groswater Bay/Table Bay, (4) Wadham Islands, and (5) Funk Island (Figure 4.41). These five island groups support almost 660,000 pairs of breeding seabirds. More than 40% of the North American breeding population of Razorbill nests on the mid-Labrador coast alone. The Gannet Islands (including the Gannet Cluster) off Hamilton Inlet, the largest breeding seabird nesting colony in Labrador, supports more than 91,000 pairs of nesting seabirds in the summer (Table 4.7). The Wadham Islands and Funk Island, 50-100 km south of the Study Area, host over 430,000 pairs of seabirds that travel great distances on foraging sorties. Colonies of terns (Arctic and Common) and gulls (Herring, Great Black-backed, Ring-billed and Glaucous), and nesting Common Eider are scattered along most of the Labrador coast and the north coast of Newfoundland.

Large numbers of Great Shearwater and Sooty Shearwater migrate from breeding islands in the south Atlantic to spend the summer in the waters offshore Newfoundland and Labrador. Three species of jaeger (Long-tailed, Pomarine and Parasitic) and two species of phalarope (Red and Red-necked) migrate through Newfoundland and Labrador offshore waters between Arctic breeding grounds and mid-latitude marine wintering grounds. Many of the 3.8 million Thick-billed Murres breeding in the eastern Canadian Arctic, and up to 10 million Dovekies from Greenland, winter in the Labrador Sea or cross it on the way to the Grand Banks and other parts of southern Atlantic Canada. Large numbers of sub-adults of Northern Fulmar and Black-legged Kittiwake from breeding colonies in the eastern Arctic and Europe spend the early parts of their lives in the Labrador Sea.

Offshore Labrador is a known wintering area for the Ivory Gull, a species designated as Endangered on Schedule 1 of *SARA*, COSEWIC, and the Newfoundland and Labrador *Endangered Species Act*. Harlequin Ducks and Barrow's Goldeneye moult and stage at some sites along the Labrador coast and around islands off the Labrador coast. Both species are designated Special Concern on Schedule 1 of *SARA* and by COSEWIC. Details on these species are located in Section 4.6 on Species at Risk. Shorebirds and other species found on the coast but not in the Study Area are not discussed in detail this report (see the Labrador Shelf SEA for information on coastal species).

Table 4.6 Monthly Occurrence and Abundance of Pelagic Seabirds in Offshore Labrador and Northern Newfoundland.

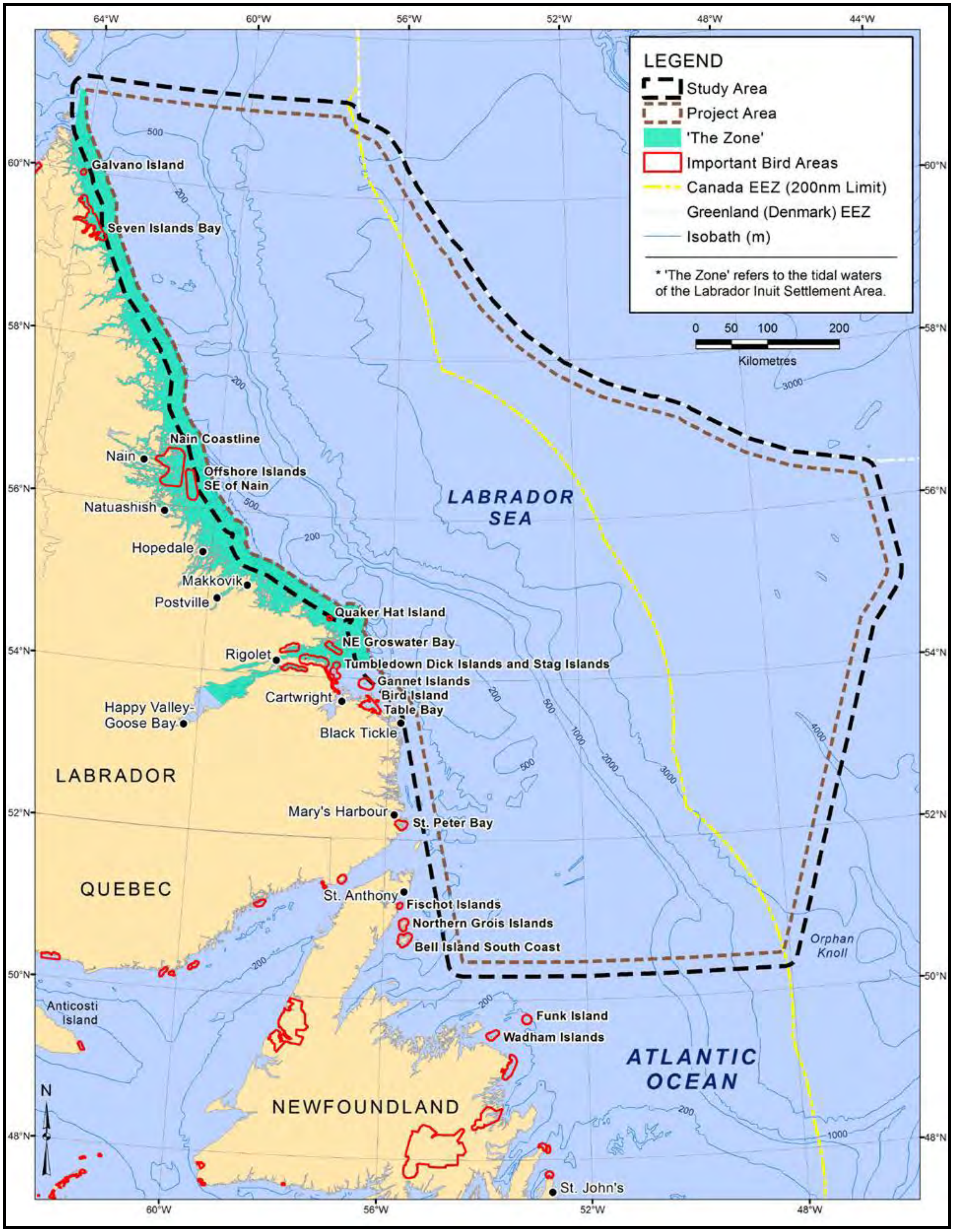
Species	Scientific Name	Abundance[1]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Northern Fulmar*	*Fulmarus glacialis*	Common												
Great Shearwater	*Puffinus gravis*	Common												
Sooty Shearwater	*Puffinus griseus*	Uncommon												
Manx Shearwater	*Puffinus puffinus*	Scarce												
Leach's Storm-Petrel*	*Oceanodroma leucorhoa*	Uncommon												
Northern Gannet	*Morus bassanus*	Uncommon												
Red-necked Phalarope*	*Phalaropus lobatus*	Uncommon												
Red Phalarope	*Phalaropus fulicarius*	Common												
Ring-billed Gull*	*Larus delawarensis*	Uncommon												
Herring Gull*	*Larus argentatus*	Common												
Iceland Gull	*Larus glaucoides*	Common												
Glaucous Gull*	*Larus hyperboreus*	Common												
Great Black-backed Gull*	*Larus marinus*	Common												
Black-legged Kittiwake*	*Rissa tridactyla*	Common												
Ivory Gull	*Pagophila eburnea*	Scarce												
Common Tern*	*Sterna hirundo*	Common												
Arctic Tern*	*Sterna paradisaea*	Common												
Great Skua	*Stercorarius skua*	Scarce												
Pomarine Jaeger	*Stercorarius pomarinus*	Uncommon												
Parasitic Jaeger	*Stercorarius parasiticus*	Uncommon												
Long-tailed Jaeger	*Stercorarius longicaudus*	Uncommon												
Dovekie	*Alle alle*	Common												
Common Murre*	*Uria aalge*	Common												
Thick-billed Murre*	*Uria lomvia*	Common												
Razorbill*	*Alca torda*	Common												
Black Guillemot*	*Cepphus grylle*	Common												
Atlantic Puffin*	*Fratercula arctica*	Common												

Source: Brown (1986); Lock et al. (1994); Godfrey (1986).

Notes: Shaded fields indicate the months when species may be expected.

* Breeds on the mid-Labrador coast and Wadham Islands.

[1] Common = likely present daily in moderate to high numbers; Uncommon = likely present daily in small numbers; Scarce = likely present regularly in very small numbers; Rare = usually absent, individuals occasionally present.



Source: Bird Studies Canada and The Canadian Nature Federation (2004). Important Bird Areas of Canada Database. Port Rowan, Ontario: Bird Studies Canada. Full metadata: http://birdmap.bsc-eoc.org/maps/metadata/caniba_poly.xml

Figure 4.41 Important Bird Areas of the Labrador Coast and Northern Newfoundland.

Table 4.7 Breeding Pairs of Pelagic Seabirds at Important Bird Areas.

Species	Number of Nesting Pairs								
	Southeast of Nain	Quaker Hat	Northeast Groswater Bay	Gannet Islands	Bird Island	Northern Groais Island	Wadham Islands	Funk Island	Total
Northern Fulmar	-	-	-	16	-			13	29
Leach's Storm-Petrel	-	-	10	20	present		10,000		10,030+
Northern Gannet								6,075	6,075
Herring Gull	-	-	present		-			500	500+
Glaucous Gull	350	-	-	-	-				350
Great Black-backed Gull	-	-	100	120	20			100	340
Black-legged Kittiwake	-	4[a]	-	113	-	2,400		810	3,323
Common Murre	2,260	-[a]	2,060[a]	36,702[a]	3,100			396,000	440,122
Thick-billed Murre	8,000	126[a]	365[a]	1,897[a]	present			250	10,767+
Razorbill	815	-[a]	3,714[a]	14,329[a]	1,530		30	200	10,638
Black Guillemot	341	-	present	110	-		25		476+
Atlantic Puffin	12,240	-[a]	17,404[a]	38,666[a]	8,070		15,950	2,000	176,855
Totals	**24,006**	**130**	**23,653+**	**91,973**	**12,720+**	**2,400**	**26,005**	**405,948**	**659,505**

Source: Important Bird Areas of Canada (www.ibacanada.ca); [a] CWS unpublished data.

4.4.1 Important Bird Areas for Seabirds

Important Bird Areas (IBAs) form a network composed of sites that are important to the natural diversity of Canadian bird species and are critical for the long-term viability of naturally occurring bird populations. The Canadian IBA program (www.ibacanada.ca) was launched in 1996 by BirdLife International partners Bird Studies Canada and the Canadian Nature Federation (now Nature Canada). The goal of the IBA program is to ensure the conservation of sites through the development and implementation of conservation plans in partnership with local stakeholders for priority IBAs. There are 19 IBAs along the Labrador coast and the north coast of Newfoundland north of 49°N (see Figure 4.41, Table 4.8). The Study Area overlaps small portions of the Seven Islands Bay, Quaker Hat and Gannet Islands IBAs. Fourteen IBAs are important for waterfowl (see the Labrador Shelf SEA [Sikumiut 2008] for details on coastal waterfowl). Eight of the 19 IBAs were designated as IBAs because of significant numbers of nesting seabirds (see Table 4.7). These eight IBAs contain almost 660,000 pairs of breeding seabirds of 11 species. The Gannet Islands contain the largest seabird colony on the coast of Labrador with 14,329 pairs of Razorbill (about 33% of the North American breeding population), 38,666 pairs of Atlantic Puffin, and 36,702 pairs of Common Murre (see Table 4.7).

4.4.2 Distribution and Abundance

There are few data on the seabirds of the Labrador and northern Newfoundland coastlines. The seabird colonies at The Gannet Islands and Funk Island are exceptions. There is updated information on the numbers of nesting murres on four of the islands in the IBA southeast of Nain (Wilhelm and Duffy 2009). Pelagic seabird abundance data in the Labrador Sea and off northern Newfoundland are available from the Canadian Wildlife Service (CWS) programme intégré de recherches sur les oiseaux pélagiques (PIROP) shipboard surveys from 1967 to 1994 (Lock et al. 1994). The more recent (2006 to 2009) CWS Eastern Canadian Seabirds at Sea (ECSAS) survey program sampled only a small portion of the Study Area (Fifield et al. 2009); however, PIROP sampled most of the area. Both programs sampled only small portions of the Study Area during the winter and spring, when much of the Study Area is ice covered.

Seabird abundance (all species combined) derived from PIROP during January to March was 1.0 to 99.99 birds/linear km in most of the 15'N x 30'W blocks that have been surveyed far offshore in the Study Area off the Labrador Coast and off northern Newfoundland (Lock et al. 1994). Seabird abundance closer to shore in the Study Area was 0.10 to 9.99 birds/linear km category in most blocks. In one block off the northeast Newfoundland Shelf over 100 birds/linear km were recorded. During April to June, abundance also ranged from 1.0 to 99.99 birds/linear km in most blocks. However, abundance averaged over 100 birds/km in one block far off the shelf. During July to September, abundance averaged 1.0 to 99.99 birds/linear km over much of the Study Area. A few survey blocks at the Labrador Shelf edge and beyond showed an abundance of >100 birds/linear km. October to December data are available for only a small portion of the Study Area but abundance in most survey blocks fell in the 1.0 to 99.99 birds/linear km range. Over 100 birds/linear km were recorded in a few blocks at or beyond the continental shelf edge. Northern Fulmar, Black-legged Kittiwake and murres made up most of the birds during these surveys. However, shearwater species made a large contribution from June to August and Dovekie was a large component during October and November (Lock et al. 1994).

Table 4.8 Important Birds Areas of the Labrador Coast and North Coast of Newfoundland (49ºN to 61ºN).

Name	Location	Vulnerable Species or Congregations
Galvano Island	59.99°N, 64.01°W	Nesting Common Eider.
Seven Islands Bay	59.40°N, 63.65°W	Premoulting staging Harlequin Duck, nesting Common Eider.
Nain Coastline	56.50°N, 61.08°W	Moulting Surf Scoter.
Offshore Islands Southeast of Nain	56.42°N, 60.58°W	Nesting Razorbill, Atlantic Puffin and murres.
Quaker Hat Island	54.75°N, 57.33°W	Nesting Razorbill and murres.
Goose Brook, Hamilton Inlet	54.30°N, 58.25°W	Staging Canada Goose.
Northeast Groswater Bay	54.40°N, 57.30°W	Nesting Razorbill, Atlantic Puffin and murres.
South Groswater Bay Coastline	54.20°N, 57.58°W	Migrating Black Scoter, nesting Common Eider.
The Backway, Rigolet	54.11°N, 58.14°W	Moulting Surf Scoter.
Tumbledown Dick Islands and Stag Islands	54.08°N, 57.18°W	Moulting Harlequin Duck.
Cape Porcupine	53.31°N, 57.04°W	Staging Surf Scoter.
Gannet Islands	53.97°N, 56.53°W	Nesting Razorbill, Atlantic Puffin, Common Murre; moulting Harlequin Duck.
Table Bay, Cartwright	53.66°N, 56.40°W	Nesting Common Eider.
Bird Island, Cartwright	53.75°N, 56.09°W	Nesting Atlantic Puffin, Common Murre and Razorbill.
St. Peter Bay	52.19°N, 55.69°W	Premoulting staging Harlequin Duck, moulting Common Eider.
Fischot Islands	51.17°N, 55.68°W	Wintering Common Eider.
Northern Groais Island	50.94°N, 55.60°W	Nesting Black-legged Kittiwake, wintering Common Eider.
Wadham Islands and adjacent marine area	49.56°N, 53.84°W	Nesting Atlantic Puffin, Black Guillemot, Leach's Storm-Petrel, Razorbill; wintering Common Eider
Funk Island	49.76°N, 53.18°W	Nesting murres, Northern Gannet, Atlantic Puffin, Black-legged Kittiwake, large gulls, Razorbill, Northern Fulmar.

Source: www.ibacanada.ca.

During the ECSAS surveys, seabird density (all species combined) during March to April ranged from 3.3 to 20.3 birds/km^2 in the four 1°N x 1°W blocks that were surveyed in the Study Area (Fifield et al. 2009). During May to August density ranged from 1.5 to 48.8 birds/km^2 in most of the survey blocks. During September and October density was 4.9 to 46.7 birds/km^2. From November to February density ranged from 3.7 to 45.1 birds/km^2 in most blocks. The majority of the bird species recorded during these surveys off Labrador and northern Newfoundland were Northern Fulmar, Black-legged Kittiwake, murres and Dovekie in all seasons (Fifield et al. 2009).

Analysis of ECSAS and PIROP data collected in fall in Subarctic and Arctic areas identified two seabird concentrations in the Labrador Sea (McKinnon et al. 2009). One of these concentrations occurs in late September and October at the eastern limit of Hudson Strait, which is consistent with Mallory and Fontaine's (2004) findings. A density of 38.8 birds/km^2 was recorded east of Resolution Island on 22 September. Another peak in density of a mean of 58.7 birds/km^2 and a maximum of 132 birds/km^2 was observed off the northeastern tip of Ungava Bay on 21 October, consisting mostly of large groups of birds resting on the surface. The other concentration area was off the mid-Labrador coast (roughly 54° to 59° N) in late October with a maximum density of 63 birds/km^2 on 23 October, due mostly to large flocks of flying birds.

4.4.2.1 Anatidae (Ducks, Geese and Swans)

The Labrador and northern Newfoundland coasts are important areas for sea ducks (tribe Mergini). The largest nesting colonies of Common Eider in Newfoundland and Labrador occur in the area of Table Bay to Groswater Bay, with a secondary concentration in Nain Bight, reflecting a level of productivity in these areas also noted for breeding seabirds. There are few published estimates of numbers; nevertheless, probably more than 10,000 pairs of Common Eiders nest in the Hamilton Inlet area (Lock 1986; Lock et al. 1994). Less is known of the moulting distribution of these stocks, although large numbers of males (~ 9,000) were recorded moulting in the mouth of Table Bay in July 1989 (Goudie et al. 1994), and more than 5,000 in St. Peter Bay in 1998 (IBA site data). Other moult aggregations are likely localized in the Labrador coastal area. Surf, Black and White-winged Scoters breed in interior Labrador and by mid-summer relatively large aggregations moult in Hamilton Inlet and Nain Bight. Sites such as Backway off Lake Melville and Nain Bight typify traditional sites where large groupings of males and non-breeders aggregate annually to complete the feather moult. By early fall (after mid-September), numbers of eiders north of Hamilton Inlet have diminished considerably, suggesting some redistribution (Lidster et al. 1993). Common Goldeneye, Barrow's Goldeneye, and Red-breasted Merganser moult in coastal areas of Labrador in smaller aggregations (generally hundreds). Barrow's Goldeneye and Harlequin Duck, both listed on Schedule 1 of *SARA* as Special Concern, are discussed in more detail in Section 4.6, Species at Risk.

4.4.2.2 Procellariidae (Fulmars, Shearwaters and Petrels)

Four species from this family occur regularly in the Study Area: Northern Fulmar, Great Shearwater, Sooty Shearwater and Manx Shearwater. Northern Fulmar has a circumpolar distribution with the centre of breeding abundance in the north Atlantic, including the Canadian Arctic, Greenland, Iceland and northeast Europe and Scandinavia. Very few nest on the coast of Newfoundland and Labrador (Lock et al. 1994). Sixteen pairs are known to breed on Gannet Islands and 13 pairs on Funk Island (see Table 4.7). However, it is a common year-round resident in eastern Newfoundland and Labrador waters outside of the pack ice (Lock et al. 1994). Banding records show that Northern Fulmars from breeding colonies in the Canadian Arctic, Greenland, and the British Isles regularly winter in Newfoundland and Labrador waters (Brown 1986; Lock et al. 1994). Five adult Northern Fulmars fitted with satellite transmitters at Cape Vera, Devon Island, Nunavut, during the breeding season spent most of December to March in the Labrador Sea between 50ºN and 55ºN (Mallory et al. 2008a). The summer populations off eastern Newfoundland and Labrador are thought to be composed of sub-adults from breeding colonies in Greenland and the eastern Atlantic. In offshore areas, Northern Fulmar has been recorded in all months of the year in densities from <1 to >100 individuals per linear km (Brown 1986).

Great Shearwater breeds in the south Atlantic, mainly on Tristan da Cunha Island and Gough Island. The adults are present at the breeding sites from October to April. They spend their non-breeding season (April to October) in the north Atlantic. A significant percentage of the total world population migrates to eastern Newfoundland and Labrador for the annual moult from June through August (Lock et al. 1994). Great Shearwater can be expected at sea off the Labrador and northern Newfoundland coasts from June to October with the largest concentrations (10 to 100 individuals/linear km) occurring along the continental shelf edge (Brown 1986). Sooty Shearwater has a similar distribution to Great Shearwater in that it nests in the Southern Hemisphere and some of the population flies to the Northern Hemisphere during the summer. Sooty Shearwater usually occurs offshore among the more numerous Great Shearwater in Newfoundland and Labrador and during the same time period.

Most of the world population of Manx Shearwater breeds on islands in the northeast Atlantic (Iceland, Scotland, Ireland, England and France) and The Azores and Canary Islands. It winters in the southwest Atlantic off eastern South America (Godfrey 1986). The small population of Manx Shearwater present in Atlantic Canada during the summer months is probably a combination of Newfoundland breeders from Middle Lawn Island (Burin Peninsula) and non-breeding sub-adults and migrants from European breeding colonies (Lee and Haney 1996). Manx Shearwater is scarce along the Labrador coast, with sightings north to 57°N.

4.4.2.3 Hydrobatidae (Storm-Petrels)

Leach's Storm-Petrel is the only species of the family Hydrobatidae occurring regularly off the Labrador coast. Leach's Storm-Petrel is a widespread and abundant species occurring in both the Atlantic and Pacific oceans. In the Atlantic, it breeds in northwest Europe (Iceland, Scotland and Norway) and in North America from southeast Labrador to Massachusetts (Huntington et al. 1996). The centre of breeding in eastern North America is the Avalon Peninsula, Newfoundland where close to four million pairs nest (Lock et al. 1994). It is a scarce breeder in Labrador with ≥ 30 pairs known to breed along the mid-Labrador coast (see Table 4.7). Leach's Storm-Petrel is scarce in Labrador waters with 0 to <1 individual per linear km recorded on Hamilton Bank and none north of 55° N, but is more abundant closer to the large colonies of the Avalon Peninsula (Brown 1986).

4.4.2.4 Sulidae (Gannets and Boobies)

The Northern Gannet breeds in the north Atlantic in Quebec, Newfoundland, Iceland, Faeroe Islands and British Isles. It winters along the coast from New Jersey to the Gulf of Mexico and British Isles to the Azores Islands. Three of the five major gannet colonies in North America are located in Newfoundland at Cape St. Mary's, Baccalieu Island, and Funk Island. Despite its name the Gannet Islands has never had a Northern Gannet nesting colony, nor are there colonies anywhere else along the Labrador coast.

Gannets feed on small to medium size fish and squid over shelf waters, avoiding deep water beyond the continental slope. They occur regularly in small numbers on Hamilton Bank from April through October (Brown 1986).

4.4.2.5 Phalaropodinae (Phalaropes)

The Red-necked and Red Phalaropes occur in the marine environment of the Labrador coast during migration. Both species migrate through Newfoundland and Labrador offshore waters en route between wintering areas in the south Atlantic and breeding grounds in the Arctic and sub-Arctic. The Red-necked Phalarope nests on freshwater ponds in Labrador as far south as Groswater Bay (Godfrey 1986). In migration, phalaropes are known to congregate in areas of upwelling and oceanographic fronts in the Labrador Sea, particularly along the continental shelf slope (Orr et al. 1982; Lock et al. 1994). Both species of phalarope are probably widespread at sea off the Labrador coast in the period from late May to October, with areas of concentration possible at the continental shelf edge, particularly during the southward migration from July to September.

4.4.2.6 Laridae (Gulls and Terns)

There has been no systematic survey of the Labrador coast for gull and tern colonies (Cotter et al. 2012). However, sufficient anecdotal and local survey data exist to understand the general distribution and abundance of gulls and terns along the coast. Herring, Ring-billed, Great Black-backed, Glaucous, Iceland and Ivory Gulls, and Black-legged Kittiwake occur regularly in Labrador and northern Newfoundland waters. Herring and Great Black-backed Gull are common and widespread breeders along the entire coast. They are absent from areas of dense pack ice during winter. Ring-billed Gull nests locally in small colonies on the coastlines north to Voisey’s Bay. Glaucous Gull is a northern species breeding south along the Labrador coast to 55°30’N. It winters at sea, particularly among pack ice and near the ice edge south to the Carolinas. Iceland Gull breeds north of Labrador, with Baffin Island being the centre of abundance. The species winters commonly south to Newfoundland and the Gulf of St. Lawrence. Ivory Gull is listed on *SARA* Schedule 1 as endangered. See Section 4.6 for details. In North America, the Ivory Gull breeds in the high Arctic and winters on sea ice between 50°N and 64°N (Godfrey 1986; Haney and MacDonald 1995). Precise estimates of the numbers wintering off the Labrador coast are not available, but the wintering population involves birds from the Canadian Arctic, Greenland, and Franz Josef Land (Tuck 1971; Gilg et al. 2010). It was never a very common bird. Small, but significant numbers of Ivory Gull are probably present on the sea ice off the Labrador coast and probably off northern Newfoundland, including the Study Area, between December and May. Black-legged Kittiwake is a true sea gull, spending all its life at sea except when it has to nest on coastal islands. It is a common resident in Newfoundland and Labrador waters, remaining outside of the main pack ice in winter. In Newfoundland and Labrador, it breeds in large colonies, mainly on the Avalon Peninsula. Black-legged Kittiwake breeds in surprisingly small numbers on the Labrador coast. The only individuals breeding on the Labrador coast are those at The Gannet Islands and a new, small colony at Quaker Hat. Large numbers of birds migrate to the Labrador Sea and Newfoundland waters to winter (Lock et al. 1994). Stable isotope analyses and tagging with global location sensors have confirmed that many of these birds originate from breeding colonies in the Canadian Arctic and Greenland (González-Solís et al. 2011; Frederiksen et al. 2012). Sub-adult kittiwakes summer at sea away from breeding colonies. Kittiwake is common on shelf waters of Labrador and northern Newfoundland away from solid pack ice throughout the year (Brown 1986).

Arctic and Common Terns are the only species of tern occurring offshore Labrador and offshore northern Newfoundland. Arctic Tern is circumpolar, breeding in both the sub-Arctic and high Arctic. Its breeding range extends south along the Atlantic coast to Maine. It migrates at sea between south Atlantic wintering grounds and north Atlantic breeding areas. Common Tern breeds in temperate and sub-Arctic North America and Eurasia. In eastern North America, it winters from South Carolina and southward. It is a common breeder both inland and in littoral waters of Newfoundland and Labrador. Both species are locally common at breeding sites along the coasts of Labrador and northern Newfoundland. Common Tern reaches its northern limit of breeding at about 56°40'N. Common Tern migrates near shore whereas Arctic Tern migrates both inshore and offshore. Terns are fairly common on the Labrador and northern Newfoundland coastlines from late May to early September.

4.4.2.7 Stercorariidae (Skuas and Jaegers)

One skua species and three species of jaeger occur regularly along the coasts of Labrador and northern Newfoundland. Great Skua breeds in the northeast Atlantic in Iceland, Faeroe Islands, Scotland and Norway, and winters farther south, but remains north of the equator. In Atlantic Canada, it is a summer visitor and spring and fall migrant. Very low densities of Great Skuas probably occur where there are concentrations of shearwaters, the target species from which they steal food. The three species of jaeger, Pomarine, Parasitic and Long-tailed, have circumpolar distributions, breeding in the low and high Arctic. They winter at sea near the equator. All three species migrate through the Study Area in spring and again in late summer/early fall. A few Parasitic Jaegers nest in Labrador north of 58°N (Godfrey 1986). In general jaegers are in offshore waters of Labrador and northern Newfoundland from mid-May to October. They are never numerous but are widespread in low densities, usually occurring where there are concentrations of other seabird species.

4.4.2.8 Alcidae (Murres, Black Guillemot, Atlantic Puffin, Razorbill, and Dovekie)

There are six species of the Alcidae in eastern North America and all of them have a significant role in the ecosystem of the Labrador and northern Newfoundland coastlines. Common Murre breeds in the north Pacific and north Atlantic oceans. In the Atlantic it breeds in northern Europe, including Iceland and Greenland, and in the northwest Atlantic from Labrador to Nova Scotia. Large colonies exist in northeastern Newfoundland, including Funk Island. Common Murre breeds in large colonies on the mid-Labrador coast with a total of 47,000 pairs at five main colonies (see Table 4.7). This species reaches the northern limit of its breeding range in eastern North America at colonies on a group of islands near Nain at 56°42'N. Murres are most numerous offshore in the Study Area after the flightless fledglings and breeding adults abandon nesting colonies in late summer until the adults return inshore to the colonies in spring. Fledgling Common Murres leave the nesting ledges at the Gannet Islands and head to sea with parents, soon to be temporarily flightless, around 9-13 August (Birkhead and Nettleship 1987). Tagging with geolocators has shown that adults departing the Gannets Islands nesting colony are present in the southern third of the Study Area during fall migration (August to October) (Montevecchi et al. 2012). A further geolocator study found that in winter (November to February) some adults from this colony are present in the southern quarter of the Study Area (McFarlane Tranquilla et al. 2013). Some adults from Newfoundland nesting colonies (i.e., Funk Island, Witless Bay) winter in the southeast corner of the Study Area.

Thick-billed Murre breeds in the Arctic, north Atlantic and north Pacific oceans. In eastern North America it breeds mainly in the Arctic. On the Labrador and northern Newfoundland coasts, Thick-billed Murre is outnumbered by Common Murre during the breeding season (see Table 4.7). It is estimated that up to four million Thick-billed Murres winter in Newfoundland and Labrador waters (Lock et al. 1994). Fledglings and adults leave the Gannet Islands nesting colony and head offshore in mid-August (Tuck 1961). Flightless fledglings and adults departing colonies in the farther north reach the Labrador Sea in September and continue their swimming, southward migration in the Labrador Current (Gaston 1982, Orr and Ward 1982). Birds tagged with geolocators at nesting colonies on the Minaret Islands (off Baffin Island) and Coates Island (Hudson Bay) were south of 62°N by 6 September (Gaston et al. 2011). Many reach Newfoundland waters by November. First-year and two year-old birds reach Newfoundland in large numbers in November and December. Tagging Thick-billed Murres with geolocators showed that birds wintering (November to February) in the Study Area originate from nesting colonies on Prince Leopold Island, Minaret Islands and Coats Island in Nunavut, Digges Islands in northern Quebec, and the Gannet Islands in Labrador (McFarlane Tranquilla et al. 2013). Band returns show that the Newfoundland wintering population originates from breeding colonies not just in the Canadian Arctic (Hudson Strait and Lancaster Sound), but west Greenland and Iceland as well (Lock et al. 1994). Thick-billed Murre is present year round off the Labrador coast. In winter this species may be common along the eastern edge of the pack ice.

Razorbill breeds in the north Atlantic from northern Europe, including Iceland and Greenland, to the mid-Labrador coast and south to Maine. About 43% (18,526 pairs) of the North American breeding population of Razorbill nests on the mid-section of Labrador coast (see Table 4.7). Most of these (14,329 pairs) are on The Gannet Islands (CWS unpubl. data). Razorbills depart the Gannet Islands colony from early August to early September and migrate south along the Labrador and eastern Newfoundland coasts (Lavers et al. 2009). A few are found off southern Labrador into November and December. Razorbill numbers in eastern Newfoundland waters peak from mid-October to mid-November (Chapdelaine 1997), however, the majority winter from southern Newfoundland to the Gulf of Maine (Lavers et al. 2009). Razorbills are present in Labrador shelf waters from April to November.

Atlantic Puffin breeds in the north Atlantic on the British Isles, Norway, Iceland, Greenland, Newfoundland and Labrador, and south to Maine. In Canada, the centre of breeding abundance is in southeast Newfoundland. The more than 82,000 pairs breeding on the mid-Labrador coasts represent about 20% of the North American breeding population. In North America, Atlantic Puffins winter mainly off southern Newfoundland and Nova Scotia. Atlantic Puffin is present off the Labrador and northern Newfoundland coasts from May to November.

Black Guillemot breeds on both sides of the Atlantic, north into Arctic waters. It nests in numerous small colonies on coastal headlands and many small rocky islands. Population size estimates are difficult to achieve because nesting occurs in hard to access rock crevices. Black Guillemot is partially migratory but remains as far north as there is open water. Unlike the other members of the Alcidae, it feeds near shore and is rarely found more than a few kilometres from shore or pack ice. Black Guillemot is a year round resident on the coast of Labrador.

Dovekie breeds mainly in Greenland, Iceland, and northern Norway, and winters at sea in the north Atlantic south to New Jersey and France. Many of the ten million pairs of Dovekie breeding in Greenland winter offshore Newfoundland and Labrador. Dovekies feed on small invertebrates often associated with shelf breaks or ice edges. Gjerdrum et al. (2008) found strong correlations between abundances of copepods (*Calanus* spp.) and Dovekie at shelf edges off northeast Newfoundland in spring 2006. The abundant Dovekie is common near ice and in open offshore waters of the Labrador coast from September to May.

4.4.3 Prey and Foraging Strategy

Seabirds in the Study Area employ a variety of foraging strategies and feed on a variety of prey species (Table 4.9). Many of the shearwaters, storm-petrels, gulls, and phalaropes capture their food by seizing it from the surface, either while flying or resting on the surface. Gannets and terns search for prey from the air, then plunge-dive to capture the prey item. Members of the auk family (Alcidae) dive from a resting position on the surface and actively pursue their prey underwater. Consequently, they spend most of their time on or under the ocean's surface, rather than flying. Diving depth and time also varies by species. Some species such as terns and phalaropes specialize in foraging in shallow depths at the surface, while at the opposite end of the range, species such as alcids and loons dive to great depths (i.e., 20 to 50 m). Larger species of seabirds feed on capelin, sand lance, and short-finned squid, crustaceans, or offal, whereas smaller species such as phalaropes and Dovekie feed primarily on copepods, amphipods, and other zooplankton (Table 4.9).

4.4.3.1 Procellariidae (Fulmar and Shearwaters)

Northern Fulmar and the four species of shearwaters that are expected to occur in the Study Area feed on a variety of invertebrates, fish and zooplankton at or very near the surface. Capelin is an important food source for shearwaters. Northern Fulmar secure prey by swimming on the surface and picking at items on the surface, dipping their head under the water, or diving a short distance under the surface. Shearwaters are also capable of shallow dives to capture prey — up to 10 m but usually less (Brown et al. 1981). They may do this flying low over the water and then plunging into the water with enough force to get them below the surface for a few seconds; they also dive from a floating position.

4.4.3.2 Hydrobatidae (Storm-Petrels)

Leach's Storm-Petrel feed at night primarily on small, vertically-migrating, mesopelagic animals including myctophid fish, decapods, and amphipods (Steele and Montevecchi 1994; Hedd and Montevecchi 2006). These storm-petrels usually feed while on the wing, picking small food items from the surface of the water.

Table 4.9 Foraging Strategy, Prey, Time with Head Under Water and Dive Depth of Seabirds in the Study Area.

Species	Prey	Foraging Strategy	Time with Head Under Water	Depth (m)
Procellariidae				
Northern Fulmar	Fish, cephalopods, crustaceans, zooplankton, offal	Surface feeding	Brief	<1
Great Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	1-10
Sooty Shearwater	Fish, zooplankton, cephalopods, crustaceans, offal	Shallow plunging, surface feeding	Brief	1-10
Manx Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	1-10
Hydrobatidae				
Leach's Storm-Petrel	Fish, crustaceans	Surface feeding	Brief	<0.5
Phalaropodinae				
Red Phalarope	Zooplankton, crustaceans	Surface feeding	Brief	0
Red-necked Phalarope	Zooplankton, crustaceans	Surface feeding	Brief	0
Laridae				
Herring Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Iceland Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5
Glaucous Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Great Black-backed Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Ivory Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Black-legged Kittiwake	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5
Arctic Tern	Fish, crustaceans, zooplankton	Surface feeding, shallow plunging	Brief	<0.5
Stercorariidae				
Great Skua	Fish, cephalopods, offal	Kleptoparasitism	Brief	<0.5
Pomarine Jaeger	Fish	Kleptoparasitism	Brief	<0.5
Parasitic Jaeger	Fish	Kleptoparasitism	Brief	<0.5
Long-tailed Jaeger	Fish, crustaceans	Kleptoparasitism, surface feeding	Brief	<0.5
Alcidae				
Dovekie	Crustaceans, zooplankton, fish	Pursuit diving	Prolonged	Max 30, average is <30
Common Murre	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 100, average 20-50
Thick-billed Murre	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 100, average 20-60
Razorbill	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 120, average 25
Atlantic Puffin	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 60, average <60

Sources: Cramp and Simmons (1977); Nettleship and Birkhead (1985); Lock et al. (1994); Gaston and Jones (1998).

4.4.3.3 Phalaropodinae (Phalaropes)

Red-necked and Red Phalaropes eat zooplankton at the surface of the water. They secure food by swimming and rapidly picking at the surface of the water: their heads probably rarely go beneath the surface.

4.4.3.4 Laridae (Gulls and Terns)

The large gulls, Herring, Great Black-backed, Glaucous and Iceland Gull, are opportunists eating a variety of food items ranging from small fish at the surface, to carrion, and refuse and offal from fishing and other ships at sea. They find this food at the surface and may plunge their head under water to grab food just below the surface but rarely is the entire body submerged. Ivory Gull often feeds from the wing over water, dip feeding for small fish and invertebrates on the surface. It occasionally plunge dives so that the entire body may be submerged momentarily. It also swims and picks at the surface of the water and walks on ice to scavenge animal remains.

Black-legged Kittiwake feeds on a variety of invertebrates and small fish. Capelin is an important part of their diet when available. It feeds by spotting prey from the wing then dropping to water surface and plunge diving. The body may be submerged very briefly. It also swims and picks at small invertebrates near the surface.

Arctic Tern feeds on small fish and invertebrates that it catches from the wing with a shallow plunge dive. The entire bird rarely goes beneath the surface. It rarely rests on the water.

4.4.3.5 Stercorariidae (Skuas and Jaegers)

Skuas and jaegers feed by chasing other species of birds until they drop food they are carrying or disgorge the contents of their stomachs. This method of securing food is called kleptoparasitism. As a result of this foraging method, skuas and jaegers are less numerous than species from which they steal food. The Long-tailed Jaeger, the smallest member of this group, also feeds on small invertebrates and fish caught by dipping to the surface of the water while remaining on the wing.

4.4.3.6 Alcidae (Dovekie, Murres, Razorbill and Atlantic Puffin)

This group of birds forages differently than the other seabirds of the Study Area. These alcids spend considerable time on the water surface, and dive deep into the water column for food. Dovekie feeds on zooplankton, including larval fish. It can dive down to 30 m and remain under water up to 41 seconds, but average dives are somewhat shallower and shorter in duration (Gaston and Jones 1998). Common Murre and Thick-billed Murre have been recorded diving to 100 m, but 20 m to 60 m is thought to be average. Dives have been timed up to 202 seconds; 60 seconds is more typical (Gaston and Jones 1998). Razorbill has been recorded diving to 120 m but 25 m is thought to be more typical with time under water about 35 seconds (Gaston and Jones 1998). Black Guillemot usually feeds in water <30 m in depth but in deep water has been recording diving to 50 m with a maximum 147 seconds under water. Average depth and duration of dives are expected to be less (Gaston and Jones 1998). Atlantic Puffin will dive to 60 m but 10 m to 45 m is thought to be more typical. Maximum length of time recorded under water is 115 seconds but a more typical dive would be about 30 seconds.

4.5 Marine Mammals and Sea Turtles

4.5.1 Marine Mammals

A total of 21 marine mammals, including 14 cetaceans, six seals, and the polar bear, occur in the Study Area (Table 4.10). Table 4.10 presents the temporal and spatial distribution, habitat and relevant *SARA* and COSEWIC designations for each species. Most marine mammals use the Project Area seasonally, and the region represents important foraging and breeding areas for some of the species.

An additional three species may very occasionally enter the Project Area and/or were historically abundant on the Labrador Shelf, including the bowhead whale (*Baleana mysticetus*), north Atlantic right whale (*Eubalaena glacialis*), and Atlantic walrus (*Odobenus rosmarus rosmarus*). Although thought to be historically common throughout the Strait of Belle Isle and Labrador Sea, bowhead whales now only rarely range as far south as the northern coast of Labrador as a result of depletion during industrial whaling (COSEWIC 2009b). Individuals occurring in northern Labrador likely represent either the Davis Strait or Hudson Bay stocks of the eastern Canada-west Greenland population; they are considered *special concern* by COSEWIC, but have no status under *SARA*.

North Atlantic right whales, considered *endangered* on Schedule 1 of *SARA* and by COSEWIC, became severely depleted by commercial whalers and are thought to have once ranged into coastal Labrador. However, no sightings have occurred in the last hundred years in the Strait of Belle Isle historical whaling area, despite evidence from bones in Red Bay, Labrador that they were once harvested in the region (COSEWIC 2003a; Brown et al. 2009). Currently, north Atlantic right whales are primarily found in Canadian waters in Roseway Basin on the Scotian Shelf and the Bay of Fundy during late summer and fall before migrating south along the eastern United States to wintering grounds in the southeast United States (COSEWIC 2003a; Brown et al. 2009).

Atlantic walrus are considered *extirpated* from Nova Scotia to Labrador, where they historically occurred (COSEWIC 2006a). Currently they are found in the eastern Canadian Arctic, where they are designated as *special concern* under COSEWIC; they are considered rare south of Hebron-Okak Bay on the Labrador coast (COSEWIC 2006a).

Thus, the available information suggests that it is very unlikely that these three species occur in the Project Area. In addition, four sightings of Risso’s dolphin (*Grampus griseus*) were made in the Study Area in 1990 based on the DFO cetacean sightings database. This species is considered *not at risk* by COSEWIC and it has no status under *SARA*. It is very rare offshore Labrador and is not expected to occur in the Study Area.

Table 4.10 Marine Mammals Known or Expected to Occur in the Labrador Sea Study Area.

Species (Scientific Name)	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Baleen Whales (Mysticetes)					
Humpback whale (*Megaptera novaeangliae*)	Common	Year-round, but mostly May-Oct.	Coastal & banks	Schedule 3: Special Concern	NAR
Blue whale (*Balaenoptera musculus*)	Rare	Year-round, but mostly spring	Coastal & pelagic	Schedule 1: Endangered	E
Fin whale (*Balaenoptera physalus*)	Common	Year-round, but mostly summer	Slope & pelagic	Schedule 1: Special Concern	SC
Sei whale (*Balaenoptera borealis*)	Uncommon	May-Sept.	Offshore & pelagic	NS	DD
Minke whale (*Balaenoptera acutorostrata*)	Common	Year-round, but mostly May-Oct.	Shelf, banks & coastal	NS	NAR
Toothed Whales (Odontocetes)					
Sperm whale (*Physeter macrocephalus*)	Uncommon	Year-round, but mostly summer	Palagic, slope & canyons	NS	NAR; LPC
Northern bottlenose whale (*Hyperoodon ampullatus*)[c]	Common	Year-round?	Palagic, slope & canyons	Schedule 1: Endangered	E
Sowerby's beaked whale (*Mesoplodon bidens*)	Rare	Summer?	Palagic, slope & canyons	Schedule 1: Special Concern	SC
Beluga whale (*Delphinapterus leucas*)[d]	Rare	Winter or Summer?	Coastal & ice edge	NS	E
Killer whale (*Orcinus orca*)	Uncommon	Year-round, but mostly June-Oct.	Widely distributed	NS	SC
Long-finned pilot whale (*Globicephala melas*)	Common	May-Sept.	Mostly pelagic	NS	NAR
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	Common	Year-round, but mostly June-Oct.	Shelf & slope	NS	NAR
White-beaked dolphin (*Lagenorhynchus albirostris*)	Common	Year-round, but mostly June-Sept.	Shelf	NS	NAR
Harbour porpoise (*Phocoena phocoena*)	Uncommon	Year-round, but mostly spring-fall	Shelf, coastal	Schedule 2: Threatened	SC
True Seals (Phocids)					
Harbour seal (*Phoca vitulina*)	Uncommon	Year-round	Coastal	NS	NAR
Harp seal (*Pagophilius groenlandicus*)	Common	Year-round, but mostly winter-	Pack ice & pelagic	NS	NC; MPC
Hooded Seal (*Cystophora cristata*)	Common	Year-round, but mostly winter-early spring	Pack ice & pelagic	NS	NAR; MPC
Bearded Seal (*Erignathus barbatus*)	Uncommon	Year-round	Coastal, shallow & ice edge	NS	DD; MPC
Grey seal (*Halichoerus grypus*)	Rare	Summer?	Coastal & shelf	NS	NAR
Ringed Seal (*Phoca hispida*)	Common	Winter-spring?	Landfast ice with snow cover	NS	NAR; HPC
Polar Bear					
Polar Bear (*Ursus maritimus*)	Uncommon	Winter-summer	Coastal & pack ice	Schedule 1: Special Concern	SC

Note: ? indicates uncertainty.
[a] Species designation under the Species at Risk Act (Government of Canada 2012); NS = No Status.
[b] Species designation under COSEWIC (COSEWIC 2013); E = Endangered, SC = Special Concern, DD = Data Deficient, NAR = Not at Risk, NC = Not Considered, LPC = Low-priority Candidate, MPC = Mid-priority Candidate, HPC = High-priority Candidate.
[c] Refers to the Scotian Shelf population, but it is unclear to which population animals in the Project Area belong. The Davis Strait-Baffin Bay-Labrador Sea population has no status under *SARA* but is considered *special concern* under COSEWIC.
[d] Population affiliation is unclear, but individuals presumably represent the Ungava Bay and/or eastern Hudson Bay populations (DFO 2005).

There is relatively little information on the occurrence and abundance of marine mammals on the Labrador Shelf. Previous environmental assessments (e.g., Canning and Pitt 2007; LGL 2010; LGL and GXT 2013) and the Labrador Shelf SEA provide summaries of marine mammal species and previously available sighting data for the Project Area and offshore Labrador waters. Canning and Pitt (2007) summarized population estimates for marine mammals that may occur in the White Rose area of the Jeanne d'Arc Basin located southeast of the Labrador Project Area; most of these species and populations presumably overlap with those found in the Project Area.

Opportunistic sightings are available, but there have been few systematic surveys of marine mammals offshore of Labrador. LGL Limited conducted aerial surveys for marine mammals and seabirds in the southern Labrador Sea offshore and coastal areas as one component of the Offshore Labrador Biological Studies (OLABS) from 1981 to 1982 (McLaren et al. 1982). Seasonal surveys ranged from the Makkovik Bank in the north to Cape Freels in the south (between 56ºN and 49.15ºN and west to 52ºW). A number of marine mammal species were observed during the OLABS surveys in the southern Labrador Sea, including:

- Minke whale;
- Fin whale;
- Humpback whale;
- Sperm whale;
- Northern bottlenose whale (tentatively identified);
- Beluga whale;
- Atlantic (long-finned) pilot whale;
- Killer whale;
- Atlantic white-sided dolphin;
- White-beaked dolphin;
- Habour porpoise;
- Harbour seal;
- Harp seal;
- Bearded seal; and
- Hooded seal.

Humpback whales were the most abundant of the baleen whale species observed, while pilot whales and unidentified dolphins were the most common toothed whales recorded. A high density of harp seals (~60,000 seals) was recorded, all in late winter to early spring (McLaren et al. 1982).

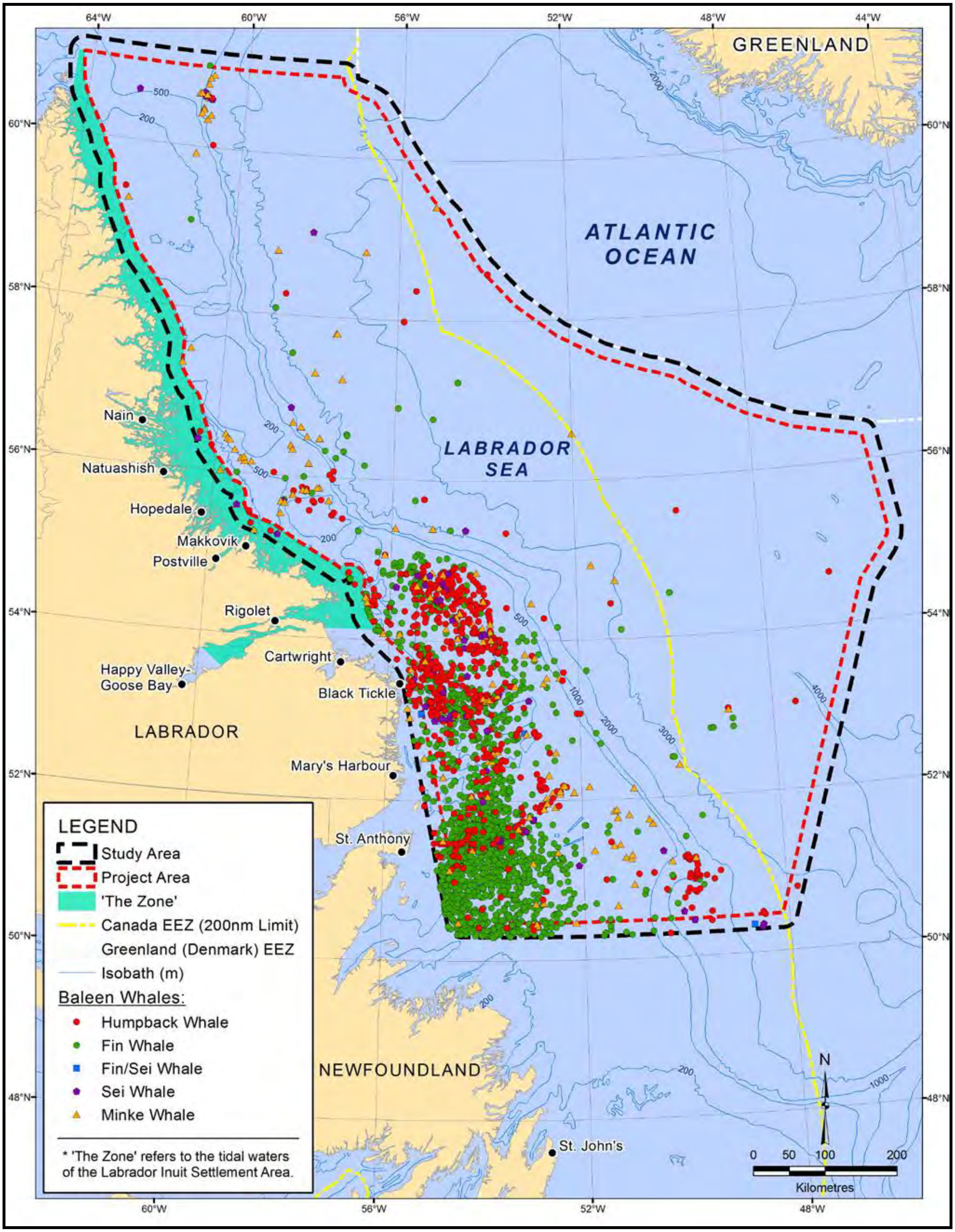
Marine mammal monitoring was also conducted by Geophysical Survey Inc. (GSI) during 2004 and 2005 geophysical surveys over the Labrador Shelf. Fisheries Liaison Officers (FLOs) served as Marine Mammal Observers (MMOs) during the surveys. From late July to early October 2004, there were 22 cetacean sightings totaling ~260 individuals, and pilot whales were the most frequently observed species (as described in Canning and Pitt 2007). From mid-June to mid-October 2005, FLOs recorded 63 cetacean sightings of ~297 individuals and pilot whales were again the most frequently recorded species (as described in Canning and Pitt 2007). Recorded species from the 2004 and 2005 surveys included:

- Humpback whale;
- Fin whale;
- Minke whale;
- Sperm whale;
- Pilot whale;
- Killer whale;
- Atlantic white-sided dolphin;
- White-beaked dolphin;
- Harbour porpoise;
- Unidentified dolphin; and
- Unidentified whale.

Lawson and Gosselin (2009) provided preliminary minimum abundance estimates, without the application of correction factors, for the most frequently sighted cetacean species detected during aerial surveys from Nova Scotia to Labrador during the summer of 2007. These abundance estimates have recently been corrected for perception and availability biases (Lawson and Gosselin, unpublished data). A total of 741,699 km^2 were surveyed off southern and eastern Newfoundland and off Labrador from 17 July to 24 August 2007, yielding a total of 584 cetacean sightings or a density of 0.0008 sightings/km^2. There were 19 sightings along the Labrador coast, but these were too few to obtain reliable abundance estimates in the Labrador stratum. However, the authors noted that marine fauna were generally reported later in 2007 than in previous years, suggesting that lower densities of animals than usual may have been encountered during the Labrador portion of the survey. During 5,363 km of on-effort trackline in Labrador, there were sightings of beluga whale, common dolphin, fin whale, minke whale, northern bottlenose whale, pilot whale, white-sided dolphin, unidentified large whale, and unidentified dolphin. There were a total of four or less sightings of each species. The spatial distribution of sightings by species was not provided, so it is unclear how animals were distributed with respect to the location of the Project Area, distance to shore, or water depth.

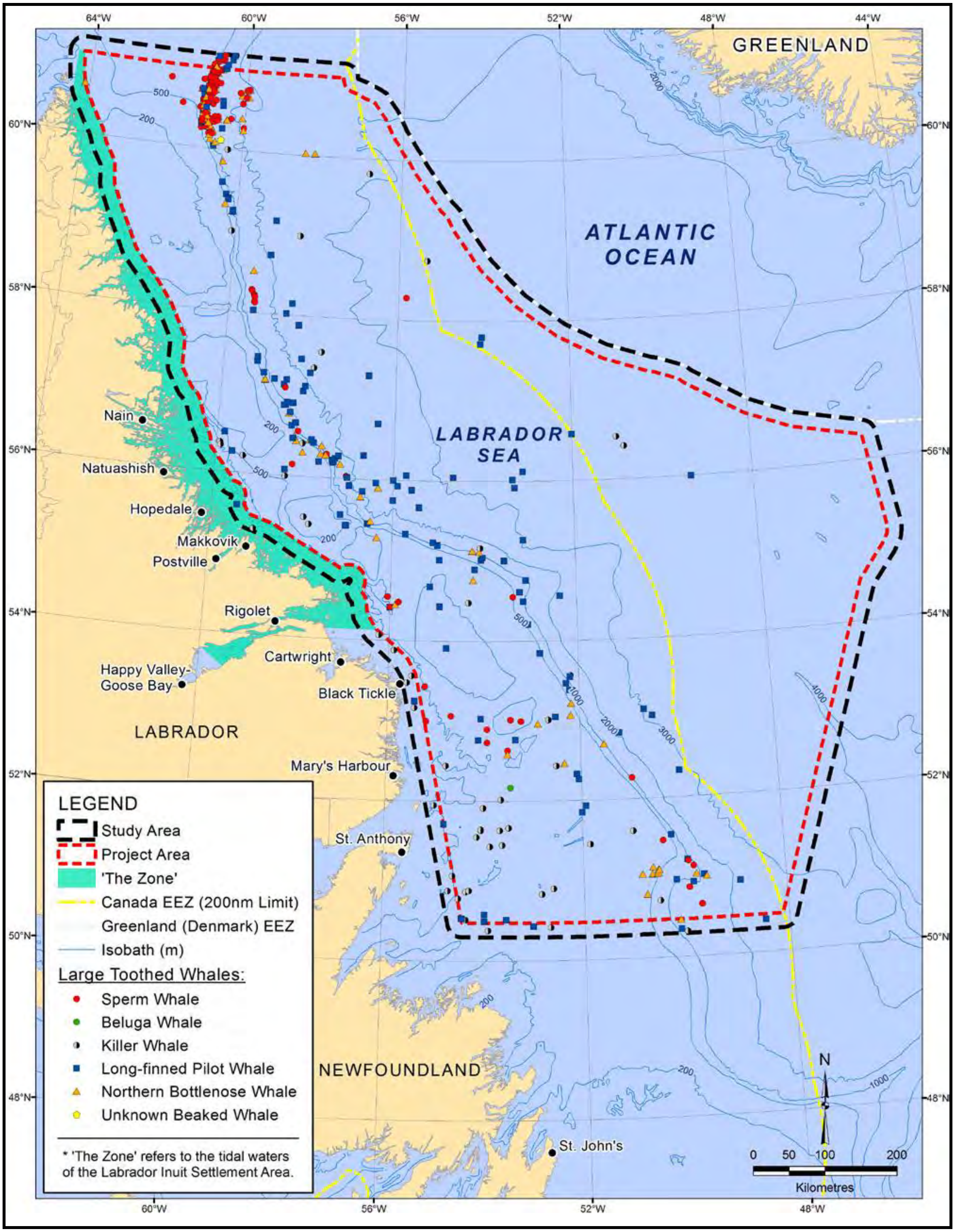
Earlier versions of a cetacean sightings database compiled by DFO in St. John's were summarized in Canning and Pitt (2007) and the Labrador Shelf SEA. The following summary provides an updated review of these data. A large database of cetacean sightings in Newfoundland and Labrador waters has been compiled by DFO in St. John's (J. Lawson, DFO Research Scientist, pers. comm. 2013) and has also been made available for the purposes of describing cetacean sightings within the Study Area. These data can be used to indicate what species have occurred in the region, but cannot provide fine-scale descriptions or predictions of abundance or distribution. The summary of sightings below combines the data sources described above as well as historical and recently added sightings from commercial whaling, fisheries observers, and the general public. Within the Study Area, sighting dates ranged from 1894 to 2007 and included baleen whales (Figure 4.42), toothed whales (Figure 4.43), and delphinids and porpoises (Figure 4.44); sightings are summarized in Table 4.11. A number of *caveats* should be noted when considering the DFO cetacean sightings data, including:

1. The sighting data have not yet been completely error-checked,
2. The quality of some of the sighting data is unknown,



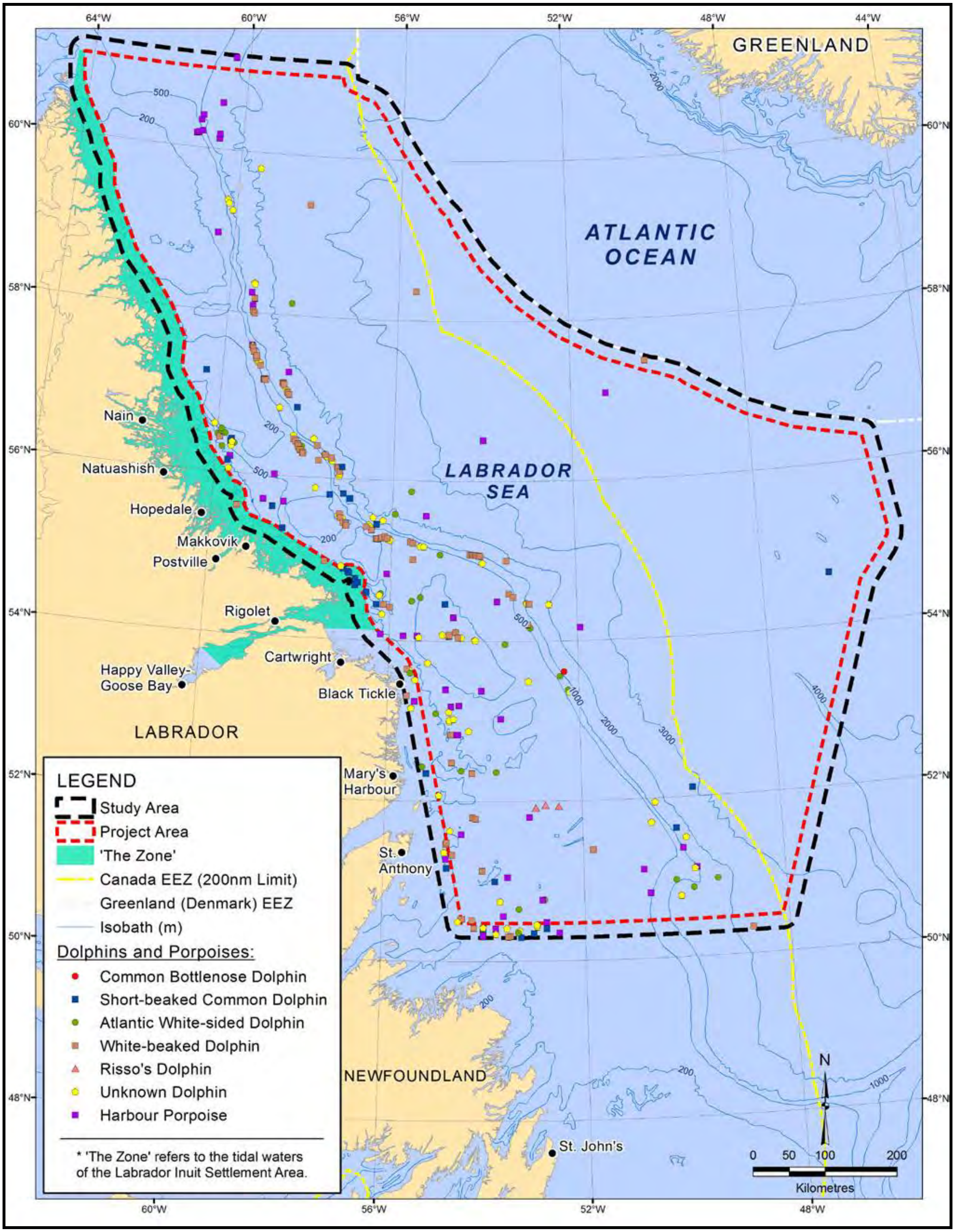
Source: DFO cetacean sightings database, see text for description of data and *caveats* associated with these data.

Figure 4.42 Baleen Whale Sightings in the Study Area.



Source: DFO cetacean sightings database, see text for description and caveats associated with these data.

Figure 4.43 Toothed Whale Sightings in the Study Area.



Source: DFO cetacean sightings database, see text for description and caveats associated with these data.

Figure 4.44 Delphinid and Porpoise Sightings in the Study Area.

Table 4.11 Cetacean Records that Occurred within the Offshore Labrador Study Area, from 1894 to 2007.

Species	Number of Sightings	Minimum Number of Individuals	Months Sighted
Mysticetes			
Fin whale	240	836	Apr to Dec
Sei whale	62	163	May, Jul-Dec
Fin/Sei whale	16	46	Jul, Sep, Oct, Dec
Humpback whale	791	5400	Apr to Jan
Minke whale	188	388	Apr to Jan
Odontocetes			
Sperm whale	168	545	Apr, Jun-Nov
Northern bottlenose whale	116	564	Apr to Dec
Killer whale	54	506	March to Dec
Pilot whale	145	2663	Jan to Dec
Common dolphin	38	611	Jul to Sep, Nov
Atlantic white-sided dolphin	36	582	Jul to Dec
White-beaked dolphin	109	747	Jul, Aug, Oct, Nov
Risso's dolphin	4	4	Nov
Beluga	1	1	Jul
Harbour Porpoise	58	382	Jun to Dec
Unidentified cetacean	3	3	Aug, Sep
Unidentified dolphin	101	669	Jan, May-Nov
Unidentified beaked whale (*Mesoplodon* sp.)	1	2	Aug
Unidentified small whale	9	27	Feb, Apr, May, Jul-Dec
Unidentified whale	100	596	May, Aug, Oct, Nov
Unidentified large whale	121	501	May-Dec

Source: DFO (see text for description and *caveats* associated with these data). Strandings and whaling data are not included.

3. Most data have been gathered from platforms of opportunity that were vessel-based. The inherent problems with negative or positive reactions by cetaceans to the approach of such vessels have not yet been factored into the data,
4. Sighting effort has not been quantified (i.e., the numbers cannot be used to estimate true species density or abundance for an area),
5. Both older and some more recent survey data have yet to be entered into this database. These other data will represent only a very small portion of the total data,
6. Numbers sighted have not been verified (especially in light of the significant differences in detectability among species),
7. For completeness, these data represent an amalgamation of sightings from a variety of years and seasons. Effort (and number of sightings) is not necessarily consistent among months, years, and areas. There are large gaps between years. Thus seasonal, depth, and distribution information should be interpreted with caution, and
8. Many sightings could not be identified to species, but are listed to the smallest taxonomic group possible.

4.5.1.1 Baleen Whales (Mysticetes)

Five species of baleen whales occur in the Project Area, including the *SARA*-listed blue whale (*endangered,* Schedule 1) and fin whale (*special concern*, Schedule 1) described in the Species at Risk section (Section 4.6). Although some individuals may be present in offshore waters of Newfoundland and Labrador year-round, most baleen whale species presumably migrate to lower latitudes during winter months.

Blue Whale

The Atlantic population of blue whale is discussed in Section 4.6 on Species at Risk. The blue whale is currently designated as *endangered* under Schedule 1 of *SARA* and by COSEWIC (see Table 4.13 in Section 4.6).

Fin Whale

The Atlantic population of fin whale is discussed in Section 4.6. The fin whale is currently designated as *special concern* under Schedule 1 of *SARA* and by COSEWIC (see Table 4.13 in Section 4.6).

Humpback Whale

The humpback whale is cosmopolitan in distribution and is most common over the continental shelf and in coastal areas (Jefferson et al. 2008). There are an estimated 11,570 individuals in the N Atlantic (Stevick et al. 2003). The western north Atlantic population of humpback whales is listed as *special concern* under Schedule 3 of *SARA* and it is considered *not at risk* by COSEWIC. Lawson and Gosselin (2009) provided an abundance estimate of 1,427 humpback whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; the corrected abundance estimate is 3,712 whales (Lawson and Gosselin, unpublished data). Most large whale entanglements in Newfoundland and Labrador are of humpback whales (Benjamins et al. 2012).

Humpback whales migrate annually from high-latitude summer foraging areas to Caribbean breeding grounds in the winter. Primary feeding areas in the north Atlantic have been described using genetic and individual identification data as the Gulf of Maine, eastern Canada, west Greenland, and the northeast Atlantic (Stevick et al. 2006). Humpback whales are common over the banks and nearshore areas of Newfoundland and Labrador from June through September, sometimes forming large aggregations to feed primarily on spawning capelin, sand lance, and krill. During aerial surveys in August 1980, Hay (1982) estimated a density of 0.0282 humpbacks per nmi^2 (0.0082 humpbacks per km^2) or a total of ~214 animals in an area offshore of central Labrador.

The Labrador Shelf SEA suggests that primary feeding areas for humpbacks are likely found along the shoreline from Hudson Strait to the southern coast of Newfoundland. This is supported by extensive sightings (*n* = 791) over the continental shelf in the Study Area, particularly during August–November, based on the DFO cetacean sightings database (see Figure 4.42). During surveys of sub-Arctic north Atlantic waters, humpback whales were sighted off Labrador and the east coast of Newfoundland

(Compton et al. 2007). Clapham et al. (1993) noted that not all individuals migrate to the tropics each year; some presumably remain near their foraging grounds in high and mid latitudes during the winter. Based on the DFO cetacean sightings database, the humpback whale was the most frequently sighted cetacean within the Study Area.

Sei Whale

Sei whale distribution is poorly known, but it occurs in all oceans and it appears to prefer mid-latitude temperate waters (Jefferson et al. 2008; Prieto et al. 2012). There is no current population estimate for the north Atlantic, but 1,400 to 2,250 individuals were estimated to use the northwest Atlantic based on catch data collected during commercial whaling (COSEWIC 2003b). In the Canadian Atlantic, sei whales have no status under *SARA* and are considered *data deficient* by COSEWIC. Sei whales appear to prefer offshore, pelagic, deep areas that are often associated with the shelf edge, and feed primarily on copepods (COSEWIC 2003b; Prieto et al. 2012).

Two stocks of sei whales are currently considered to occur in eastern Canada, on the Scotian Shelf and in the Labrador Sea, although there is limited evidence supporting the definition of the Labrador Sea stock (COSEWIC 2003b). However, there are numerous observations in the region according to the Labrador Shelf SEA, and there were 62 sightings of sei whales in the Study Area based on the DFO cetacean sightings database (see Figure 4.42). Most sightings were made during August through October within the 500-m isopleth off southern Labrador, but some sightings were made in deeper water farther offshore. According to Prieto et al. (2010), the Labrador Sea appears to be an important feeding area for sei whales from the northeast Atlantic. One sei whale that was tagged in the Azores during 2005 (Olsen et al. 2009) and seven individuals that were tagged in the Azores during 2008–2009 travelled to the Labrador Sea, where they spent extended periods of time on the northern shelf, presumably to feed (Prieto et al. 2010).

Minke Whale

The smallest of the baleen whales, minke whales have a cosmopolitan distribution and use polar, temperate, and tropical regions (Jefferson et al. 2008). There are four populations recognized in the north Atlantic, including the Canadian east coast, west Greenland, central north Atlantic, and northeast Atlantic stocks (Donovan 1991). However, DNA data suggest that there may be as few as two different stocks in the north Atlantic (Anderwald et al. 2011). There are an estimated 20,741 individuals in the Canadian east coast stock, which ranges from the Gulf of Mexico to Davis Strait (Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 1,315 minke whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; the corrected abundance estimate is 4,691 whales (Lawson and Gosselin, unpublished data). Minke whales have no status under *SARA* and are considered *not at risk* in the Atlantic by COSEWIC. Minke whales are common over the banks and coastal regions of Newfoundland and Labrador from early spring to fall, arriving as early as April and typically remaining as late as October and November; however, some may stay through the winter (see Labrador Shelf SEA (Sikumiut 2008)). Minke whale sightings are common in the Study Area; according to the DFO cetacean sightings database, there were 188 sightings from April to December, and two sightings during January (see Figure 4.42). During August–September surveys of sub-Arctic north Atlantic waters, minke whales were sighted in the Strait of Belle Isle and off the east coast of Newfoundland (Compton et al. 2007). Minke whales were also sighted four times in the Labrador stratum during DFO's 2007 aerial survey (Lawson and Gosselin 2009). In a study off northern Newfoundland and southern Labrador, Perkins and Whitehead (1977) most frequently observed minkes occurring singly, but groups of up to five individuals were also often encountered. Minke whales tend to forage in continental shelf waters on small schooling fish like capelin and sand lance, making relatively short duration dives (Stewart and Leatherwood 1985).

4.5.1.2 Toothed Whales (Odontocetes)

Nine species of toothed whales occur in the Project Area (see Table 4.10), ranging from the largest of odontocetes, the sperm whale (~18 m for an adult male; Reeves and Whitehead 1997) to one of the smallest, the harbour porpoise (~1.6 m for an average adult (COSEWIC 2006b)). Many of these species seem to be present in the Labrador Sea only seasonally, but there is generally little information on the distribution and abundance of these species. The northern bottlenose whale (Scotian Shelf population) is designated as *endangered* on Schedule 1 of *SARA*, and Sowerby's beaked whale is considered *special concern* (Schedule 1); these two species are described in detail in Section 4.6. In addition, the harbour porpoise is considered as *threatened* (Schedule 2), and COSEWIC has designated the beluga whale as *endangered*, the killer whale as *special concern*, and the sperm whale as a *low priority candidate species* by COSEWIC.

Northern Bottlenose Whale

Northern bottlenose whale is discussed in Section 4.6 on Species at Risk. The Scotian Shelf population of northern bottlenose whale is designated *endangered* under Schedule 1 of *SARA* and by COSEWIC (see Table 4.13 in Section 4.6). The Davis Strait-Baffin Bay-Labrador Sea population has no status under *SARA* but is considered of *special concern* by COSEWIC. It is unclear whether northern bottlenose whales occurring in the Study Area belong to the Davis Strait population, Scotian Shelf population, or both.

Sowerby's Beaked Whale

Sowerby's beaked whale is discussed in Section 4.6 on Species at Risk. Sowerby's beaked whale is considered as *special concern* under Schedule 1 of *SARA* and by COSEWIC (see Table 4.13 in Section 4.6).

Harbour Porpoise

Harbour porpoises occur in continental shelf regions of the northern hemisphere; in the northwest Atlantic, they occur from Baffin Island to New England (Jefferson et al. 2008). There are at least three populations recognized in the northwest Atlantic: eastern Newfoundland and Labrador, the Gulf of St. Lawrence, and the Gulf of Maine/Bay of Fundy (Palka et al. 1996). Lawson and Gosselin (2009) provided an abundance estimate of 1,195 harbour porpoises for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; the corrected abundance estimate is 3,326 porpoises

(Lawson and Gosselin, unpublished data). In the Atlantic, harbour porpoises are considered *threatened* (Schedule 2) by *SARA* and of *special concern* by COSEWIC (see Table 4.13 in Section 4.6).

Limited information is available regarding distribution and movements of harbour porpoises in Newfoundland and Labrador. Data on harbour porpoises incidentally caught in groundfish gillnets suggest that they occur around the entire island of Newfoundland and in southern Labrador (Lawson et al. 2004). Bycatch data from the driftnet fishery also indicate that harbour porpoises occur over the continental shelf and as far north as Nain and the Labrador Sea (Stenson et al. 2011). Harbour porpoises were also regularly reported as bycatch in waters >2,000 m deep in the Labrador Sea (Stenson et al. 2011). Harbour porpoises have also been sighted along the 1,000 m depth contour on the Canadian side of Davis Strait between 58ºN to 61º15'N (COSEWIC 2006b). In general, harbour porpoises are primarily observed over continental shelves and in areas with coastal fronts or upwelling that concentrate small schooling fish, although sightings also occasionally occur in deeper waters (Read 1999). Bycaught porpoises in Newfoundland appear to primarily consume capelin, Atlantic herring, sand lance, and lantern fish (COSEWIC 2006b). Harbour porpoises typically occur singly or in small groups of up to three individuals, occasionally occurring in larger groups (COSEWIC 2006b). The Labrador Shelf SEA indicates that harbour porpoises are most likely to occur in the Labrador Sea from spring to fall. There were 58 harbour porpoise sightings in the Study Area during June through December in the DFO cetacean sightings database, with some sightings in water >2,000 m deep (see Figure 4.44).

Beluga Whale

Beluga whales have a circumpolar distribution, being found in Arctic waters of Alaska, Canada, Greenland, Russia, and Norway (Jefferson et al. 2008). Based on distinct summer distributions and genetic isolation, seven populations are recognized in Canada with animals occurring offshore of Labrador likely representing either the Ungava Bay or eastern Hudson Bay populations (COSEWIC 2004). The Ungava Bay population is too small to estimate and might have been *extirpated* while the eastern Hudson Bay population includes ~2,000 individuals (COSEWIC 2004). Although they have no status under *SARA*, the Ungava Bay and eastern Hudson Bay populations of belugas are currently considered *endangered* by COSEWIC (see Table 4.13 in Section 4.6).

Belugas were considered common in northern Labrador coastal waters during summer months until the 1950s, but are now considered scarce and are reported occasionally each summer (COSEWIC 2004). During the summer of 2012, two sightings were made in Groswater Bay, Labrador (Chaulk et al. 2013). DFO (2005) suggests that eastern Hudson Bay animals overwinter along the Labrador coast. Two satellite-tagged individuals from the eastern Hudson Bay population were tracked to positions near Nain, Labrador in January (Lewis et al. 2003 *in* COSEWIC 2004). Beluga whales migrate between open-water overwintering areas to spring and summer calving and foraging areas, typically close to river estuaries or located in offshore areas. In the fall, they may forage intensively in deep-water areas offshore, eating a variety of fish and invertebrates (COSEWIC 2004). There were four beluga whale sightings (of 89 individuals) during a summer 2007 aerial survey offshore of Labrador (Lawson and Gosselin 2009). There was one beluga sighting during July in the DFO cetacean sightings database for the Study Area (see Figure 4.43).

Killer Whale

Killer whales have a cosmopolitan distribution and occur in all oceans from polar pack ice to the equator, but they appear to be most common in coastal areas of higher latitudes (Jefferson et al. 2008). Killer whales offshore of Labrador and eastern Newfoundland are likely members of the northwest Atlantic/eastern Arctic population, which is categorized as *special concern* by COSEWIC but has no status under *SARA* (see Table 4.13 in Section 4.6). The number of killer whales in the northwest Atlantic/eastern Arctic population is unknown (COSEWIC 2008b), but at least 67 individuals have been identified in the northwest Atlantic (Lawson and Stevens 2013).

Killer whale movements are generally related to the distribution and abundance of their primary prey, which can include fish, other marine mammals, seabirds, and cephalopods (Ford et al. 2000). In Newfoundland and Labrador, killer whales have been observed approaching, attacking, and/or consuming other cetaceans, seals, seabirds and several species of fish; however, it is not known if there is any prey specialization among killer whale groups or individuals (Lawson et al. 2007). Stable isotope analysis of samples from seven killer whales suggests that killer whales off Newfoundland and Labrador mainly feed on fish, although one individual was found to have fed mostly on baleen whales (Matthews and Ferguson 2011). Observed group sizes range from 1 to 30 individuals (rarely more than 15), averaging 5.2 whales (Lawson and Stevens 2013). Although they occur at relatively low densities, killer whales are considered year-round residents of Newfoundland and Labrador (Lien et al. 1988; Lawson et al. 2007; Lawson and Stevens 2013). Sightings seem to be increasing in recent years, but it is unclear if this is due to increasing abundance or observer effort. While sightings are also more common in coastal areas than offshore (Lawson et al. 2007; Lawson and Stevens 2013), it is unclear whether this is due to higher observer effort nearshore or a true representation of killer whale distribution. Based on the DFO cetacean sightings database, there have been 54 killer whale sightings in the Study Area from March to December (see Figure 4.43), with most sightings occurring during July–October (see Figure 4.43). A killer whale outfitted with a satellite tag at Admiralty Inlet, Baffin Island, on 15 August 2009, was tracked making a long-distance movement into the north Atlantic, traveling through the Study Area during late October/early November (Matthews et al. 2011). However, it is uncertain whether killer whales from populations in other areas, such as the Canadian Arctic, Greenland, or Iceland mix with whales off Newfoundland and Labrador (Lawson and Stevens 2013).

Sperm Whale

The sperm whale is most common in tropical and temperate waters, but is widely distributed and occurs from the edge of the polar pack ice to the equator (Jefferson et al. 2008). Whitehead (2002) estimated a total of 13,190 sperm whales for the Iceland-Faroes area, the area north of it, and the east coast of North America combined. Waring et al. (2013) reported an estimate of 1,593 animals for the U.S. Atlantic. Sperm whales have no status under *SARA* and are designated *not at risk* by COSEWIC. However, they are a *low priority candidate* species under COSEWIC (see Table 4.13 in Section 4.6).

Large aggregations or small groups of females and juveniles occur in tropical and sub-tropical regions, but males are most common singly or in small same-sex groups occurring at higher latitudes (Whitehead 2003). Since males tend to range further north, sperm whales encountered in the Labrador Sea are more likely to be single males. However, mixed groups with females and juveniles have occasionally been observed in higher latitudes, and males can still form large same-sex aggregations (Whitehead and Weilgart 2000; Whitehead 2003). Sperm whales appear to prefer deep waters off the continental shelf, particularly areas with high secondary productivity, steep slopes, and canyons that may concentrate their primary prey of large-bodied squid (Jaquet and Whitehead 1996; Waring et al. 2001). Sperm whales are deep divers, routinely diving to hundreds of metres, sometimes to depths over 1,000 m and remaining submerged up to an hour (Whitehead and Weilgart 2000). Sperm whales are most likely to occur in deep water and high relief areas offshore of Labrador during summer months. They were the most frequently sighted toothed whale in the Study Area, based on the DFO cetacean sightings database; there were 168 sperm whale sightings, most occurring from July to October (see Figure 4.43).

Long-finned Pilot Whale

The long-finned pilot whale is widespread in the N Atlantic and considered an abundant year-round resident of Newfoundland and Labrador (Nelson and Lien 1996). Although the total number of long-finned pilot whales off the east coast of the U.S. and Canada is uncertain, an estimated 12,619 individuals occur in the northwest Atlantic (Waring et al. 2013). During an August 1980 aerial survey, Hay (1982) estimated a density of 0.0606 animals per nmi^2 offshore of central Labrador. In the DFO cetacean sightings database, long-finned pilot whales were one of the most commonly identified toothed whales within the Study Area (n = 145), occurring year-round, but with most sightings occurring during July and August (see Figure 4.43). There were also three pilot whale sightings during a summer 2007 aerial survey in the Labrador stratum (Lawson and Gosselin 2009).

Long-finned pilot whales have no status under *SARA* and are considered *not at risk* by COSEWIC. Pilot whales studied near Nova Scotia have an average group size of 20 individuals, but groups range in size from 2 to 135 animals (Ottensmeyer and Whitehead 2003). Pilot whale distribution is linked with areas of high relief, the shelf break, or slope, and they often exhibit inshore-offshore movements coinciding with movements of their prey (Jefferson et al. 2008). Short-finned squid are a primary prey item in Newfoundland, but they also consume other cephalopods and fish (Nelson and Lien 1996).

Atlantic White-sided Dolphin

Atlantic white-sided dolphins occur in temperate and sub-Arctic regions of the north Atlantic (Jefferson et al. 2008). There may be at least three distinct stocks in the north Atlantic, including the Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea areas, which combined are estimated to total ~48,819 animals in the NW Atlantic (Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 1,507 white-sided dolphins for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; the corrected abundance estimate is 3,384 dolphins (Lawson and Gosselin, unpublished data). Atlantic white-sided dolphins have no status under *SARA* and are considered *not at risk* by COSEWIC. Atlantic white-sided dolphins occur regularly from spring to fall in offshore areas of Newfoundland and Labrador, but less is known of their winter distribution. Sightings in the north Atlantic seem to coincide with the 100-m depth contour and areas of high relief (see Labrador SEA (Sikumiut 2008)). Based on bycatch data from 1965–2001, white-sided dolphins were the most frequently caught species in the Labrador Sea during July–October; spring bycatch rates were much lower (Stenson et al. 2011). There were 36 sightings in the DFO cetacean sightings database in the Study Area from July through December (see Figure 4.44). There was a single August sighting during a summer 2007 aerial survey offshore of Labrador (Lawson and Gosselin 2009). Prey items range from cephalopods to pelagic or benthopelagic fishes like capelin, herring, hake, sand lance, and cod (Selzer and Payne 1988). Off New England, calving occurs from May to August, and Atlantic white-sided dolphins tend to occur in large groups ranging from 2 to 2,500 individuals, averaging 52.4 (Weinrich et al. 2001).

White-beaked Dolphin

White-beaked dolphins have a more northerly distribution than most dolphin species, occurring in cold temperate and sub-Arctic waters of the north Atlantic (Jefferson et al. 2008). It is unknown how many occur off Labrador and northeastern Newfoundland, but based on ship-board surveys undertaken in the summer of 1982, Alling and Whitehead (1987) provided an abundance estimate of 3,486 white-beaked dolphins for Labrador. More recently, Waring et al. (2013) reported a total of 2,003 individuals in the north Atlantic. Lawson and Gosselin (2009) provided an abundance estimate of 1,842 white-beaked dolphins for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; the corrected abundance estimate is 15,625 dolphins (Lawson and Gosselin, unpublished data). White-beaked dolphins have no status under *SARA* and are considered *not at risk* by COSEWIC. According to the Labrador Shelf SEA, sightings of white-beaked dolphins are generally common in the Study Area. In the DFO cetacean sightings database, 109 sightings were made in the Study Area from July through November, but especially during August (see Figure 4.44), although none were seen during a summer 2007 aerial survey offshore of Labrador (Lawson and Gosselin 2009). White-beaked dolphins are thought to remain at high latitudes year-round and are generally observed in continental shelf and slope areas, although they also occur in shallow coastal areas (Lien et al. 2001). They typically occur in groups of less than 30 animals, but group sizes up to the low hundreds have also been reported (Lien et al. 2001). White-beaked dolphins have a range of prey items, including squid, crustaceans, and a number of small mesopelagic and schooling fishes like herring, haddock, hake, and cod (Jefferson et al. 2008).

Short-beaked Common Dolphin

The short-beaked common dolphin is widely distributed over the continental shelf in temperate, tropical and subtropical regions (Jefferson et al. 2008). An estimated 67,191 individuals reside in the northwest Atlantic (Waring et al. 2013), but an unknown number are found in eastern Canada (Gaskin 1992). Lawson and Gosselin (2009) provided an abundance estimate of 576 common dolphins for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; the corrected abundance estimate is 1,806 dolphins (Lawson and Gosselin, unpublished data). Short-beaked common dolphins form groups ranging in size from several dozens to over 10,000, often moving rapidly and displaying many aerial behaviours such as porpoising and bowriding (Jefferson et al. 2008). They are found in a variety of habitats, ranging from 100 to 2,000 m deep, but appear to prefer areas with high seafloor relief (Selzer and Payne 1988) and are often associated with features of the Gulf Stream (Hamazaki 2002). The abundance and distribution of short-beaked common dolphins also coincides with peaks in abundance of mackerel, butterfish and squid (Selzer and Payne 1988). Gaskin (1992) indicated that common dolphins can be abundant off the coast of Nova Scotia and Newfoundland for a few months during the summer. There were 38 sightings of common dolphins reported in the DFO cetacean sightings database in the Study Area, primarily during July to September (see Figure 4.44).

4.5.1.3 True Seals (Phocids)

Six species of seals occur in the Project Area (see Table 4.11). None of these species are designated under *SARA*. However, harp, hooded and bearded seals are considered *mid priority candidate species*. Ringed seal is considered a *high priority candidate species* by COSEWIC.

Ringed Seal

Ringed seals are an ice-associated seal with a circumpolar distribution throughout the Arctic, occurring in areas with seasonal ice cover (Jefferson et al. 2008). They occasionally range as far south as northern Newfoundland. There is limited abundance information for ringed seals due to difficulties in accurately surveying ringed seals, but there are an estimated 1.3 million individuals in an area that includes the eastern Canadian Arctic, Labrador Sea, and west Greenland (NAMMCO n.d.). Ringed seals are the most abundant seal species in northern Labrador and are considered common throughout their range (Stenson 1994). Ringed seals have no status under *SARA* and are considered *not at risk* by COSEWIC, although they are currently a *high priority candidate* species (see Table 4.13 in Section 4.6). Ringed seals prefer annual landfast ice with extensive snow cover, but also occur in offshore pack ice; pupping occurs in late winter to early spring using snow lairs built above the ice next to a breathing hole (Smith and Stirling 1975). Moulting occurs on the ice following the spring breeding season until ice breakup, and intensive feeding occurs from late July through October in pelagic areas or among pack ice (Smith and Hammill 1981 *in* the Labrador Shelf SEA (Sikumiut 2008)). Ringed seals eat a variety of crustaceans, as well as Arctic cod, capelin, and sand lance (NAMMCO n.d.).

Harp Seal

Harp seals occur in the north Atlantic and Arctic oceans, from the Gulf of St. Lawrence to Russia (Jefferson et al. 2008). They are considered the most abundant seal in the northwest Atlantic. Based on survey data, the population size for eastern Canada was estimated at 8.3 million harp seals for 2008 (DFO 2012d). Reproductive rates declined after 2008, and the population size for 2012 was estimated at 7.1 million (Hammill et al. 2013a). COSEWIC is considering the harp seals as a *mid priority candidate* species; it has no status under *SARA* (see Table 4.13 in Section 4.6). Harp seals are common during spring off northeast Newfoundland and southern Labrador where they congregate to breed and pup on the pack ice; the majority of the northwest Atlantic population uses this region while the small remainder uses the Gulf of St. Lawrence (Lavigne and Kovacs 1988). Large concentrations are found on the sea ice off northeastern Newfoundland where they moult during April and May (DFO 2012d). Harp seals migrate to Arctic and Greenland waters during summer, but some harp seals remain in southern waters (DFO 2012d). Offshore areas of southern Labrador and eastern Newfoundland appear to be major wintering areas (Stenson and Sjare 1997; Lacoste and Stenson 2000). Off Newfoundland and Labrador, harp seal diets are composed of capelin, Arctic cod, sand lance, herring, Atlantic cod, redfish, and Greenland halibut (Hammill and Stenson 2000).

Hooded Seal

Hooded seals are found in the north Atlantic, ranging from Nova Scotia to the high Arctic in Canada (Jefferson et al. 2008). There are an estimated 593,500 individuals in the Canadian Atlantic, the majority of which (~535,800 animals) whelp and breed in the pack ice off northeast Newfoundland/southern Labrador in late winter-early spring (Hammill and Stenson 2006). Hooded seals have no status under *SARA* and are considered *not at risk* by COSEWIC; however, they are currently a *mid priority candidate* species. Four primary pupping and mating areas occur in the north Atlantic and include northeast Newfoundland/southern Labrador, the Gulf of St. Lawrence, Davis Strait, and northeast Greenland (Jefferson et al. 2008). Hooded seals aggregate in eastern Greenland to moult during early summer before dispersing to Davis Strait or the Greenland Sea for late summer and fall (see Hammill and Stenson 2006). Less is known about winter distribution, although there have been winter sightings on the Grand Banks; recent telemetry data suggests that hooded seals move along the continental shelf edge after leaving Greenland moulting grounds to Davis Strait and Baffin Bay followed by southerly migrations into the Labrador Sea during winter (Andersen et al. 2009). Hooded seals consume benthic invertebrates like shrimp, Greenland halibut, redfish, Arctic cod, and squid (Hammill and Stenson 2000).

Bearded Seal

The bearded seal is an ice-affiliated seal occurring throughout Arctic regions, mainly over the continental shelf and areas with moving ice or ice leads (Jefferson et al. 2008). An estimated 190,000 bearded seals may exist within the Canadian Arctic (Cleator 1996), but no estimates are available for Labrador waters. Bearded seals have no status under *SARA* and are considered *data deficient* by COSEWIC; however, they are a *mid priority candidate* species (see Table 4.13 in Section 4.6). Although they may remain in or near sea ice year-round, bearded seals are considered more pelagic during summer and fall (Laidre et al. 2008). There is little information on the distribution or movements of bearded seals in Labrador, but they appear to be found at low densities along the entire coast and more commonly in northern portions (Stenson 1994; Cleator 1996). Bearded seals are benthic feeders, consuming a variety of crustaceans, mollusks, and some benthic fishes like sculpins, flatfish, and cod (see Labrador Shelf SEA for additional detail).

Harbour Seal

Although generally restricted to nearshore areas, the harbour seal has a widespread distribution in the northern hemisphere (Jefferson et al. 2008). In the western Atlantic, it is distributed from the U.S. east coast to Baffin Island and western Greenland. The estimate for the northwest Atlantic stock for 2001 was 99,340 individuals; however, as this estimate is more than eight years old, it is deemed unreliable, and no current abundance estimate is available (Waring et al. 2013). There are few quantitative estimates of abundance for Atlantic Canada (Hammill et al. 2010), but Sjare et al. (2005) suggest that areas along the Labrador coast south of Cartwright likely support the highest densities. In addition, little distribution information exists for harbour seals along the Labrador coast. Hunters have indicated the following areas contain concentrations of harbour seals: Paradise River, Double Mer Lake, an area near Cape Harrison north of Groswater Bay, bays near Hopedale, Sandy Island area near Natuashish, and river mouths and estuaries around Nain (Sjare et al. 2005). Harbour seals are likely year-round residents, occurring at low densities near coastal areas. Fish, shrimp, and squid are consumed by harbour seals in Newfoundland and Labrador, particularly cod, sand lance, capelin, and herring (Sjare et al. 2005). Harbour seals have no status under *SARA* and are considered *not at risk* by COSEWIC.

Grey Seal

Grey seals inhabit cold temperate to sub-Arctic regions of the north Atlantic, ranging in Canada from Nova Scotia to Labrador (Jefferson et al. 2008). Grey seals have no status under *SARA* and are considered *not at risk* by COSEWIC. Over the last several decades, the northwest Atlantic population has increased dramatically (Bowen 2011); the population estimates in 2010 ranged from 348,900 seals (Thomas et al. 2011) to 402,700 (Hammill and Stenson 2011). The majority breed during the winter on Sable Island, south of Nova Scotia, but pups are also born in the Gulf of St. Lawrence, and along the coast of Nova Scotia (DFO 2010c). An unknown number range into eastern Newfoundland and Labrador. Grey seals are generally coastal, but forage over the continental shelf (Lesage and Hammill 2001). Along the east coast of Newfoundland, their diet seems to be dominated by capelin and winter flounder, although other fish species including Atlantic cod, sculpins, and sand lance are also taken (Hammill et al. 2013b). Grey seals presumably move northward, ranging occasionally into Labrador waters, from July to September (Stobo et al. 1990).

4.5.1.4 Polar Bear

The polar bear is discussed in Section 4.6, Species at Risk. The polar bear is listed as a species of *special concern* under Schedule 1 of *SARA* and is considered as *special concern* by COSEWIC (see Table 4.13 in Section 4.6).

4.5.2 Sea Turtles

Sea turtles are likely not common within the Labrador Sea, but three species could potentially occur within the Project Area. Table 4.12 provides a summary of habitat, occurrence and status in the Project Area for leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), and Kemp's Ridley sea turtles (*Lepidochelys kempii*). Of these species, the leatherback sea turtle is designated as *endangered* under COSEWIC and *SARA*; the loggerhead sea turtle is designated as *endangered* by COSEWIC, but it has no status under *SARA* (see Table 4.13 in Section 4.6; see Section 4.6, Species at Risk for profile).

The loggerhead sea turtle has no status under *SARA*, but it is designated as *endangered* by COSEWIC. There are no current population estimates for loggerhead turtles in Atlantic Canada (DFO 2010d). However, it is the most common sea turtle in North American waters, but rarely ventures as far north as Labrador (Spotila 2004), as it prefers water between 20–25°C (DFO 2010d). Adults can migrate considerable distances between near-equatorial nesting areas and temperate foraging areas (Hawkes et al. 2007). Loggerheads appear to move with the Gulf Stream into eastern Canada waters during summer, especially the Scotian Shelf, Georges Bank and Grand Banks from July through October (Smith 2001, 2002 *in* Brazner and McMillan 2008; Javitech 2002, 2003 *in* Brazner and McMillan 2008). In the northwest Atlantic, thousands of mostly immature loggerheads have been bycaught in the

Canadian pelagic longline fishery since 1999 (Brazner and McMillan 2008; Paul et al. 2010). Thus, there appears to be a seasonal population of juvenile loggerheads in Atlantic Canada (COSEWIC 2010c). Loggerheads may be seen in the open seas during migration and foraging (e.g., Mansfield et al. 2009). While foraging at sea, loggerheads likely consume gelatinous zooplankton and squid (Spotila 2004).

Table 4.12 Sea Turtles Potentially Occurring in the Labrador Sea Study Area.

Species	Project Area		***SARA* Status**[a]	**COSEWIC Status**[b]	**Activities**	**Habitat**
	Occurrence	**Timing**				
Leatherback sea turtle	Rare	June to Nov	Schedule 1: Endangered	E	Feeding	Open water, bays
Loggerhead sea turtle	Very rare	Summer	NS	E	Feeding	Open water
Kemp's Ridley sea turtle	Very rare	Summer	NS	NC	Feeding	Open water

[a] Species designation under the *Species at Risk Act*; NS = No Status.
[b] Species designation by COSEWIC; E = Endangered, NC = Not Considered.

Kemp's Ridley sea turtle has no status under *SARA* and has not been considered by COSEWIC. The Kemp's Ridley sea turtle is restricted in its distribution, primarily occurring only in the Gulf of Mexico, but some juveniles sometimes feed along the U.S. east coast and rarely range into eastern Canada waters (Spotila 2004). Movements outside of the Gulf of Mexico likely occur during summer and in coastal areas. There are records of Kemp's Ridley turtle for Nova Scotia, but the presence of this turtle off Newfoundland has not been confirmed (McAlpine et al. 2007).

4.6 Species at Risk

The *Species at Risk Act* (*SARA*) was assented to in December 2002 with certain provisions coming into force in June 2003 (e.g., independent assessments of species by COSEWIC) and June 2004 (e.g., prohibitions against harming or harassing listed *endangered* or *threatened* species or damaging or destroying their critical habitat). The information provided in this section is current as of January 2014 on the websites for *SARA* (http://www.sararegistry.gc.ca/default_e.cfm) and COSEWIC (http://www.cosepac.gc.ca/index.htm).

Species are listed under *SARA* on Schedules 1 to 3 with only those designated as *endangered* or *threatened* on Schedule 1 having immediate legal implications. Nonetheless, attention must be paid to all of the *SARA*-listed species because of their sensitivities to perturbation and the potential for status upgrades. Schedule 1 is the official list of wildlife Species at Risk in Canada. Once a species/ population is designated, the measures to protect and recover it are implemented. The two cetacean species/populations, one sea turtle species, one seabird species, and three fish species/populations that are legally protected under *SARA* and have potential to occur in the Study Area are listed in Table 4.13 in Section 4.6 of this EA. Atlantic wolffish, the Atlantic population of fin whales, Sowerby's beaked whale, polar bear, Harlequin Duck, and Barrow's Goldeneye are designated as *special concern* on Schedule 1 (Table 4.13). Schedules 2 and 3 of *SARA* identify species that were designated "at risk" by COSEWIC prior to October 1999 and must be reassessed using revised criteria before they can be considered for addition to Schedule 1. Species that potentially occur in the Study Area and are considered at risk but which have not received specific legal protection (i.e., proscribed penalties and

Table 4.13 *SARA* Schedule 1 and COSEWIC-listed Marine Species that Potentially Occur in the Study Area.

Species		***SARA* Schedule 1**			**COSEWIC**			
Common Name	**Scientific Name**	***Endangered***	***Threatened***	***Special Concern***	***Endangered***	***Threatened***	***Special Concern***	***Candidate Species***
Blue whale	*Balaenoptera musculus*	X			X			
Northern bottlenose whale (Scotian Shelf population)	*Hyperoodon ampullatus*	X			X			
Leatherback sea turtle	*Dermochelys coriacea*	X			X			
Ivory gull	*Pagophila eburnea*	X			X			
White shark	*Carcharodon carcharias*	X			X			
Northern wolffish	*Anarhichas denticulatus*		X			X		
Spotted wolffish	*Anarhichas minor*		X			X		
Atlantic wolffish	*Anarhichas lupus*			X			X	
Fin whale (Atlantic population)	*Balaenoptera physalus*			X			X	
Sowerby's beaked whale	*Misoplodon bidens*			X			X	
Polar bear	*Ursus maritimus*			X			X	
Harlequin Duck	*Histrionicus histrionicus*			X			X	
Barrow's Goldeneye	*Bucephala islandica*			X			X	
Loggerhead sea turtle	*Caretta caretta*				X			
Atlantic cod (NL[a] population)	*Gadus morhua*				X			
Porbeagle shark	*Lamna nasus*				X			
Roundnose grenadier	*Coryphaenoides rupestris*				X			
Atlantic salmon (various populations)	*Salmo salar*				X	X	X	
Beluga (Eastern Hudson Bay population)	*Delphinapterus leucas*				X			
Beluga (Ungava Bay population)	*Delphinapterus leucas*				X			
Cusk	*Brosme brosme*				X			
American plaice (NL[a] population)	*Hippoglossoides platessoides*					X		
American eel	*Anguilla rostrata*					X		
Acadian redfish	*Sebastes fasciatus*					X		
Deepwater redfish	*Sebastes mentella*					X		
Northern bottlenose whale (Davis Strait-Baffin Bay-Labrador Sea population)	*Mesoplodon bidens*						X	

Species		*SARA* Schedule 1			COSEWIC			
Common Name	**Scientific Name**	***Endangered***	***Threatened***	***Special Concern***	***Endangered***	***Threatened***	***Special Concern***	***Candidate Species***
Harbour porpoise	*Phocoena phocoena*						X	
Killer whale (NW Atlantic/E Arctic populations)	*Orcinus orca*						X	
Blue shark	*Prionace glauca*						X	
Roughhead grenadier	*Macrourus berglax*						X	
Spiny dogfish	*Squalus acanthias*						X	
Ringed seal	*Phoca hispida*							High priority
Lumpfish	*Cyclopterus lumpus*							High priority
Hooded seal	*Cystophora cristata*							Mid priority
Harp seal	*Phoca groenlandica*							Mid priority
Bearded seal	*Erignathus barbatus*							Mid priority
Spinytail skate	*Bathyraja spinicauda*							Mid priority
Pollock	*Pollachius virens*							Mid priority
Greenland shark	*Somniosus microcephalus*							Mid priority
Sperm whale	*Physeter macrocephalus*							Low priority

Sources: *SARA* website (http://www.sararegistry.gc.ca/default_e.cfm) (as of January 2014); COSEWIC website (http://www.cosepac.gc.ca/index.htm) (as of January 2014).

[a]Newfoundland and Labrador.

legal requirement for recovery strategies and plans) under *SARA* are also listed in Table 4.13 as are *endangered*, *threatened* or species of *special concern* under COSEWIC. Other non-*SARA* listed marine species that potentially occur in the Study Area and are listed by COSEWIC as *candidate species* are also included in Table 4.13.

Under *SARA*, a 'recovery strategy' and corresponding 'action plan' must be prepared for *endangered*, *threatened*, and *extirpated* species. A 'management plan' must be prepared for species considered as *special concern*. Final recovery strategies have been prepared for five species currently designated as either *endangered* or *threatened* under Schedule 1 and potentially occurring in the Project Area: (1) the leatherback sea turtle (ALTRT 2006); (2) the spotted wolffish (Kulka et al. 2007), (3) the northern wolffish (Kulka et al. 2007), (4) the blue whale (Beauchamp et al. 2009), and (5) the Scotian Shelf population of the northern bottlenose whale (DFO 2010e). A recovery strategy has also been proposed for the Ivory Gull (Environment Canada 2013c). In addition, management plans have been prepared for the Atlantic wolffish (Kulka et al. 2007), Harlequin Duck (Environment Canada 2007), and Barrow's Goldeneye (Environment Canada 2013d), all currently designated as *special concern* on Schedule 1.

MKI will monitor *SARA* issues through the law gazettes, the Internet and communication with DFO and Environment Canada, and will adaptively manage any issues that may arise in the future. The company will comply with relevant regulations pertaining to *SARA* Recovery Strategies and Action Plans. MKI will continue to exercise due caution to minimize impacts on these species during all of its operations. MKI also understands that other marine species might be designated as *endangered* or *threatened* on Schedule 1 during the course of the Project (2014-2018), and will continue to monitor any status changes.

Species profiles and any related special or sensitive habitats are described in the following sections.

4.6.1 Profiles of *SARA* Schedule 1 Species/Populations

Only those species/populations that are listed under *SARA* Schedule 1 as *endangered*, *threatened* or *special concern* are profiled in detail in this section. Other marine animals listed in Table 4.13 are described in Section 4.0, Biological Environment.

4.6.1.1 Blue Whale

The blue whale has a cosmopolitan distribution, but tends to be more frequently observed in deep water than in coastal environments (Jefferson et al. 2008). Blue whales became severely depleted during industrial whaling and still occur at relatively low densities in the north Atlantic. The Atlantic population of blue whales is considered *endangered* on *SARA* Schedule 1 and by COSEWIC. Blue whales likely number in the low hundreds in the northwest Atlantic (COSEWIC 2002); the recovery strategy for blue whales in the northwest Atlantic notes a long-term recovery goal of 1,000 mature individuals through the achievement of three 5-year objectives; no Critical Habitat was identified (Beauchamp et al. 2009). Blue whales have been sighted only sporadically off the Labrador coast (COSEWIC 2002). However, resightings of an individual support one proposed hypothesis that blue whales from eastern Canada migrate in the spring to Davis Strait (COSEWIC 2002). According to the Labrador Shelf SEA, there have been rare sightings of blue whales off Labrador, although this may at least partially be attributable to poor observer coverage in the Project Area. In the DFO cetacean sightings database, there were no records of blue whales for the Study Area, but there is also likely reduced effort offshore of Labrador. However, there were two blue whale records just outside the southwestern portion of the Study Area. Blue whales feed primarily on krill, and their distribution is often associated with areas of upwelling or shelf edges where their prey may concentrate. The Labrador Shelf SEA suggests that blue whales are likely to occur on the Labrador Shelf in late winter and spring, but have been sighted in the region year-round.

4.6.1.2 Northern Bottlenose Whale

The distribution of northern bottlenose whales is restricted to the north Atlantic, primarily in deep, offshore areas with two regions of concentration: the Gully and adjacent submarine canyons on the eastern Scotian Shelf, and Davis Strait off northern Labrador (Reeves et al. 1993). Throughout their range, including Labrador, northern bottlenose whales were harvested extensively during industrial whaling, which likely greatly reduced total numbers (COSEWIC 2011). The total abundance of northern bottlenose whales in the north Atlantic is unknown. However, the current estimate for the Scotian Shelf population is 143 individuals (O'Brien and Whitehead 2013). The size of the Baffin Bay-Davis Strait-Labrador Sea population is uncertain (COSEWIC 2011; Whitehead and Hooker 2012).

The Scotian Shelf population is designated *endangered* under Schedule 1 of *SARA* (COSEWIC 2011). The recovery goal for this population it to "achieve a stable or increasing population and to maintain, at a minimum, current distribution" (DFO 2010e). The Gully Marine Protected Area, and areas deeper than 500 m in Haldimand and Shortland Canyons have been designated as critical habitat (DFO 2010e). The Davis Strait population has no status under *SARA* but is considered *special concern* by COSEWIC (2011). The Davis Strait population is considered to occur in Newfoundland and Labrador year-round, with mating and births occurring from April to June, with a peak in April (Benjaminsen 1972 *in* COSEWIC 2011). The calving season of the Scotian Shelf population peaks in August (Whitehead et al. 1997). No matches of photoidentified individuals have been made between the Scotian Shelf and the Baffin-Labrador populations (COSEWIC 2011), and nuclear and mitochondrial markers revealed very little interchange between these two populations (Dalebout et al. 2006). The encounter rate during boat surveys was 0.03 encounters/h for the Labrador-Davis Strait population, and 0.50 for the Gully (COSEWIC 2011 *as cited in* Whitehead and Hooker 2012). Occurring primarily in deep waters over canyons and the shelf edge, whales tagged on the Scotian Shelf routinely dove to depths over 800 m and remained submerged for over an hour (Hooker and Baird 1999). Foraging apparently occurs at depth, primarily on deep-water squid and fish (COSEWIC 2011; DFO 2011b).

Northern bottlenose whales are likely to occur at low densities, but year-round, throughout the deep, offshore waters of the Labrador Sea (see Labrador Shelf SEA). However, it is unclear to which population animals occurring in Labrador and Newfoundland, including the Study Area, belong (DFO 2011b; Harris et al. 2013). Based on the DFO cetacean sightings database, 116 groups of northern bottlenose whales have been sighted in the deeper waters and near the shelf break of the Study Area from April to December (se Figure 4.43). There was also one northern bottlenose whale sighting (of a single animal) during a summer 2007 aerial survey offshore of Labrador (Lawson and Gosselin 2009; see Section 4.5).

4.6.1.3 Leatherback Sea Turtle

The largest and most widely ranging of sea turtles, the leatherback sea turtle, is distributed from sub-polar and cool temperate foraging grounds to tropical and sub-tropical nesting areas in all of the world's oceans (Spotila 2004). Exhibiting wide-ranging oceanic movements, leatherbacks occur in pelagic regions of the north Atlantic to forage on gelatinous zooplankton (Hays et al. 2006). Leatherback sea turtles forage on jellyfish, such as lion's mane and moon jellyfish, in Atlantic Canadian waters; they consume an average of 330 kg wet mass of jellyfish per day (Heaslip et al. 2012). Three primary habitats, likely used as foraging areas by leatherback turtles in Atlantic Canada, were identified using satellite tracking data: (1) the area near Georges Bank, (2) southeastern Gulf of St. Lawrence and waters east of Cape Breton, and (3) waters south and east of Burin Peninsula, Newfoundland (DFO 2011c). These areas may be used to identify critical habitat in the forthcoming amendment to the 2006 leatherback sea turtle recovery plan (DFO 2013j). Genetic analysis on leatherback turtles captured off Nova Scotia revealed that the majority originated from natal beaches in Trinidad, followed by French Guiana, Costa Rica, St. Croix, and Florida (Stewart et al. 2013).

There are an estimated 34,000 to 94,000 leatherback adults in the N Atlantic (TEWG 2007), but there is no current estimate of the number of leatherbacks using eastern Canadian waters (COSEWIC 2012c). Nonetheless, James et al. (2006) suggested that Canadian waters support high densities of leatherbacks during the summer and fall, and that Canadian waters should be considered critical foraging habitat for this species. Even though the species appears to be virtually absent during the winter months (James 2000), leatherback turtles have been sighted off the east coast of Canada, and off Newfoundland, during the winter (McAlpine et al. 2007).

The leatherback sea turtle is designated as *endangered* (Schedule 1) by *SARA* and COSEWIC. In the recovery strategy for leatherback sea turtle in the Canadian Atlantic Ocean, the recovery goal is to "achieve the long-term viability of the leatherback turtle populations frequenting Atlantic Canadian waters" via six supporting objectives (ALTRT 2006). Adult leatherbacks are considered regular summer visitors to eastern Newfoundland, with observations occurring from ~July to October, with a peak in August and September (Goff and Lien 1988). Most sea turtles migrate southward by mid-October (James et al. 2007; Sherrill-Mix et al. 2008). James et al. (2006) noted that increasing sea surface temperatures in Canadian waters result in a significant increase in turtle sightings. Most leatherbacks that occur in Atlantic Canadian waters are large sub-adults and adults, with a female-biased sex ratio among mature turtles (James et al. 2007). DFO Newfoundland Region has maintained a database of leatherback turtle sightings and entanglements in Newfoundland and Labrador (J. Lawson, DFO Research Scientist, pers. comm., 2013), but records for Labrador are rare. Threlfall (1978) reported on the first record of a leatherback turtle from Labrador off Nain at 56º45'N.

4.6.1.4 Ivory Gull

Ivory Gull is designated *endangered* on Schedule 1 of *SARA*. The Ivory Gull nests at several sites in the High Arctic. There are small, scattered colonies in the Canadian Arctic, Greenland, Spitsbergen and the northern islands and archipelagos of Russia in the Kara Sea. The current status of the global Ivory Gull population is poorly known. It is rare on a global scale with fewer than 14,000 pairs (COSEWIC 2006c). The Canadian Arctic supports a significant but declining population of Ivory Gull. The

Canadian breeding population was estimated at 2,400 individuals in the early 1980s (Thomas and MacDonald 1987). Extensive surveys of historic breeding sites and adjacent breeding habitat in 2002 and 2003, and interviews with Inuit residents, indicate the breeding population in Canada has declined by 80% (Mallory et al. 2003; Gilchrist and Mallory 2005). Currently, the Canadian breeding population is estimated at approximately 400 pairs, based on surveys conducted between 2003 and 2006 (Mallory et al. 2008b). Reasons for the apparent decline of the Canadian breeding population are uncertain. The winter range of the Ivory Gull in the northwest Atlantic is among sea ice from the Davis Strait south through the Labrador Sea to about 50º N (Orr and Parsons 1982). In some years, this includes the Strait of Belle Isle, and northern Gulf of St. Lawrence, the east coast of Newfoundland (particularly the Northern Peninsula of Newfoundland), and the Lower North Shore of Québec (COSEWIC 2006c). The population that winters off the Labrador and northern Newfoundland coasts include Ivory Gulls breeding in the eastern Canadian Arctic, Greenland and Franz Josef Land, based upon banding recoveries and satellite transmitters (Tuck 1971; Gilg et al. 2010). Ten adult Ivory Gulls banded in early April 1964 and 1966 in the Labrador Sea were recovered shot in Greenland 2 to 17 years later (Lyngs 2003).

A recent marine bird survey conducted within the pack ice off the coast of Newfoundland and Labrador in March 2004 observed few Ivory Gulls (0.02 per 10 min watch), compared with 1978, when Ivory Gulls were commonly observed at that time of year in this region (0.69 per 10 min. watch; Stenhouse and Wells, unpubl. data *in* COSEWIC 2006c). During the OLABS program in 1981 to 1982, twelve Ivory Gulls were observed on Makkovik Bank during 16-18 April 1981 (McLaren et al. 1983). Most of 150 Ivory Gulls recorded during surveys conducted off Labrador and northeast Newfoundland in the time period of 16-21 February 1982 were located on Makkovik and Hamilton Banks. In general, Ivory Gulls were observed where ice cover ranged from 26% to 75% especially at or near the edge of pack ice. Ivory Gull is known as 'ice partridge' to some residents of coastal Labrador and northern Newfoundland, indicating a regular presence in the winter months. The diet of Ivory Gull includes lanternfish and Arctic cod, crustaceans and carrion (Mallory et al. 2008b). Ivory Gulls are sometimes observed scavenging byproducts of the Newfoundland and Labrador seal hunt during late winter and spring.

Ivory Gull is probably present in globally significant numbers in the Study Area when pack ice is present or near the Study Area from December to April or May.

4.6.1.5 White Shark

Worldwide, this species is rare but does occur with some predictability in certain areas. The white shark is widely distributed in sub-polar to tropical seas of both hemispheres, but it is most frequently observed and captured in inshore waters over the continental shelves of the northwest Atlantic, Mediterranean Sea, southern Africa, southern Australia, New Zealand, and the eastern north Pacific. The species is not found in cold polar waters (*SARA* website accessed January 2014). The status of the Atlantic population of the white shark for both Schedule 1 of *SARA* and COSEWIC is *endangered*.

Off Atlantic Canada, the white shark has been recorded from the northeastern Newfoundland Shelf, the Strait of Belle Isle, the St. Pierre Bank, Placentia Bay, Sable Island Bank, the Forchu Misaine Bank, in St. Margaret's Bay, off Cape La Have, in Passamaquoddy Bay, in the Bay of Fundy, in the

Northumberland Strait, and in the Laurentian Channel as far inland as the Portneuf River Estuary. The species is highly mobile, and individuals in Atlantic Canada are likely seasonal migrants belonging to a widespread northwest Atlantic population. It occurs in both inshore and offshore waters, ranging in depth from just below the surface to just above the bottom, down to a depth of at least 1,280 m (*SARA* website accessed January 2014).

The female produces eggs which remain in her body until they are ready to hatch. When the young emerge, they are born live. Litter size varies, with an average of 7 pups. Length at birth is assumed to be between 109 and 165 cm. Possible white shark pupping areas on the west and east coasts of North America include off southern California and the Mid-Atlantic Bight, respectively (*SARA* website accessed January 2014).

White shark is an apex predator with a wide prey base feeding primarily on many types of fish, and marine mammals, as well as squid, molluscs, crustaceans, marine birds, and reptiles. There has, however, been one recorded occurrence of an orca preying on a white shark (*SARA* website accessed January 2014).

4.6.1.6 Wolffishes

Three species of wolffish (i.e., northern, spotted, and Atlantic) are the only marine fishes currently listed under Schedule 1 of *SARA*. Both the northern and spotted wolffishes are currently listed as *threatened* on Schedule 1 of *SARA* and under COSEWIC. The Atlantic wolffish is currently considered as *special concern* on Schedule 1 of *SARA* and under COSEWIC. The combined recovery strategy for northern and spotted wolffishes and management plan for Atlantic wolffish was finalized in 2008 (Kulka et al. 2007). Recently, a report on the progress of the implementation of the recovery strategy and management plan was published (DFO 2013d). It reports that the recovery strategy (Kulka et al. 2007) is presently being updated and will include identified critical habitat for both northern and spotted wolffish. The progress report also states that the status of each of the three wolffish species was re-assessed by COSEWIC in November 2012 and that the recommendation was to retain the current designations. At a 2010 meeting for the Zonal Advisory Process for the Pre-COSEWIC Assessment of these three wolffish species, it was stated that there have not been any significant advances in DFO's understanding of life history characteristics of the three species in recent times (DFO 2011d).

Northern Wolffish

The northern wolffish is a deepwater fish of cold northern seas that has been caught at depths ranging from 38 to 1,504 m, with observed densest concentrations between 500 and 1,000 m at water temperatures of 2 to 5°C. During 1980-1984, this species was most concentrated on the northeast Newfoundland and Labrador shelf and banks, the southwest and southeast slopes of the Grand Banks, and along the Laurentian Channel. Between 1995 and 2003, the area occupied and density within the area was considerably reduced compared to results of earlier surveys. Northern wolffish are known to inhabit a wide range of bottom substrate types, including mud, sand, pebbles, small rock and hard bottom, with highest concentrations observed over sand and shell hash in the fall, and coarse sand in the spring. Unlike other wolffish species, both juvenile and adult stages of this species have been found a considerable distance above the bottom, as indicated by diet (Kulka et al. 2007).

Prey of northern wolffish are primarily bathypelagic (>200 m depth) biota such as ctenophores and medusa, but also include mesopelagic biota (<200 m depth) and benthic invertebrates. Pelagic fish represent the largest percentage of stomach contents on the basis of volume. Tagging studies have suggested limited migratory behaviour by these wolffish. Northern wolffish typically spawn late in the year on rocky bottom. Cohesive masses of fertilized eggs are laid in crevices but are unattached to the substrate. Pelagic larvae hatch after an undetermined egg incubation time, and typically feed on crustaceans, fish larvae and fish eggs (Kulka et al. 2007).

During DFO RV surveys conducted in the Study Area during 2007-2011, 381 northern wolffish were caught (see Table 4.4 in Section 4.3.7). Most of the northern wolfish were caught in the southern part of the Study Area at a variety of depths but catches also occurred in NAFO Divisions 2G and 2H to the north (see Figure 4.37 in Section 4.3.7).

Spotted Wolffish

The life history of the spotted wolffish is very similar to that of the northern wolffish except that it seldom inhabits the deepest areas used by the northern wolffish. Although spotted wolffish have been caught at depths ranging from 56 to 1,046 m, the observed densest concentrations occur between 200 and 750 m at water temperatures of 1.5 to 5°C. During 1980-1984, spotted wolffish were most concentrated on the northeast Newfoundland and Labrador shelf and banks, the southwest and southeast slopes of the Grand Banks, along the Laurentian Channel, and in the Gulf of St. Lawrence. Between 1995 and 2003, the area occupied and density within the area was considerably reduced compared to results of earlier surveys. As with northern wolffish, spotted wolffish also inhabit a wide range of bottom substrate types, including mud, sand, pebbles, small rock and hard bottom, with highest concentrations observed over sand and shell hash in the fall, and coarse sand in the spring (Kulka et al. 2007).

Prey of spotted wolffish are primarily benthic (>75%), typically including echinoderms, crustaceans, and molluscs associated with both sandy and hard bottom substrates. This species is referred to as an echinoderm specialist (i.e., benthivore) (DFO 2011d). Fish also constitutes part of the spotted wolffish diet (<25%). Tagging studies indicate the spotted wolffish migrations are local and limited. Spotted wolffish reproduction includes internal fertilization. In Newfoundland and Labrador waters, this typically occurs in July and August on stony bottom. Cohesive masses of eggs are deposited in crevices, remaining unattached to the substrate. After an undetermined incubation time, pelagic larvae hatch and start to feed on crustaceans, fish larvae and fish eggs within a few days of hatching (Kulka et al. 2007).

During DFO RV surveys conducted in the Study Area during 2007-2011, 524 spotted wolffish were caught (see Table 4.4 in Section 4.3.7). Spotted wolfish catches were most concentrated in the central and southern parts of the Study Area but catches were also made in NAFO Division 2G to the north (see Figure 4.38 in Section 4.3.7).

Atlantic Wolffish

Atlantic wolffish is primarily demersal and inhabit shallower areas than the northern and spotted wolffishes. This species has been observed from near shore to a depth of 918 m at water temperatures ranging from -1 to 10°C, but are most common at water depths of 150 to 350 m with water temperatures ranging from 1.5 to 4°C. During 1980-1984, this species was most concentrated in the same areas as the northern wolffish, with additional concentrations on the southern Grand Banks and the Gulf of St. Lawrence. More recently, the area occupied and density within the area was considerably reduced in the northern part of its confirmed range, but has remained relatively constant in the Gulf of St. Lawrence. Unlike the northern and spotted wolffishes, Atlantic wolffish are often observed by divers close to shore, and they form dense concentrations offshore. During its feeding period, this wolffish species appear to prefer complex reliefs of rocks without algal growth and sand. Shelters in these rock reliefs are typically situated on 15-30° slopes with good water circulation. There is some indication that Atlantic wolffish form colonial settlements during the feeding period (Kulka et al. 2007).

Prey of Atlantic wolffish are primarily benthic (>85%), typically including echinoderms (e.g., sea urchins), crustaceans (e.g., crabs) and molluscs (e.g., scallops) associated with both sandy and hard bottom substrates. This species is referred to as a mollusc specialist (i.e., benthivore) (DFO 2011d). Fish also constitutes part of the spotted wolffish diet (<15%) (e.g., redfish). Migration by Atlantic wolffish is also limited, with seasonal inshore movement in the spring when mature fish are found in areas with water depths <15 m. These wolffish seem to prefer stony bottom substrate for spawning in September and October in Newfoundland and Labrador waters. After internal fertilization, cohesive masses of eggs are deposited in crevices on the bottom, remaining unattached to the substrate. The egg mass is guarded and maintained by the male Atlantic wolffish for the 7 to 9 month incubation time, after which pelagic larvae hatch and commence to feed on crustaceans, fish larvae and fish eggs within a few days of hatching (Kulka et al. 2007).

During DFO RV surveys conducted in the Study Area during 2007-2011, 3,336 Atlantic wolffish were caught (see Table 4.4 in Section 4.3.7). Atlantic wolfish catches were most concentrated in the central and northern parts of the Study Area but catches were also made in NAFO Divisions 2J and 3K to the south (see Figure 4.39 in Section 4.3.7).

4.6.1.7 Fin Whale

Fin whales are distributed throughout the world's oceans, but are most common in temperate and polarregions (Jefferson et al. 2008). Fin whales were heavily targeted by commercial whalers in Newfoundland and Labrador; the current best estimate for the northwest Atlantic is 3,522 individuals (Waring et al. 2013). They are designated as *special concern* on Schedule 1 of *SARA* and by COSEWIC. Lawson and Gosselin (2009) provided an abundance estimate of 890 fin whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coast; the corrected abundance estimate is 1,555 whales (Lawson and Gosselin, unpublished data).

Fin whales continue to regularly occur in Newfoundland and Labrador waters, particularly during summer months (Labrador Shelf SEA). Fin whales within the Labrador Shelf area mainly occur nearshore (COSEWIC 2005). Based on the DFO cetacean sightings database, 240 fin whale sighting have been made throughout the Study Area from April to December; however, the greatest number of observations occurred in the southwestern portion of the Study Area within the 500-m isopleth during August to November (see Figure 4.42). There was also a single fin whale sighting offshore of Labrador during a summer 2007 aerial survey (Lawson and Gosselin 2009; see Section 4.5). They feed on small schooling fish and krill and tend to be found in areas where these prey concentrate, such as in areas of upwelling, shelf breaks, and banks (COSEWIC 2005). Fin whales may stay on the Labrador shelf year-round or migrate to warmer mid-latitude waters, but little information on winter habitat is currently available.

4.6.1.8 Sowerby's Beaked Whale

The Sowerby's beaked whale is designated as *special concern* (Schedule 1) by *SARA* and COSEWIC. It is a small beaked whale found only in the north Atlantic, primarily in deep, offshore temperate to subarctic waters (COSEWIC 2006d). It is the most northerly distributed of the *Mesoplodon* spp., with all but one record occurring in the northwest Atlantic between New England and Labrador (MacLeod 2000; MacLeod et al. 2006). COSEWIC (2006d) noted that mesoplodonts observed in Davis Strait during summer 2003 were likely Sowerby's beaked whales. There are an unknown number of Sowerby's beaked whales in the north Atlantic, but they are only rarely encountered offshore of eastern Newfoundland and Labrador. They are most often observed in deep water, along the shelf edge and slope. One sighting of four individuals was made during a seismic survey in Orphan Basin in 2005 (Moulton et al. 2006a). Based on the DFO cetacean sightings database, there was one sighting of an unidentified *Mesoplodon* sp. within the Study Area during August. It is unclear if Sowerby's beaked whales are uncommon or poorly surveyed because of their deep-diving behaviour, small size, and offshore habitat. Observations most frequently occur during the summer, but observer effort is considerably increased during this season in offshore areas northeast of Newfoundland and Labrador (COSEWIC 2006d). Based on analysis of stomach contents, they appear to prefer mid- to deep-water fish and squid (MacLeod et al. 2003; Pereira et al. 2011). Despite the paucity of confirmed sightings, Sowerby's beaked whales may occur in low densities in deep areas offshore of Labrador.

4.6.1.9 Polar Bear

The polar bear has a circumpolar distribution in the Arctic Ocean and ranges from Newfoundland to Ellesmere Island in eastern Canada (Jefferson et al. 2008). Thirteen sub-populations are recognized, including the Davis Strait population that ranges from southern Baffin Island, Davis Strait, southwestern Greenland, along Labrador, and to northeastern Newfoundland (COSEWIC 2008c). Within Canada, Greenland, and Alaska, there are an estimated 15,500 individuals (COSEWIC 2008c), including ~2,158 bears in the Davis Strait population (Peacock et al. 2013). Polar bears are designated as *special concern* under Schedule 1 of *SARA* and by COSEWIC. Polar bears are generally more common in northern Labrador, particularly on pack ice during winter and spring, but were perhaps more common historically in southern Labrador prior to human encroachment and harvest (see Labrador Shelf SEA). However, elders from Nain, Labrador have indicated an increase in polar bears as well as a shoreward shift in distribution in recent years, potentially as a response to climate change (COSEWIC 2008c). Ringed seals are the primary prey of polar bears, and the polar bear's distribution is closely associated with that of seals. Polar bears are found in sea ice areas along the coast from early winter until breakup in late spring, when they retreat to coastal areas until sea ice returns in the fall. Pregnant females excavate dens in the late fall, typically close to the coast, and cubs are born between November and January (COSEWIC 2008c).

4.6.1.10 Harlequin Duck

The eastern North American population of Harlequin Duck is designated *special concern* by COSEWIC and is listed as such on Schedule 1 of *SARA*. This species nests along clear, swiftly flowing streams in eastern Siberia, Alaska, Yukon, and Mackenzie District of the Northwest Territories south to Idaho and Oregon, and in eastern North America from northern Québec, Labrador, and western Newfoundland to northern New Brunswick (Robertson and Goudie 1999). In Labrador it nests from Navchak Bay to Hopedale, in watersheds between Hopedale and Groswater Bay, and watersheds along the Churchill River (Robertson and Goudie 1999). During winter the western North American population is distributed along coastlines from the Aleutian Islands to Oregon (Robertson and Goudie 1999). More than half of the eastern North America population winters along coasts from Maine southward to Maryland: the remainder winter along southwestern Greenland (Robertson and Goudie 1999). Breeding pairs south of Hamilton Inlet appear to moult along the Labrador coast at sites such as the Gannet Islands off Table Bay, Tumbledown Dick Island and Stag Islands in Groswater Bay, and St. Peter's Bay in southern Labrador, whereas many of the pairs breeding north of Hamilton Inlet stage along the adjacent coastline and cross the Study Area in late June to mid-July to moult and over-winter in southwestern Greenland (Chubbs et al. 2008; Trimper et al. 2008). The number of Harlequins moulting at the Gannet Islands increased from 180 to 248 from 1999 to 2003 (Trimper et al. 2008). At Tumbledown Dick Islands and Stag Islands about 50 and 60 moulting individuals have been counted (Gilliland et al. 2002). A total of 28 have moulted around the islands in the northeast Groswater Bay IBA (Robertson et al. 2002). Around the islands in the St. Peter Bay 30 to 72 moulting individuals have been counted (Trimper et al. 2008). A total of 159 moulting individuals have been counted at the north shore of Northern Groais Island (Gilliland et al. 2002). As with other sea ducks, the Harlequin Duck has delayed maturation, low annual production, variable breeding success, and is long-lived (Goudie et al. 1994, Robertson and Goudie 1999, Thomas and Robert 2001). These traits make populations susceptible to negative impacts when adult mortality is high, such as may occur in concentrated moulting or wintering birds coming in contact with an oil spill. In addition, strong natal philopatry to wintering areas impedes recolonization of habitat where birds have been extirpated (Robertson et al. 2000). A management plan has been finalized for the eastern population of this species (Environment Canada 2007).

4.6.1.11 Barrow's Goldeneye

The population of Barrow's Goldeneye in eastern North America is designated *special concern* by COSEWIC and is listed on Schedule 1 of *SARA*. Unlike the Common Goldeneye, it has a restricted distribution. The Barrow's Goldeneye breeds in Iceland, the interiors of Alaska, the Yukon, British Columbia, and Alberta, but the breeding grounds of the eastern North American population have only recently been identified — in the Laurentian Highlands of east-central Quebec (Eadie et al. 2000). There are unconfirmed reports that this species has nested in Labrador. On the breeding ground, Barrow's Goldeneye nests around freshwater lakes and ponds where it feeds mostly on aquatic insects. It winters along the Pacific coast of Alaska and British Columbia in western North America, and in eastern North America is found in scattered areas of the coastlines of Atlantic Canada and the eastern

U.S., with the largest concentrations along the St. Lawrence Estuary (Eadie et al. 2000, Robert et al. 2002). Wintering birds have not been found along the Labrador coastline (Eadie et al. 2000). During winter it feeds over hard substrates primarily on mollusks. In the eastern North American population, the data on the moult migration of males are few, but most males appear to migrate to protected bays and inlets along the east coast of Hudson Bay, Ungava Bay and the Labrador coast, and the remainder to freshwater lakes in northern Quebec (Savard and Dupuis 1999, Robert et al. 2000). Moulting birds along the Labrador coast are mainly found from Makkovik to Ramah Bay (including Nain Bight, Hebron Fjord, and Primo Inlet) but also at Cape White Handkerchief, Rowsell Bay (Savard and Dupuis 1999, Robert et al. 2000; 2002). Males arrive in these moulting areas from mid-June to the end of July and depart from mid-September to late October, with peak numbers in August (Robert et al. 2002). This species has low lifetime reproductive but is long-lived and has high adult survival, so population is size is sensitive to adult mortality (Eadie et al. 2000). The species has a small global population size and there is little information on the breeding, moulting, and critical wintering areas of the eastern North American population. A management plan has been finalized for the eastern population of this species (Environment Canada 2013d).

4.7 Sensitive Areas

There are a variety of regulatory frameworks that deal directly or indirectly with sensitive areas in Newfoundland and Labrador. Marine fisheries are administered by DFO through the federal *Fisheries Act*. Management of marine mammals, including species at risk, is controlled by DFO under the *Marine Mammals Regulations* of the *Fisheries Act*. All species at risk are administered under the *Species at Risk Act* (2002) which lists the species and provides measures to protect those species. Migratory birds, including species at risk, are solely or jointly managed (depending on the species) between Canada and the US through the CWS branch of Environment Canada. Current legislation and agreements regarding migratory birds include the Convention for the Protection of Migratory Birds (1916), *Migratory Birds Convention Act* and the North American Waterfowl Management Plan (CWS and United States Fish and Wildlife Services (USFWS) 1986; CWS, USFWS, and SEMARNAP 1998). Waterfowl are managed according to “flyways” denoting wintering and summering habitat connected by international migration corridors. The Labrador region falls within the Atlantic Flyway. Wildlife will be co-managed with the Nunatsiavut Government according to their recent agreement.

Provincial parks are administered under the *Provincial Parks Act* (1970), while sensitive areas such as ecological reserves are administered under the provincial *Wilderness and Ecological Reserves Act* (1980). National parks are administered under the *National Parks Act* (2000) and National Marine Conservation Areas (NCMAs) is established under the *Canada National Marine Conservation Areas Act* (2002). Marine Protected Areas (MPAs) are administered under the *Oceans Act* (1996) which includes *Gilbert Bay Marine Protected Regulations* (2005) outlining the regulations applicable to Gilbert Bay, a marine protected area within Labrador coastal waters.

Sensitive areas that occur at least partially within the Study and/or Project Areas include the following (based on Husky EA (Stantec 2010)) (Figure 4.45):

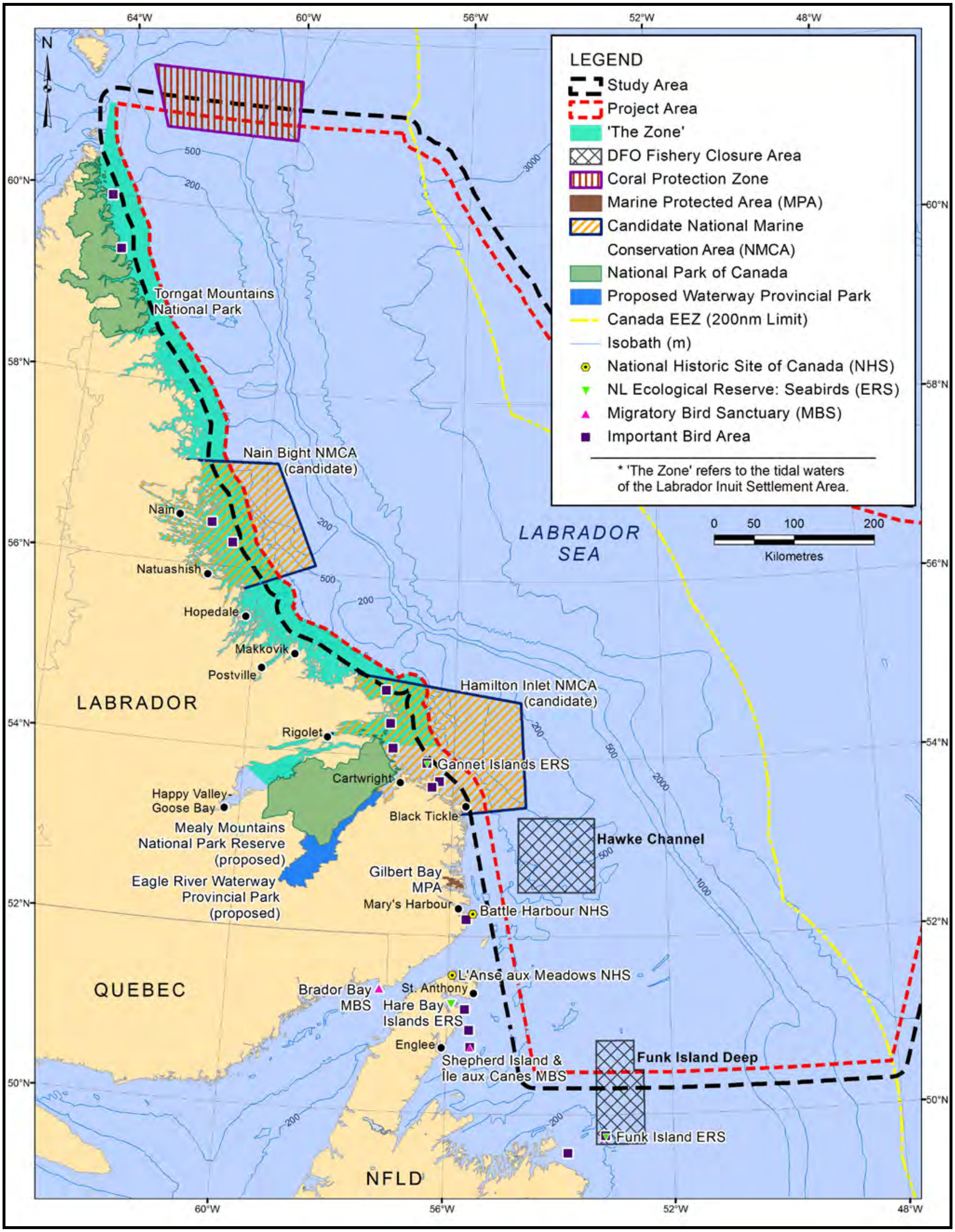


Figure 4.45 Sensitive Areas Overlapping or Proximate to the Project and/or Study Areas.

- Hawke Channel Fishery Closure Area;
- Funk Island Deep Fishery Closure Area;
- Coral Protection Zone;
- Nain Bight Candidate National Marine Conservation Area (NMCA);
- Hamilton Inlet Candidate National Marine Conservation Area (NMCA); and
- The Zone.

Sensitive areas that occur proximate to the Study Area include the following (based on Husky EA (Stantec 2010)) (see Figure 4.45):

- Cabot Island Funk Island Fishery Closure Area;
- Gilbert Bay Marine Protected Area (MPA);
- Battle Harbour National Historic Site (NHS);
- Gannett Islands Ecological Reserve;
- Fourteen (14) Important Bird Areas (IBAs);
- Torngat Mountains National Park;
- Mealy Mountains National Park (proposed); and
- Eagle River Waterway Provincial Park (proposed).

As noted in the Labrador Shelf SEA, the banks and channels of the Labrador Shelf are relatively high in terms of productivity and species diversity. It should also be noted that important areas within the Study Area, though not specifically designated, may be important areas for corals, spawning, nursing, rearing, and/or migratory areas, and areas of traditional harvesting activities.

Table 4.14 provides information on each of the sensitive areas identified above.

Table 4.14 Sensitive Areas Overlapping or Proximate to the Project and/or Study Areas

Sensitive Area	Description
Overlapping Project and/or Study Area	
Funk Island Deep Fishery Closure Area	Its general purpose is to protect Atlantic cod and snow crab, and their habitats by reducing bottom damage by bottom contact gear. Approximately half of this closure area overlaps with the southern Study Area. It has an area of 7,923 km^2. This area was closed by DFO to gillnet fishing year-round since 2002. This area was closed by DFO to inshore shrimp trawling year-round since 2005. This area has voluntary closure to large vessel shrimp fleet.
Coral Protection Zone	A portion of this area overlaps with both the Project Area and the Study Area The focus of this area is coral. This area is a voluntary fishery closure area.
Nain Bight Candidate National Marine Conservation Area	This candidate area extends seaward from Nain to include part of Nain Bank, and has substantial overlap with the Study and Project Areas.

Sensitive Area	Description
	There is increased biological productivity in the area. There is diverse and abundant avifauna, including numerous alcid species, Eider Ducks and Harlequin Ducks.
Hamilton Inlet Candidate National Marine Conservation Area	This candidate area extends seaward from Nain to include part of Nain Bank, and has substantial overlap with the Study and Project Areas. There is increased biological productivity in the area. There is diverse and abundant avifauna, including numerous alcid species, Eider Ducks and Harlequin Ducks.
The Zone	The Study Area extends 14 km into the Zone. The Zone was established under the *Labrador Inuit Land Claims Agreement* (2005). It encompasses 48,690 km^2 of ocean extending to the limit of Canada's territorial sea (Government of Newfoundland and Labrador 2012). A co-management board (The Torngat Joint Fisheries Board) appointed by the Government of Canada, Government of Newfoundland and Labrador, and the Nunatsiavut Government will be established as the primary body for making recommendations to governments on the conservation and management of fish in this area. The provincial and federal governments will retain the overall responsibility for the conservation and management of the fishery in this area. Within the Zone, Labrador Inuit will have the right to harvest fish and marine mammals for Inuit food, social and ceremonial purposes. If conservation requires that fishing by Inuit be limited, the limits will be set by the federal minister based on a recommendation of the Nunatsiavut Government. Inuit will be guaranteed a percentage of new or additional commercial fishing licences for specified species within and in waters adjacent to the Zone.
Proximate to Study and Project Area	
Hawke Channel Fishery Closure Area	Although surrounded by the Project Area, the Hawke Channel Fishery Closure Area does not overlap with the Project Area. Its general purpose is to address impacts of trawls and gillnets on snow crab and Atlantic cod. It has an area of 8,575 km^2. Initially only 1,372 km^2 in 2002 but expanded in 2003. This area was closed by DFO to gillnet fishing and trawling year-round since 2002.
Cabot Island-Funk Island Fishery Closure Area	The Cabot Island-Funk Island Fishery Closure Area is at least 28 km from the Project Area. It has an area of 5,741 km^2. This area is closed to otter trawling between 1 May and 30 November
Gilbert Bay Marine Protected Area	The Gilbert Bay MPA is 39 km from the Project Area.

Sensitive Area	Description
	This MPA has an area of 47 km^2. This MPA was designated in 2005. The focus of this MPA is a resident population of Atlantic cod that is genetically distinct from other Labrador cod.
Battle Harbour National Historic Site	The Battle Harbour National Historic Site is 34 km from the Project Area. Mercantile saltfish premises first established here in 1770s developed into a thriving community that was known as the ‘Capital of Labrador’.
Gannett Islands Ecological Reserve	The Gannett Islands Ecological Reserve is 22 km from the Project Area. It is the largest razorbill colony in North America and largest seabird colony in Labrador
Important Bird Areas	The closest IBA to the Project Area is 19 km away. There are 14 IBAs in the vicinity of the Study Area. See Section 4.4 for details.
Torngat Mountains National Park	The Torngat Mountains National Park is 22 km from the Project Area.
Mealy Mountains National Park (proposed)	The proposed Mealy Mountains National Park is 53 km from the Project Area.
Eagle River Waterway Provincial Park (proposed)	The proposed Eagle River Waterway Provincial Park is 91 km from the Project Area.

5.0 Effects Assessment

Two general types of effects are considered in this document:

1. Effects of the environment on the Project; and
2. Effects of the Project on the environment, particularly the biological environment.

Methods of effects assessment used here are comparable to those used in recent east coast offshore seismic (e.g., LGL 2007, 2010) and drilling EAs (e.g., LGL 2006). These documents conform to the (now repealed) *Canadian Environmental Assessment Act* (*CEAA*) of 1992 and its associated Responsible Authority's Guide and the CEA Agency Operational Policy Statement (OPS-EPO/5-2000; CEA Agency 2000). Cumulative effects are incorporated within the procedures in accordance with *CEAA* (CEA Agency 1994) as adapted from Barnes and Davey (1999).

5.1 Scoping

The C-NLOPB provided a draft (dated 5 November 2013) and a final (dated 21 November 2013) Scoping Document for the Project which outlined the factors to be considered in the assessment. In addition, various stakeholders were contacted for input (see below, Section 5.2). Another aspect of scoping for the effects assessment involved reviewing relevant and recent EAs that were conducted in Newfoundland and Labrador waters including (but not limited to) the MKI Labrador EIS (RPS 2011), the Chevron Labrador seismic EA (LGL 2010), the Labrador Shelf infill-extension seismic EA (Canning and Pitt 2007), and the Labrador Shelf SEA (Sikumiut 2008). Reviews of present state of knowledge on the effects of seismic as well as the biological setting of the Study Area were also conducted.

5.2 Consultations

5.2.1 MKI Consultation Policy and Approach

MKI's policy for consultation on marine seismic projects is to consult (primarily through in-person meetings) with relevant agencies, stakeholders and rights-holders (e.g., beneficiaries) during the pre-survey and survey stages. MKI will initiate meetings and respond to requests for meetings with the interested groups throughout this period. After the survey is complete MKI will conduct follow-up discussions. The same approach would be followed before, during and after any survey work for 2014-2018. In summary, each year MKI will meet as follows:

- Before the survey is permitted: to provide Project information, gather information about area fisheries, determine issues or concerns, discuss communications and mitigations;
- After the survey is permitted, during the survey activities: to report on the progress of the survey, to determine if any survey-related issues have come up, and to discuss potential solutions; and
- After the survey is complete: to provide an up-date on the Project, hear if there were any issues, and to present results of the MMO and FLO reports.

The in-person meetings include the direct participation of MKI's Project Manager and Environmental Manager, and other issue-specific personnel support as needed.

5.2.2 Program Consultations

The program consultations were organized and coordinated by Nexus Coastal Resource Management. In addition to Nexus personnel, representatives of MKI and LGL also attended some of the consultation meetings. In-person meetings were held in both Labrador and Newfoundland. The consultation meetings were conducted during 2-13 December 2013, and 12-17 January 2014. Stake holder meetings in St. John's took place between December 2nd and December 5th 2013. During the in-person meetings, PowerPoint presentations with details about the proponents and the proposed Project were given. The presentations included provisional maps of the proposed 2014 survey lines and the Project and Study Areas as well as several maps showing fish-harvesting locations (key species) in relation to those lines. Nexus/MKI recorded information about commercial fish harvesting details, including Traditional Environmental/Ecological Knowledge (TEK) related to the Project, and noted any issues, concerns and advice about mitigations (particularly avoiding concurrent fisheries) and communications. Questions were invited at all times. Information packages were provided before or at the meetings (including additional copies for wider distribution), as were coordinates for locating the full Project Description through the C-NLOPB Registry. Some agencies and groups did not request in-person meetings but they were provided information packages and invited to comment. Appendix 1 contains a table that provides details of the consultations, including stakeholder group name, names of contacts within that group, details of the engagement, comments/concerns/requests, and responses to these. Where possible, particular sections of the EA are referred to in the responses.

Stakeholder groups that were engaged include the following (in the order they appear in Appendix 1):

- Cartwright Fishers Committee;
- Labrador Fishermen's Union Shrimp Company;
- Cartwright Town Council;
- Torngat Secretariat;
- Torngat Fish Producers Cooperative;
- Town of Happy valley-Goose Bay;
- Nunatsiavut Government: Department of Lands and Natural Resources, and the Department of Education and Economic Development;
- Innu Nation;
- Nunacor and NunatuKavut Department of Natural Resources and Environment;
- Hopedale Inuit Community Government;
- L'Anse au Loup Harbour Authority;
- L'Anse au Loup Town Council;
- Makkovik Inuit Community Government;
- Nain Inuit Community Government;
- Innu Nation and Mushuau Innu Band;
- Town of Northwest River;
- Sivunivut Inuit Community Corporation;

- Postville Inuit Community Government;
- Rigolet Inuit Community Government;
- Transport Canada;
- Environment Canada;
- Fisheries and Oceans Canada;
- Newfoundland and Labrador Department of Fisheries and Aquaculture;
- City of St. John's;
- St. John's Port Authority;
- Nature Newfoundland and Labrador;
- Fish, Food and Allied Workers Union (FFAW)/One Ocean;
- Newfoundland Association of Seafood Producers;
- Ocean Choice International (OCI);
- Gulf Shrimp Limited and Quinlan Brothers;
- St. Anthony Port Authority;
- St. Anthony Basin Resources Inc.; and
- St. Anthony Town Council.

As has been the case for other seismic project assessments in the Newfoundland and Labrador sector, the most consistent issue raised during the consultations related to potential conflict with the commercial fisheries – specifically ensuring that the survey does not interfere with or otherwise impact harvesting success (Section 4.3 describes the important fisheries in the Study and Project Areas). Consequently, fish harvester groups and agencies were a key focus of the consultations.

Other topics of discussion included potential effects on marine biota, employment opportunities, the importance of ongoing communication between the Operator and potentially affected groups,

5.2.3 Follow-Up

As described above, MKI will conduct follow-up discussions with all interested groups during and after the survey. This would include reporting on the progress of the survey, monitoring the effectiveness of the mitigations, determining if any survey-related issues had arisen, and presenting monitoring results.

5.3 Valued Environmental Components

The Valued Environmental Component (VEC) approach was used to focus the assessment on those biological resources of most potential concern and value to society.

VECs include the following groups:

- rare or at risk species or habitats (as defined by COSEWIC and *SARA*);
- species or habitats that are unique to an area, or are valued for their aesthetic properties;
- species that are harvested by people (e.g., commercial fish species); and
- species that have at least some potential to be affected by the Project.

VECs were identified based on previous EAs conducted in the Labrador Sea, Jeanne d'Arc Basin and Orphan Basin areas (see Section 5.0), the scoping document received from the C-NLOPB, DFO and Environment Canada comments, and consultations with other stakeholders and agencies.

The VECs and the rationale for their inclusion are as follows:

- **Fish and Fish Habitat** with emphasis on the three principal commercial species: (1) northern shrimp, (2) snow crab, and (3) Greenland halibut (turbot), and *SARA* species (e.g., wolffishes). It is recognized that there are many other fish species, commercial or prey species, that could be considered but it is LGL's professional opinion that this suite of species captures all of the relevant issues concerning the potential effects of seismic surveys on important invertebrate and fish populations of the Project Area.

- **Fisheries** (primarily commercial harvesting) were the most referenced VEC of concern during consultations. While they are directly linked to the fish VEC above in that an impact on fish could affect fishery success for that species, the greater concern expressed was interference with fishing, either through the sound produced by the array (scaring fish from fishing gear) or interference with fixed fishing gear (caused by the ships or the seismic streamer). All fisheries are considered where relevant (i.e., commercial, subsistence/ ceremonial, recreational). The commercial fishery is a universally acknowledged important element in the society, culture, economic and aesthetic environment of Newfoundland and Labrador. Also included in this VEC are research surveys (which are conducted using types of fishing gear), those conducted by both DFO and industry. This VEC is of prime concern from both a public and scientific perspective, at local, national and international scales.

- **Seabirds** with emphasis on those species most sensitive to seismic activities (e.g., deep divers such as murres) or vessel stranding (e.g., petrels), and *SARA* species (e.g., Ivory Gull). Newfoundland and Labrador waters support some of the largest seabird colonies in the world, and the Labrador Shelf area hosts large populations during all seasons. They are important socially, culturally, economically, aesthetically, ecologically and scientifically. This VEC is of concern from both a public and scientific perspective, at local, national and international scales.

- **Marine Mammals** with emphasis on those species potentially most sensitive to low frequency sound (e.g., baleen whales) or *SARA* species (e.g., blue whale). Whales and seals are key elements in the social and biological environments of Newfoundland and Labrador. The economic and aesthetic importance of whales is evidenced by the large number of tour boats that feature whale watching as part of a growing tourist industry. This VEC is also of concern from both a public and scientific perspective, at local, national and international scales.

- **Sea Turtles**, although very uncommon in the Study Area, are mostly *threatened* and *endangered* on a global scale, and the leatherback sea turtle which forages in eastern

Canadian waters is considered *endangered* under *SARA*. While they are of little or no economic, social or cultural importance to Newfoundland and Labrador, their *endangered* status warrants their inclusion as a VEC.

- **Species at Risk** are those designated as *endangered* or *threatened* on Schedule 1 of *SARA*. In addition, species listed as *special concern* have been considered here as well. All species at risk in Newfoundland and Labrador offshore waters are captured in the VECs listed above. However, because of their special status, they are also discussed separately.

- **Sensitive Areas** are areas considered to be unique due to their ecological and/or conservation sensitivities. Examples of sensitive areas in the Study Area include Ecologically and Biologically Significant Areas (EBSAs) and coral conservation areas.

5.4 Boundaries

For the purposes of this EA, the following boundaries are defined.

5.4.1 Temporal

The temporal boundaries of the Project are 1 May to 30 November.

5.4.2 Project Area

The 'Project Area' is defined as the area within the C-NLOPB jurisdiction where seismic data could be acquired and all vessel movements with deployed equipment will occur (see Figure 1.1). The coordinates of the Project Area (WGS84, unprojected geographic coordinates) are presented in Table 5.1. The western boundary of the Project Area is 20 km offshore of The Zone.

Table 5.1 Coordinates of the Project Area Corners (WGS84, unprojected geographic coordinates).

Project Area 'Corner'	WGS84 (Decimal Degrees)	
	Latitude (°N)	Longitude (°W)
Northwest *	61.000	-64.253
Northeast	61.000	-57.587
Southwest	50.481	-54.424
Southeast	50.463	-48.130
Eastern extent	55.144	-45.187

Notes:
* coincident with northeastern tip of 'The Zone'

5.4.3 Affected Area

The 'Affected Area' varies according to the specific vertical and horizontal distributions and sensitivities of the VECs of interest and is defined as that area within which effects (physical or important behavioural ones) have been reported to occur.

5.4.4 Study Area

An area larger than (i.e., 20 km beyond) the Project Area that encompasses any potential effects (including those from accidental events) reported in the literature.

5.4.5 Regional Area

The regional boundary is the boundary as defined in the Labrador Shelf SEA Area and is retained here for consistency. An exception to this boundary is the inclusion of the major Grand Banks developments when considering cumulative effects.

5.5 Effects Assessment Procedures

The systematic assessment of the potential effects of the Project phase involved three major steps:

1. preparation of interaction (between Project activities and the environment) matrices;
2. identification and evaluation of potential effects including description of mitigation measures and residual effects; and
3. preparation of residual effects summary tables, including evaluation of cumulative effects.

5.5.1 Identification and Evaluation of Effects

Interaction matrices were prepared that identify all possible Project activities which could interact with any of the VECs. The interaction matrices are used only to identify potential interactions; they make no assumptions about the potential effects of the interactions. Interactions were then evaluated for their potential to cause effects. In instances where the potential for an effect of an interaction was deemed impossible or extremely remote, these interactions were not considered further. In this way, the assessment could focus on key issues and the more substantive environmental effects.

An interaction was considered to produce a potential effect if it could change the abundance or distribution of VECs, or change the prey species or habitats used by VECs. The potential for an effect was assessed by considering:

- the location and timing of the interaction;
- the literature on similar interactions and associated effects (seismic EAs and monitoring reports for offshore Newfoundland and Labrador as well as Nova Scotia);
- when necessary, consultation with other experts; and
- results of similar effects assessments, especially monitoring studies done in other areas.

When data were insufficient to allow certain or precise effects evaluations, predictions were made based on professional judgement. In such cases, the uncertainty is documented in the EA. Effects were evaluated for the proposed seismic survey, which include mitigation measures that are mandatory or have become standard operating procedure in the industry.

5.5.2 Classifying Anticipated Environmental Effects

The concept of classifying environmental effects simply means determining whether they are negative or positive. The following includes some of the key factors that are considered for determining negative environmental effects, most of which are included in the CEA Agency guidelines (CEA Agency 1994):

- negative effects on the health of biota;
- loss of rare or *endangered* species;
- reductions in biological diversity;
- loss or avoidance of productive habitat;
- fragmentation of habitat or interruption of movement corridors and migration routes;
- transformation of natural landscapes;
- discharge of persistent and/or toxic chemicals;
- toxicity effects on human health;
- loss of, or detrimental change in, current use of lands and resources for traditional purposes;
- foreclosure of future resource use or production; and
- negative effects on human health or well-being, including economic well-being, such as fishing income.

5.5.3 Mitigation

Where needed, mitigation measures appropriate for each effect predicted in the matrix were identified (Section 5.6), and the effects of various Project activities were then evaluated assuming that appropriate mitigation measures are applied. Residual effects predictions were made taking into consideration these mitigations.

5.5.4 Evaluation Criteria for Assessing Environmental Effects

Several criteria were taken into account when evaluating the nature and extent of environmental effects. These criteria include (CEA Agency 1994):

- magnitude;
- geographic extent;
- duration and frequency;
- reversibility; and
- ecological, socio-cultural, and economic context.

Magnitude describes the nature and extent of the environmental effect for each activity. Geographic extent refers to the specific area (km^2) affected by the Project activity, which may vary depending on the activity and the relevant VEC. Duration and frequency describe how long and how often a project activity and/or environmental effect will occur. Reversibility refers to the ability of a VEC to return to an equal or improved condition at the end of the Project. The ecological, socio-cultural and economic context describes the current status of the area affected by the Project in terms of existing environmental effects. The Study Area is not considered to be strongly affected by human activities.

Magnitude was defined as:

Negligible	An interaction that may create a measureable effect on individuals but would never approach the value of the 'low' rating. Rating = 0.
Low	Affects >0 to 10 percent of individuals in the affected area (e.g., geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 1.
Medium	Affects >10 to 25 percent of individuals in the affected area (see geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 2.
High	Affects more than 25 percent of individuals in the affected area (e.g., geographic extent). Effects can be outright mortality, sublethal or exclusion due to disturbance. Rating = 3.

Definitions of magnitude used in this EA have been used previously in numerous offshore oil-related environmental assessments under CEAA. These include assessments of the Chevron Labrador Shelf seismic EA (LGL 2010), Labrador Shelf infill-extension EA (Canning and Pitt 2007), the White Rose Oilfield Comprehensive Study (Husky 2000), the Husky Jeanne d'Arc Basin exploration drilling EAs and update (LGL 2002, 2005a, 2006), the Husky Jeanne d'Arc Basin 3-D seismic EA and update (LGL 2005b; Moulton et al. 2006b), the StatoilHydro Jeanne d'Arc Basin area seismic and geohazard program EA (LGL 2008), and the ConocoPhillips Laurentian Sub-Basin exploration drilling EA and supplement (Buchanan et al. 2006; LGL 2009a), and seismic EA (LGL 2009b).

Durations are defined as:

1 = <1 month
2 = 1 – 12 month
3 = 13 – 36 month
4 = 37 – 72 month
5 = >72 month

Short duration can be considered 12 months or less, and medium duration can be defined as 13 to 36 months.

5.5.5 Cumulative Effects

The cumulative effects assessment is consistent with the principles provided in the CEAA "Cumulative Effects Practitioner's Guide" (Hegmann et al. 1999) and the CEA Agency Operational Policy Statement on addressing cumulative effects (CEA Agency 2007). Projects and activities considered in the cumulative effects assessment included other human activities in Newfoundland and Labrador offshore waters, with emphasis on the Regional Area of the Labrador Shelf area.

- Survey program within-project cumulative impacts. For the most part, and unless otherwise indicated, within-project cumulative effects are fully integrated within this assessment. Note that the seismic lines for the 2014 program will be long and widely spaced with occasional crossing points, effectively resulting in 'one time' exposures of biota and fishing grounds to maximum energy from the discharging airguns.
- Existing offshore oil developments in Newfoundland and Labrador: Hibernia (GBS platform), Terra Nova FPSO, and White Rose FPSO;
- Other offshore oil exploration activity (particularly seismic surveys and exploratory drilling as outlined on the C-NLOPB website). Offshore oil and gas industry projects currently listed on the C-NLOPB public registry (as viewed 29 January 2014) for offshore Labrador include: GXT's seismic, gravity, and magnetic survey for the Labrador Shelf, 2013-2015; Husky Energy's Labrador shelf seismic, 2009-2017; Chevron's Labrador Seismic Program, 2010-2017. In addition, ARKex Ltd and TGS-NOPEC have a Labrador Sea Gravity Gradient Survey planned for 2014-2018.
- Commercial fisheries;
- Marine transportation (tankers, cargo ships, supply vessels, naval vessels, fishing vessel transits, etc.); and
- Hunting activities (marine birds and seals).

5.5.6 Integrated Residual Environmental Effects

Upon completion of the evaluation of environmental effects, the residual environmental effects (effects after project-specific mitigation measures are imposed) are assigned a rating of significance for:

- each project activity or accident scenario;
- the cumulative effects of project activities within the Project; and
- the cumulative effects of combined projects in the Labrador Sea.

The last of these points considers all residual environmental effects, including project and other-project cumulative environmental effects. As such, this represents an integrated residual environmental effects evaluation.

The analysis and prediction of the significance of environmental effects, including cumulative environmental effects, encompasses the following:

- determination of the significance of residual environmental effects;
- establishment of the level of confidence for prediction; and
- evaluation of the scientific certainty and probability of occurrence of the residual impact prediction.

Ratings for level of confidence, probability of occurrence, and determination of scientific certainty associated with each prediction are presented in the table of residual environmental effects. The guidelines used to assess these ratings are discussed in detail in the sections below.

5.5.7 Significance Rating

Significant environmental effects are those that are considered to be of sufficient magnitude, duration, frequency, geographic extent, and/or reversibility to cause a change in the VEC that will alter its status or integrity beyond an acceptable level. Establishment of the criteria is based on professional judgment, but is transparent and repeatable. In this EA, a *significant* effect is defined as:

> *Having a high magnitude; or medium magnitude for a duration of greater than one year and over a geographic extent greater than 100 km^2*

An effect can be considered *significant*, *not significant*, or *positive*.

5.5.8 Level of Confidence

The significance of the residual environmental effects is based on a review of relevant literature, consultation with experts, and professional judgment. In some instances, making predictions of potential residual environmental effects is difficult because of the limitations of available data or data gaps. Ratings are therefore provided to indicate, qualitatively, the level of confidence for each prediction.

5.5.9 Determination of Whether Predicted Environmental Effects are Likely to Occur

As per other EAs (e.g., LGL 2010; LGL and GXT 2013), the following criteria for the evaluation of the likelihood of any predicted significant effects are used.

- probability of occurrence; and
- scientific certainty.

It should be noted that these two criteria are used only for predictions of significant effects.

5.5.10 Follow-up Monitoring

Because any effects of the Project on the environment will be relatively short-term and transitory, there is no need to conduct follow-up monitoring. However, there will be some monitoring (described below in the Mitigations sections) during the course of the Project, and if these observations indicate evidence of an anticipated effect on a VEC or an accidental release of fuel, then the need for follow-up monitoring and other actions will be assessed in consultation with the C-NLOPB.

5.6 Mitigation Measures

The effects assessments that follow in this chapter (in Sections 5.8–5.11) consider the potential effects of the Labrador Sea Seismic Program in light of the specific mitigation measures that will be applied for this Project in this environment. The purpose of these measures is to eliminate or reduce the potential impacts that might affect the area VECs (as identified in Section 5.3). MKI recognizes that the careful and thorough implementation of, and adherence to, these measures will be critical for ensuring that the Project does not result in unacceptable environmental consequences.

This section details the various measures that will be established and applied for this Project. Many of these are specially tailored to this program, while others are founded in regulations, guidelines, or "best environmental practices". Collectively, they are based on or take guidance from several sources, including:

- Discussions and advice received during consultations for this Project (Section 5.2 and Appendix 1), and for other relevant EAs
- The C-NLOPB Scoping Documents, and the Environmental Planning, Mitigation and Reporting guidance in Appendix 2 of the Board's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012)
- DFO's *Statement of Practice with respect to the Mitigation of Seismic Sound in the Marine Environment*
- National and international acts, regulations or conventions, such as the *Fisheries Act* and Regulations, *International Convention for the Prevention of Pollution from Ships* (MARPOL), and International Maritime Organization (IMO) standards.
- Other standards and guidance, such as the One Ocean *Protocol for Seismic Survey Programs in Newfoundland and Labrador* (2013), and the Joint Nature Conservation Committee (JNCC) *Guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys* (2010)
- Industry best practices
- Expert judgement/experience from past surveys

The mitigations that follow are organized under principal categories, that is (1) Survey Layout and Location; (2) Communications and Liaison; (3) Fisheries Avoidance; (4) Fishing Gear Damage Program; (5) Marine Mammal/ Wildlife Protection; and (6) Pollution Prevention and Emergency Response. Because several of the specific mitigation plans listed under these categories mitigate potential effects on more than one VEC (e.g., seismic array ramp-up/soft start can warn away marine mammals and fish), the relevant VECs are noted for each of the measures.

These measures will be adhered to in each survey year, with adjustments as necessary based on monitoring and follow-up.

1. Survey Layout and Location
(Fish, Fisheries, Marine Mammals/Sea Turtles, Seabirds, Cumulative Effects)

The layout of MKI 2D seismic surveys, with very long and widely spaced lines, means that in most areas (fishing grounds and wildlife habitat) there will be only one-time exposures to Project activities. With the seismic ship travelling at ~8–9 km hour, for any given location, the survey will be 10–20 km away within a few hours and will not return there, except for the crossing points, which will likely be separated by several days or even weeks in timing. Typically, only parts of a few of the lines would pass over any key fishing ground in any program year. The layout of 3D seismic surveys includes more narrowly spaced lines meaning that exposures at any location within the survey area will occur more frequently.

The western limit of the Project Area is about 20 km away at its closest point of approach to the more sensitive coastal areas, though for most lines the distance will be greater than this. The survey will not enter the Nunatsiavut Zone (the Tidal Waters of the Labrador Inuit Settlement Area), or within identified sensitive areas such as Gilbert Bay, Nain Bight and Hamilton Inlet, or the Hawke Channel, which is a highly concentrated fixed-gear fishing area.

2. Communications and Liaison (Fisheries, Science Surveys, Effects of the Environment on the Project, Other Marine Users)

Consultations and discussions for this Project have indicated that frequent, timely and effective communications with fishing industry organizations/participants must be a central part of the fisheries mitigations for the survey. This will work, (1) to ensure that the seismic program does not operate in the area of active fisheries, and (2) to allow the survey to plan its acquisition and proceed in the most efficient way possible in light of concurrent fishing locations.

Information Exchange. Detailed and up-to-date information about the fisheries likely to be active in specific parts of the Project Area at specific times.

Maps of past fish harvesting activities (see Section 4.3 of this EA) are a valuable planning tool, but exact times and locations change somewhat from year to year. To be accurate, the information flow about current fishing activities will need to be a continuing process that is updated as fishing seasons open and close, and as quotas are taken. This information will be accessed through continuing information exchanges with the relevant fishing organizations on a regular basis, including through the mechanisms described below, such as the FFAW Petroleum Information Liaison person, the FLOs, direct contacts with representatives of the Labrador fisheries organizations, and with DFO (for fisheries survey/research information). Operational details of these communications will be finalized with the relevant organizations as the fishing season information and plans are known.

Weekly Status Meetings. MKI will hold weekly update meetings with FFAW and other invited fishery groups throughout the survey. Status maps will be provided at these face-to-face meetings where the past week's acquisition will be reviewed and the expected plan for the upcoming week will be shown and discussed. Minutes of the meeting will be agreed to, and maps and information will be forwarded to other interested parties including, but not limited to, the C-NLOPB, Torngat Fisheries and the Nunatsiavut Government.

Fisheries Liaison Officers (FLOs). The survey will place FLOs on board the seismic ship and picket vessel to communicate with fishing vessels at sea, and relay information to shore as needed (at least two FLOs – one FFAW representative on the seismic vessel and a representative of Inuit/Nunatsiavut interests on the picket vessel). The FLOs are the primary at-sea liaison between the commercial fishing industry and the seismic survey program. In past seismic surveys, FLOs have been very effective for "real time" communications, and to assist the vessel in planning activities in light of current fisheries and fishing gear locations.

As described in the One Ocean Protocol document, "the FLO is tasked with identifying potential at-sea conflicts between fishing and petroleum operations". His/her duties include radio contact with fishing boats in the area, informing fishers nearby about the seismic program (including providing coordinates of planned survey lines), helping to identify fishing plans (when in area, when leaving) and any fishing gear in and near the seismic survey program area so it can be avoided, advising on best course of action to avoid gear and/or other fishing activities, providing information about changes in relevant fisheries, and sending daily reports. The FLO roles and duties - based on past practice, and the One Ocean Protocol document (Section 4.6 FLO Operational Responsibilities, Protocols and Communications) - will include the following:

- While stationed on the seismic vessel and picket vessel, observe activities which may affect the fishing industry and petroleum operations;
- Initiate and maintain radio contact with fishing boats in the area and ensure all communication with fishing vessels is conducted via the FLO;
- Inform fishers nearby about the seismic survey program and provide coordinates and relevant spatial and temporal details;
- Help identify/locate any fishing gear in and near the seismic survey program area so it can be avoided;
- Determine gear type, layout, fishing plans (when in area, when leaving);
- Advise bridge about best course of action to avoid gear and/or fishing activities;
- Serve as initial contact if damaged gear is encountered, verify damage, help identify owners and file an incident report;
- Regularly discuss/convey fisheries related aspects including changes in relevant fisheries, status of species quotas and closures with the onboard Client Representative;
- Report to and confer with the onboard Client Representative regarding operational situations;
- Attend regular operations briefings;
- Attend safety meetings and participate in all relevant Health Safety and Environment (HSE) initiatives and procedures as requested;
- Complete and submit a daily report (electronic/hardcopy) including all observations, communications and meetings attended to the onboard Client Representative; and
- Other duties as identified and approved through consultation with the Operator and Service Provider.

The One Ocean Protocol document also notes that the FFAW/One Ocean Petroleum Industry Liaison (see below) usually prepares a Summary Report on fishing activity for the FLO, including Vessel Monitoring System (VMS) data (see below) before departure on the seismic ship, and continues to provide data to the FLO while on board the seismic vessel on an as-needed basis throughout the program. (see www.oneocean.ca/pdf/2013%20Seismic%20Protocol%20Document.pdf.)

The FLO would also assist if there are any gear damage incidents, as detailed below (Fishing Gear Damage Program).

Single Point of Contact (SPOC.) The role of the shore-based SPOC (as noted in the C-NLOPB Guidelines) is also to facilitate communication between the Project and other marine users, and particularly with fisheries. It has become a standard and effective mitigation for seismic surveys over many years. Typical services provided are as follow:

- Documenting the locations of known vessels for seismic survey operators; provide current information about the locations of seismic activities and fishing activities.
- Regularly update survey vessels on expected locations of fishing activities in their operating areas.
- Assisting with updates to the seismic vessels about changes in relevant fisheries, the progress of species quotas and closures.
- Maintaining additional contact with fishers known to be in active survey areas, directly or through the FLOs, the FFAW, other fishing organizations (such as the Torngat Co-op), and One Ocean.
- Providing information directly to fishers when requested via email or a toll-free phone line maintained for this purpose, based on the best-available data provided to them by the survey.
- Attempting to identify (from CFV id numbers, etc.) any gear located in the water or involved in an incident, as requested by the survey operator.
- Providing survey information to fisheries groups and organizations as required.
- Providing initial contacts (via email and/or the toll free phone number) for any gear damage or loss claims, for the survey's fishing gear compensation program.

SPOC contact information will be broadcast in the Coast Guard Notices to Shipping and communicated to fishers through their organizations. The SPOC will also have duties if there are any gear damage incidents, as detailed below (Fishing Gear Damage Program).

FFAW/One Ocean Petroleum Industry Liaison Contacts. As an initiative of One Ocean (whose mission is to be the medium for information exchange regarding industry operational activities between the fishing and petroleum industries in Newfoundland and Labrador), an arrangement was undertaken for the employment of a Petroleum Industry Liaison (PIL) at the FFAW. The principle objective of the PIL is to ensure the views and concerns of fish harvesters are considered by the offshore petroleum industry and regulators during the development, review and execution of exploration, development and production activities. As such, the PIL is the main contact for petroleum related activities at the FFAW. MKI will utilize the PIL as the key contact for communications between the Project and FFAW-represented fishing interests.

VMS Data. MKI will use VMS data (as available) to understand and help avoid fishing locations and monitor other area marine activities, for logistics and safety. The One Ocean Protocol notes (Section 3.3) that "One Ocean and Fisheries and Oceans Canada (DFO) have an arrangement to provide Vessel Monitoring System (VMS) information to petroleum company members of One Ocean. The VMS program at DFO Newfoundland Region provides a satellite based, near real time, positional tracking system of fishing vessels within the Canadian Exclusive Economic Zone (EEZ), as well as foreign and domestic vessels in the northwest Atlantic Fisheries Organization (NAFO) Regulatory Area outside the 200 nautical mile limit. The ability to access current fisheries data (location of activity) is an important component in the development of operational plans for offshore petroleum related activities. The VMS data generated by DFO consists of coordinates only and does not divulge information of a confidential or sensitive nature." MKI has requested (through One Ocean) that the Project have access to these data.

Notices to Shipping. As a standard procedure and requirement, MKI will file and update NotShips with Canadian Coast Guard Radio/ECAREG advising marine interests of the seismic survey's general operating area for the period covered by the Notice. The Notices will include contact information (email and toll-free phone number) for the survey's Fishing Gear Damage program (see below).

Survey Start-Up Sessions (Project Ships' Crews). MKI places a strong emphasis on informing the at-sea Project personnel on each ship before the survey begins, through several presentation modules, about the environmental issues and concerns in the area in which they will be working, MKI's environmental commitments and regulatory requirements, safety, emergency response, the duties and authority of the MMOs and the FLOs, and the cultural importance and legal status of Aboriginal interests in the area. These sessions will include showing the Canadian Association of Petroleum Producers "Fishery Liaison Officer Video" about the importance of FLO participation in offshore Newfoundland and Labrador exploration activities, as recommended in the One Ocean Protocol. The FLOs, MMOs and MKI Project Manager will be present at these meetings.

Communications Follow-Up. As stated in the Consultations section (Section 5.2), MKI will continue to consult with fisheries (and other) groups before and during the survey (with the active participation of MKI Managers) and will also conduct follow-up discussions with all interested groups after the survey. This would include reporting on the progress of the survey, monitoring the effectiveness of the mitigations and whether any survey-related issues had come up, and (after survey) to present monitoring results.

Other Notifications/Communication. MKI will also follow several procedures/vehicles to facilitate excellent communications for the survey, including the following:

- MKI will employ the latest technology in at-sea communications with and between the survey ships (VHF, HF, Satellite telephone and internet, VMS).
- MKI will provide information (the NotShip text) to the CBC Fisheries Broadcast.

Further details of the communications plans will be developed during MKI's continuing discussions with fisheries representatives.

3. Fisheries Avoidance (Fisheries, Science Surveys)

Avoiding Fishing Areas. To the best of its ability, MKI will avoid active fishing areas during the seismic survey. Specifically, MKI will monitor the location of fishing activities and plan its work away from those grounds when fishing is active there. The communications protocols and methods described above will be the key means for MKI to have the information to plan around and away from fish harvesting. Continuing contact between the Project and fishing group representatives, the on-board FLOs, the SPOC, DFO and the FFAW PIL will be essential for this process.

MKI understands that fish harvesters are not required to move their vessels or gear from the seismic survey program area and will not be told to do so. This information will be clearly communicated at the start-up meetings (described above).

No Gear Deployment Enroute to Survey Area. MKI will not deploy its array or streamer (s) in NL waters during transits to the survey area. In addition, the FLOs will advise the vessel en-route to the area to ensure fishing gear is avoided by the ships during transits.

Avoidance of Fisheries Science Surveys. As with the commercial fishery, those involved in DFO and joint DFO/Industry research surveys will need to exchange detailed locational information with those involved in the seismic surveying. For previous NL surveys, a temporal and spatial separation plan has been implemented (on DFO advice) to ensure that seismic operations did not interfere with the research survey. The procedures, which MKI will follow, involve adequate "quiet time" before the research vessel arrived at its survey location. The avoidance protocol includes a 30 km (16 nm) spatial separation and a 7 day pre-research survey temporal separation.

Use of Scout Vessel. If there is a possibility of the survey program working in areas adjacent to active fishing, MKI will use a vessel (the program picket vessel or an additional smaller vessel) to scout ahead, usually along the planned route of a survey line, to make sure there are no fishing boats or gear in the area. Information about any sightings or radio communications will be relayed back to the survey ship and the FLOs.

Monitoring and Follow-up. As described above, MKI in discussions with relevant groups and mechanisms (such as the FLOs), will continue to monitor the effectiveness of the mitigations during the survey, and consider the results before subsequent year programs.

4. Fishing Gear Damage Program (Fisheries)

Fishing Gear Damage or Loss Compensation Program. A compensation Program will be made available by MKI which is consistent with C-NLOPB guidelines and past practices. This program covers any damage to fishing gear (or vessels) caused by the survey vessels or survey gear, and includes the value of any harvest lost as a direct result of an incident. The Notices to Shipping filed by the vessels for survey work and for transits to and from the survey area will also inform fishers that they may contact the SPOC toll free by telephone or email if they believe that they have sustained survey-related gear damage. This information will also be communicated through other means (e.g., the Newsletter, contact through fisheries organizations).

The SPOC will follow through with any claim received, in communication with MKI, the FLOs and the relevant fisheries organization. For responding to a claim, MKI will follow procedures (which have been employed successfully in the past by other Operators) similar to those outlined in the One Ocean Protocol document.

Damage or Loss Incident Response. The One Ocean Protocol (Section 4.8 and 4.9) describes responses to a gear conflict to be followed on board a Project ship. MKI will have such procedures in place and will respond to them and any subsequent compensation claim. More specifically, in case of an observed or reported incident, one of the FLOs will follow the following procedures:

- If personnel on board the seismic and/or scout vessel observe fishing gear (abandoned, adrift or active) it should be communicated to the FLO. Gear should not be touched/retrieved by project personnel as it is illegal for anyone but the gear owner to move the gear;
- If the picket vessel makes the observation, personnel should record exact positions and name or Canadian Fishing Vessel (CFV) number on the gear (buoy/highflyer) and report it to the FLO;
- The FLO will communicate with fishing vessels in the vicinity in an attempt to identify the gear owner;
- If the CFV number is known, the FLO or the SPOC may be able to identify and contact the owner;
- If identification and contact with the gear owner is successful, the FLO will attempt to determine the plans/schedule of the gear owner with respect to the gear and will encourage the owner to communicate with the FLO at sea;
- If it is not possible to contact the gear owner, the survey ship should attempt to work in another area and return to the location at a later time;
- The FLO will record the information in the daily report and submit it to the on-board Client representative;
- If there is any indication a Project vessel or its equipment made contact with fishing gear it should be communicated to the FLO immediately;
- The FLO will contact the on-board Client Representative and vessel Master as soon as possible after discovery of the incident;
- The FLO will take all reasonable action to prevent any further or continuing damage;
- If possible, photograph the gear or gear debris in the water and after recovery;
- If necessary, secure and retain any of the gear debris;
- Record the incident in the Daily Report;
- File a Fishing Gear Incident Report and give it to the on-board MKI Client Representative; and
- Any contact with fishing gear must be reported immediately even if no damage to the gear has occurred.

Appendix F of the One Ocean Protocol document contains an incident reporting form which meets the requirements of the C-NLOPB Guidelines in assessing a claim. MKI understands that all such incidents must be reported to the C-NLOPB, which maintains a 24-hour answering service at 709-682-4426 for this purpose (709-778-1400 during working hours). Reports on contacts with fishing gear will include the exact time and location of initial contact, loss of contact and a description of any identifying markings on the gear. Incidents will be reported to MKI (Project Manager and Environmental Manager) by their onboard Client Representative; MKI will then report it to the C-NLOPB following the Board's incident reporting guidelines and/or any other requirements.

5. Marine Mammal / Wildlife Protection (Marine Mammals, Sea Turtles, Seabirds, Fish)

The following marine mammal and sea turtle related measures are based on the Statement of Canadian Practice which is also contained in the C-NLOPB Guidelines.

Use of a Safety Zone. The survey (MMOs) will establish a safety zone which is a circle with a radius of at least 500 m as measured from the center of the air source array. It will be used at all times the safety zone is visible when the array is operating and before operations during the pre-start up watch.

Pre-Start Up Watch. A qualified MMO will continuously observe the safety zone for a minimum period of 30 minutes before array start up and maintain a regular watch of the safety zone at all other times the array is active. The array ramp up can only start (or restarting if the array has been inactive for more than 30 minutes) if the full extent of the safety zone is visible and no cetacean, sea turtle or other marine mammal listed as endangered or threatened on Schedule 1 of *SARA* has been seen for at least 30 minutes.

Ramp-Up/Soft Start. If array activation is permitted (based on the pre-watch) a gradual ramp-up (slow increase in power) of the air source array may take place over a minimum of 20 minutes beginning with the activation of a single source element of the air source array, preferably the smallest source element in terms of energy output, and a gradual activation of additional source elements of the air source array will follow until the operating level is reached.

Shut-down of Array. The air source array will be shut down immediately if any of the following is observed by the MMO in the safety zone:

a) a marine mammal or sea turtle listed as endangered or threatened on Schedule 1 of *SARA*; or
b) any other marine mammal or sea turtle that has been identified in an EA process as a species for which there could be significant adverse effects.

Line Changes and Maintenance Shut-Downs. When seismic surveying (data collection) ceases during line changes, for maintenance or for other operational reasons, the air source array(s) will be

a) shut down completely; or
b) reduced to a single source element.

If the air source array(s) is reduced to a single source element, visual monitoring of the safety zone and shut-down requirements will be maintained, and ramp up will be required when seismic surveying resumes.

Operations in Low Visibility. If the full extent of the safety zone is not visible, and the array has been inactive for more than 30 minutes, pre-watch, ramp up and acquisition will not commence until visibility conditions allow.

Seabird Strandings. Any seabirds (most likely Leach's Storm-Petrel) that become stranded on the vessels will be released using the mitigation methods consistent with *The Leach's Storm-Petrel: General Information and Handling Instructions* by U. Williams (Petro-Canada) and J. Chardine (CWS) (n.d.). It is understood by MKI that a CWS *Migratory Bird Handling Permit* will be required. MKI will request the ships to minimize lighting on board to the extent that it does not affect safety.

Wildlife Data Collection. Marine mammal/sea turtle observations will be made during ramp-ups and during data acquisition periods, and at other times on an opportunistic basis. This will include observations about marine mammal responses and behaviour to the ships and/or the array. Seabird surveys, i.e., standardized counts, will be conducted throughout the seismic program from the seismic vessel by MMOs experienced in the identification of seabirds at sea. Protocols modified and approved for use from ships at sea by Environment Canada as outlined in the Eastern Canada Seabirds at Sea (ECSAS) Standardized Protocol for Pelagic Seabird Surveys from Moving and Stationary Platforms will be utilized (Gjerdrum et al. 2012). A schedule of conducting seabird surveys (e.g., three times per day) at widely spaced intervals will be followed. Surveys can only be conducted when visibility is >300 m and adequate light conditions permit positive species identification. Data will be collected by a qualified environmental observer(s) (MMO) and FLOs.

Reporting. A monitoring report will be submitted to the C-NLOPB within one year after completion of the surveys as per the C-NLOPB *Guidelines*. In the unlikely event that marine mammals, turtles or birds are injured or killed by Project equipment or accidental spills of fuel, a report will immediately be filed with C-NLOPB and the need for follow-up monitoring assessed.

6. Pollution Prevention / Emergency Response (Fisheries, Marine Mammals, Sea Turtles, Seabirds, Fish, Cumulative Effects)

Waste Management. As described in the Project Description sections of this EA, wastes produced from the vessels, including hazardous and non-hazardous waste material, will be managed in accordance with MARPOL and with the vessel-specific waste management plans. PGS has a garbage management plan in place for the *Sanco Spirit*, and there is a waste management plan in place for the *Blain M*. A waste log will be kept onboard the *Sanco Spirit*. All solid wastes will be sorted by type, compacted where practicable, and stored on board before disposal to an appropriate certified reception facility. Non-Toxic combustible material and waste oil from the vessels will be burned on-board in approved incinerators. The shipboard incinerators will have been examined and tested in accordance with the requirements for shipboard incinerators IMO Res. MEPC 76(40) for disposing of ships-generated waste appended to the Guideline for the implementation of Annex V of MARPOL 73/78. Sufficient and adequate facilities will be available on vessels to store solid wastes generated. The contracted vessels policies and procedures will be reviewed against the MKI waste management plan, which will be filed with the C-NLOPB. Only ports with licensed waste contractors will be used for any waste returned from offshore.

Discharge Prevention and Management. Vessel discharges will not exceed those of standard vessel operations and will adhere to all applicable regulations. The main discharges include grey water (wastewater from washing, bathing, laundry, and food preparation), black water (human wastes), bilge water, deck drainage and discharges from machinery spaces. All discharges will comply with requirements in the International Convention for the Prevention of Pollution of Ships, 1973, as modified by Protocol of 1978 (MARPOL 73/78) and its annexes. Ground galley food waste can be discharged when a vessel is more than 3 miles offshore. Non-ground galley food waste can be discharged when a vessel is more than 12 miles offshore.

Air Emission Control. The vessels will have an International Air Pollution Prevention Certificate issued under the provisions of the Protocol of 1997 as amended by resolution MEPC.176(58) in 2008, to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as the Convention). Atmospheric emissions will be those associated with standard operations for marine vessels in general, including the seismic vessel and picket vessel. Vessels will only use diesel and gasoil with a sulphur content of no more than 1% (weight) following the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, for the North American Emission Control Area, which was implemented in Canada in August 2012 (see http://www.tc.gc.ca/eng/marinesafety/bulletins-2012-03-eng.htm).

Response to Accidental Events. In the unlikely event of the accidental release of hydrocarbons during the Project, MKI will implement the measures outlined in the Shipboard Oil Pollution Emergency Plans (SOPEPs) which will be filed with the C-NLOPB. In addition, MKI has an emergency response plan in place which bridges the emergency plans of all project entities and vessels to the local facilities and the Halifax Search and Rescue Region. The MKI representative onboard will represent MKI in all offshore Quality, Health, Safety & Environment (QHSE) activities. The Vessel Supervisor will represent MKI onshore from an office in St. John's.

The SOPEPs are designed to assist the ships' personnel in dealing with an unexpected discharge of oil. The primary purpose is to set in motion the necessary actions to stop or minimize the discharge of oil and to mitigate its effects. Effective planning ensures that the necessary actions are taken in a structured, logical and timely manner. The primary objectives of this Plan are to prevent oil pollution, to stop or minimize oil outflow when damage to the ship occurs, to stop or minimize oil outflow when an operational spill occurs, and to help contain/clean-up a spill.

The ships also carry Spill Kits which typically contain such equipment as:

- Air operated pump;
- Polypropylene scoops;
- Swabs, shovels, brooms with handle;
- Bags with absorbent;
- Absorbent sheets;
- Absorbent bond;
- Guard bond;
- Plastic drums;
- Plastic garbage bin;
- Plastic bags;
- Rubber gloves and boots; and
- Chemical protective suits.

In the event of the spill, the two ships would work and use their gear together to respond to and contain the released hydrocarbons.

Use of Solid Core Streamer. MKI will use a solid core streamer, manufactured by PGS, so streamer floatation fluid will not cause a leakage hazard.

The following summarizes these mitigations organized by potential effect on VECs (Table 5.2).

Table 5.2 Summary of Mitigations Measures by Potential Effect.

Potential Effects	**Primary Mitigations**
Interference with fishing vessels/mobile and fixed gear fisheries	• Upfront communications, liaison and planning to avoid fishing activity • Continuing communications throughout the program • FLOs • SPOC • Advisories and communications • VMS data • Avoidance • Start-up meetings on ships
Fishing gear damage	• Upfront communications, liaison and planning to avoid fishing gear • Use of picket vessel • SPOC • Advisories and communications • FLOs • Compensation program • Reporting and documentation • Start-up meetings on ships
Interference with shipping	• Advisories and at-sea communications • FLOs (fishing vessels) • Use of picket vessel • SPOC (fishing vessels) • VMS data
Interference with DFO/FFAW research program	• Communications and scheduling • Avoidance
Temporary or permanent hearing damage/disturbance to marine animals	• Pre-watch of safety zone • Delay start-up if marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations
Temporary or permanent hearing damage/ disturbance to Species at Risk or other key habitats	• Pre-watch of safety zone • Delay start-up if marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. [No critical habitat has been identified in or near the Study Area.]
Injury (mortality) to stranded seabirds	• Daily monitoring of vessel • Handling and release protocols • Minimize lighting if safe
Seabird oiling	• Adherence to MARPOL • Spill contingency and response plans • Use of solid streamer

5.7 Effects of the Environment on the Project

The physical environment of the Project Area is described in Section 3.0 of this EA and the Labrador Shelf SEA (Sikumiut 2008), and the reader is referred to these sources to assist in determining the effects on the Project. Furthermore, safety issues are assessed in some detail during the permitting and program application processes. Nonetheless, effects on the Project are important to consider, at least on a high level, because they may sometimes lead to effects on the environment.

Given the Project time frame of May to November for seismic operations and the requirement of a seismic survey to avoid periods and locations of sea ice, sea ice should have no effect on the Project. Icebergs in the early summer may cause some survey delays if survey lines have to be altered to avoid them. Most physical environmental constraints on seismic surveys are those imposed by wind and wave. The Project scheduling avoids the most continuous extreme weather conditions, and MKI and its contractors will be thoroughly familiar with east coast operating conditions. As a prediction of the effects of the environment on the Project, MKI will likely use an estimate of 20% weather-related down time for the Project for planning purposes. Seismic vessels typically suspend surveys once wind and wave conditions reach certain levels because the ambient noise affects the data. They also do not want to damage towed gear which would cause costly delays.

There are also expected to be effects on the Project because of the commercial fisheries activities expected in the Project Area. These will require that the seismic ship avoid certain zones within the Project Area at certain times, when harvesting is active, especially when fishing gear is in the water. The effects on the Project will be minimized through advanced planning and good communications, as described in the Mitigation measures (Section 5.6).

Effects of the biological environment on the Project are unlikely, other than for array shutdowns if required when marine mammals or sea turtles enter the Safety Zone.

Collectively, these potential effects cannot be considered to cause a significant effect on the Project, otherwise the Project would not be acceptable to the Proponent.

5.8 Effects of the Project on the Environment

This effects assessment is organized so that issues generic to any type of ship activity in the Labrador Sea such as fisheries vessels, DFO research vessels, military ships, marine transporters, or the proposed seismic surveys are discussed first. A detailed effects assessment then follows, which focuses on the effects of noise (primarily on marine mammals, fish and fisheries) and the towed seismic streamer (primarily on fishing gear), which is the major distinction between the effects of seismic surveys versus those of other marine vessels. The applicable mitigation measures (detailed in Section 5.6) are also noted for the relevant activity. The detailed assessment includes the generic effects in the ratings and predictions tables but does not discuss these generic issues in any detail.

5.8.1 Generic Activities - Air Quality

The atmospheric emissions from Project activities will be those from the Project vessels engines and generators, and vessel incinerators, all of which will be within the range of emissions from typical marine vessels on the east coast such as fishing, research, or offshore supply vessels. As such, there will be no particular or unique health or safety concerns associated with project emissions.

Given that the Project will use low sulphur content (no more than 1%) fuel (following Canadian 2012 ECA regulations) and that it will add negligible atmospheric emissions (relative to total northwest Atlantic ship traffic) to a windy oceanic environment, there will be no measureable adverse effect on air quality or human health in the Project Area.

5.8.2 Generic Activities - Marine Use

Project-related traffic will include one seismic survey vessel and one picket vessel. The seismic and picket vessels will operate within the Project Area (see Figure 1.1), except when transiting to or from the survey area. The seismic and/or picket vessel may operate occasionally to and from the Project Area for re-provisioning, re-fuelling, and crew changes.

Other ships operating in the area could include freighters, tankers, fishing vessels, research vessels, naval vessels, and private yachts. The Department of National Defence (DND) has indicated that it will likely be operating in the vicinity of the Study Area during the Project timeframe. DND will be kept informed of the dates and locations of seismic activities. As advised, if any suspected unexploded ordnance locations are found, they will be recorded and reported to the Canadian Coast Guard. Mitigations (detailed in Section 5.6) will minimize potential conflicts and any adverse effects with other vessels; these include:

- At sea communications (VHF, HF, Satellite, radar etc.);
- Utilization of FLOs for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- Picket vessel to alert other vessels of towed gear in water;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact (SPOC).

MKI will also coordinate with DFO, St. John's, to avoid any potential conflicts with research vessels that may be operating in the area. Given the expected vessel density conditions and mitigations described above, there should be *negligible* adverse effects on other marine users of the Project Area.

5.8.3 Generic Activities - Waste Handling

Project waste will be generated by about 50 personnel. Waste will include:

- Gray/black water;

- Galley waste; and
- Solid waste.

As described in Section 5.6, vessel discharges will not exceed those of standard vessel operations and will adhere as a minimum to all applicable regulations and applicable international standards. The main discharges include grey water (wastewater from washing, bathing, laundry, and food preparation), black water (human wastes), bilge water, deck drainage and discharges from machinery spaces. Wastes produced from the seismic and picket vessels, including hazardous and non-hazardous waste material, will be managed in accordance with MARPOL and with the vessel specific waste management plans.

Waste produced by the Project will handled and treated appropriately and therefore have *negligible* effect on the environment in the Project Area.

5.8.4 Fish and Fish Habitat VEC

Despite the probability of interaction between Project activities and the 'fish habitat' component of the Fish and Fish Habitat VEC (i.e., water and sediment quality, phytoplankton, zooplankton, and benthos) (Table 5.3), residual effects are predicted to be *negligible* and thus *not significant*. The seismic program will not result in any direct physical disturbance of the bottom substrate. Also, the probability of an accidental event (i.e., hydrocarbon release) of sufficient magnitude to cause a significant effect on fish habitat is low. Therefore, other than in Table 5.3, no further reference to the 'fish habitat' component of the Fish and Fish Habitat VEC is made in this assessment section. Ichthyoplankton, invertebrate eggs and larvae, and macro-benthos are considered part of the 'fish' component of the Fish and Fish Habitat VEC.

The following sections discuss the Project activities that will interact with the Fish and Fish Habitat VEC, including assessment of the potential effects of these interactions.

Table 5.3 Potential Interactions of the Project Activities and the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat							
Project Activities	**Non-Biological Environment**	**Feeding**		**Reproduction**		**Adult Stage**	
	Water and Sediment Quality	**Plankton**	**Benthos**	**Eggs and Larvae**	**Juveniles [d]**	**Pelagic Fish**	**Groundfish**
Vessel Lights		X				X	
Sanitary/Domestic Waste	X	X		X		X	
Atmospheric Emissions	X	X		X		X	
Garbage [a]							
Sound							
Airgun Array		X	X	X	X	X	X
Seismic Vessel						X	
Picket Vessel						X	
Echosounder						X	
Helicopter [b]							

Valued Environmental Component: Fish and Fish Habitat							
Project Activities	**Non-Biological Environment**	**Feeding**		**Reproduction**		**Adult Stage**	
	Water and Sediment Quality	**Plankton**	**Benthos**	**Eggs and Larvae**	**Juveniles [d]**	**Pelagic Fish**	**Groundfish**
Presence of:							
Seismic Vessel							
Picket Vessel							
Helicopter [b]							
Shore Facilities [c]							
Accidental Releases	X	X		X		X	
Other Projects and Activities							
Oil and Gas Activities in the Labrador Sea	X	X	X	X	X	X	X
Oil and Gas Activities on Grand Banks and Orphan Basin	X	X	X	X	X	X	X
Fisheries	X	X	X	X	X	X	X
Marine Transportation	X	X	X	X	X	X	

[a] Not applicable as garbage will be brought ashore.
[b] No helicopter use is planned for 2014 , but helicopters may be used during programs in 2015-2018.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.
[d] Juveniles are young fish that have left the plankton and are often found closely associated with substrates.

5.8.4.1 Underwater Sound

Exposure to anthropogenic underwater sounds has the potential to cause physical (i.e., pathological and physiological) and behavioural effects on marine invertebrates and fishes. Studies that conclude that there are physical and physiological effects typically involve captive subjects that are unable to move away from the sound source and are therefore exposed to higher sound levels than they would be under natural conditions. Comprehensive literature reviews related to auditory capabilities of fishes and marine invertebrates and the potential effects of exposure to seismic airgun noise on them are contained in Appendices 2 and 3. The following sections related to the Fish and Fish Habitat VEC contain summaries of the information contained in the two appendices.

Sound Detection

Sensory systems, like those that allow for hearing, provide information about an animal's physical, biological, and social environments in both air and water. Extensive work has been done to understand the structures, mechanisms, and functions of animal sensory systems in aquatic environments (Atema et al. 1988; Kapoor and Hara 2001; Collin and Marshall 2003).

Underwater sound has both a pressure component and a particle displacement component. While all marine invertebrates and fishes appear to have the capability of detecting the particle displacement component of underwater sound, only certain fish species appear to be sensitive to the pressure component (Breithaupt 2002; Casper and Mann 2006; Popper and Fay 2010).

Invertebrates

The sound detection abilities of marine invertebrates are the subject of ongoing debate. Aquatic invertebrates, with the exception of aquatic insects, do not possess the equivalent physical structures present in fish and marine mammals that can be stimulated by the pressure component of sound. It appears that marine invertebrates respond to vibrations (i.e., particle displacement) rather than pressure (Breithaupt 2002). Statocysts, organs of balance containing mineral grains that stimulate sensory cells as the animal moves, apparently function as a vibration detector for at least some species of marine invertebrates (Popper and Fay 1999). The statocyst is a gravity receptor and allows the swimming animal to maintain a suitable orientation.

Among the marine invertebrates, decapod crustaceans and cephalopods have been the most intensively studied in terms of sound detection and the effects of exposure to sound. Crustaceans appear to be most sensitive to low frequency sounds (i.e., <1,000 Hz) (Budelmann 1992; Popper et al. 2001). Both cephalopods (Packard et al. 1990) and crustaceans (Heuch and Karlsen 1997) have been shown to possess acute infrasound (i.e., <20 Hz) sensitivity. Some studies suggest that there are invertebrate species, such as the American lobster (*Homarus americanus*), that may also be sensitive to frequencies >1,000 Hz (Pye and Watson III 2004).

A recent study concluded that planktonic coral larvae can detect and respond to sound, the first description of an auditory response in the invertebrate phylum Cnidaria (Vermeij et al. 2010). Eggleston et al. (2013) have presented results of laboratory and field experiments that suggest oyster larvae use underwater sound to optimize settlement. Similarly, in a study by Stocks et al. (2012), it was found that marine invertebrate larvae of several species responded to sound and, in some cases, appeared to distinguish between different sound frequencies.

Fishes

Marine fishes are known to vary widely in their abilities to detect sound. Although hearing capability data only exist for fewer than 100 of the 27,000 fish species (Hastings and Popper 2005), current data suggest that most species of fish detect sounds with frequencies <1,500 Hz (Popper and Fay 2010). Some marine fishes, such as shads and menhaden, can detect sound at frequencies >180 kHz (Mann et al. 1997, 1998, 2001). These fishes have highly specialized otophysic connections (e.g., Weberian apparatus) between pressure receptive organs, such as the swim bladder, and the inner ear. There are other fishes (e.g., Atlantic salmon (*Salmo salar*) and European eel (*Anguilla anguilla*) that are acutely sensitive to infrasound (Sand and Karlsen 2000). Reviews of fish sound-detection mechanisms and capabilities are presented in Fay and Popper (2000) and Ladich and Popper (2004).

All fishes have hearing (inner ear) and skin-based mechanosensory systems (lateral lines). Amoser and Ladich (2005) hypothesized that, as species within a particular family of fish may live under different ambient sound conditions, the hearing abilities of the individual species are likely to have adapted to the dominant conditions of their specific environments. The ability of fish to hear a range of biotic and abiotic sounds may affect their survival rate, with better adapted fish having an advantage over those that cannot detect prevailing sounds (Amoser and Ladich 2005).

Fish ears are able to respond to changes in pressure and particle displacement in the water (van Bergeijk 1964; Schuijf 1981; Kalmijn 1988, 1989; Shellert and Popper 1992; Hawkins 1993; Fay 2005). Two major pathways have been identified for sound transmittance: (1) the otoliths, calcium carbonate masses in the inner ear that act as accelerometers when exposed to the particle displacement component of sound, which cause shearing forces that stimulate sensory hair cells; and (2) the swim bladder, which expands and contracts in a sound field, re-radiating the sound's signal within the fish and in turn stimulating the inner ear (Popper and Fay 1993).

Researchers have noted that fish without an air-filled cavity (swim bladder), or with a reduced swim bladder or limited connectivity between the swim bladder and inner ear, are limited to detecting particle displacement and not pressure, and therefore have relatively poor hearing abilities (Casper and Mann 2006). These species have commonly been known as 'hearing generalists' (Popper and Fay 1999), although a recent reconsideration suggests that this classification is oversimplified (Popper and Fay 2010). Rather, there is a range of hearing capabilities across species that is more like a continuum, presumably based on the relative contributions of pressure to the overall hearing capabilities of a species (Popper and Fay 2010). Results of direct study of fish sensitivity to particle displacement have been reported in numerous recently published papers (e.g., Horodysky et al. 2008; Wysocki et al. 2009; Kojima et al. 2010).

Sound Production

Many invertebrates and fishes produce sounds. It is believed that these sounds are used for communication in a wide range of behavioural and environmental contexts. The behaviours most often associated with acoustic communication include territorial behaviour, mate searching, courtship and aggression. Sound production provides a means of long distance communication as well as communication when underwater visibility is poor (Zelick et al. 1999).

Invertebrate groups with species capable of producing sound include barnacles, amphipods, shrimps, crabs, and lobsters (Au and Banks 1998; Tolstoganova 2002; Pye and Watson III 2004; Henninger and Watson III 2005; Buscaino et al. 2011). Invertebrates typically produce sound by scraping or rubbing various parts of their bodies together.

More than 700 fish species are known to produce sounds (Myrberg 1981, Kaatz 2002 *in* Anderson et al. 2008). Fishes produce sounds mainly by using modified muscles attached to their swim bladders (i.e., drumming) or rubbing body parts together (i.e., stridulating). Examples of 'soniferous' fishes include Atlantic cod (Finstad and Nordeide 2004; Rowe and Hutchings 2004), toadfishes (Locascio and Mann 2008; Vasconcelos and Ladich 2008), and basses (Albers 2008; Johnston et al. 2008).

Effects of Exposure to Airgun Sound

Most airgun sound energy is associated with frequencies <500 Hz, although there is also some energy at higher frequencies.

Physical Effects

For the purposes of this EA, physical effects include both pathological and physiological effects.

Invertebrates

To date, experimentation intended to investigate the physical effects of exposure to seismic airgun sound on marine invertebrates has been limited to crustaceans and cephalopods. Both egg/larvae and juvenile/adult stages have been used in the limited number of studies.

Dungeness crab (*Cancer magister*) larvae and snow crab (*Chionoecetes opilio*) fertilized eggs have both been studies with respect to the effects of exposure to airgun sound. In their field study, Pearson et al. (1994) did not find any statistically significant differences in immediate survival, long-term survival, or time to moult between the treatment and control Dungeness crab larvae, even when exposure occurred within one metre of the sound source. Christian et al. (2003, 2004) found a significant difference in development rate between treatment and control fertilized eggs containing embryos. The egg mass exposed to seismic sound had a higher proportion of less-developed eggs than did the unexposed mass. It should be noted that both egg masses came from a single female and any measure of natural variability was unattainable. In another field study involving snow crab, neither acute nor chronic lethal or sub-lethal injury to crab embryos was apparent after egg-bearing females were exposed to seismic sound emitted during a commercial seismic survey (DFO 2004a,b). In a recent study, wild New Zealand scallop larvae were exposed to recorded seismic sound and results suggested developmental delays and body abnormalities due to cumulative exposure (de Soto et al. 2013)

Adult American lobster (*Homarus americanus*), snow crab, and blue mussels (*Mytilus edulis*) have also been used as subjects during the study of the potential effects of exposure to airgun sound on marine invertebrates. Payne et al. (2007) exposed adult lobsters in a laboratory-based study and observed for both acute and chronic physical effects. No pathological effects were seen but significant differences in levels of serum protein, enzymes and calcium were observed. During histological analysis four months after exposure, Payne et al. (2007) noted the presence of glycogen deposits in the hepatopancreas of some exposed animals, perhaps due to stress or disturbance of cellular processes. Christian et al. (2003, 2004) did not observe any physical effects in adult snow crab exposed to seismic airgun sound. Physical differences between treatment and control female snow crabs were observed during a study in the Gulf of St. Lawrence but due to study design, these differences could not be linked to the airgun sound (DFO 2004a,b).

McCauley et al. (2000a,b) exposed caged cephalopods to sound from a single 20 in^3 airgun with maximum SPLs of >200 dB re 1 $\mu Pa_{0\text{-}p}$. Statocysts were removed and preserved, but at the time of publication, results of the statocyst analyses were not available. No squid or cuttlefish mortalities were reported as a result of these exposures.

See Appendix 3 for more details related to the study of the physical effects of exposure to airgun sound on marine invertebrates.

Fishes

Several review papers on the effects of anthropogenic sources of underwater sound on fishes have been published recently (Popper 2009; Popper and Hastings 2009a,b; Slabbekoorn et al. 2010, Fay and Popper 2012). These papers consider various sources of anthropogenic sound, including seismic airguns. As with marine invertebrates, both egg/larvae and juvenile/adult stages have been used in the study of physical effects of exposure to airgun sound on fishes.

Fertilized capelin (*Mallotus villosus*) eggs and monkfish (*Lophius americanus*) larvae were exposed to seismic airgun sound in the laboratory and subsequently examined and monitored for possible effects of the exposure (Payne et al. 2009). No statistical differences in mortality/morbidity between treatment and control subjects were found at one to four days post-exposure in any of the trials for either the capelin eggs or the monkfish larvae.

In uncontrolled experiments, Kostyuchenko (1973) exposed the eggs of numerous fish species (anchovy, red mullet, crucian carp, blue runner) to various sound sources, including seismic airguns. With the seismic airgun discharge as close as 0.5 m from the eggs, over 75% of them survived the exposure. Egg survival rate increased to over 90% when the subjects were 10 m from the airgun sound source.

Eggs, yolk sac larvae, post-yolk sac larvae, post-larvae, and fry of various commercially important fish species (cod, saithe, herring, turbot, and plaice) were exposed to received SPLs ranging from 220 to 242 dB re 1 µPa (unspecified measure type) (Booman et al. 1996). These received levels corresponded to exposure distances ranging from 0.75 to 6 m. The authors reported some cases of injury and mortality but most of these occurred as a result of exposures at very close range.

Saetre and Ona (1996) applied a "worst-case scenario" mathematical model to investigate the effects of seismic sound on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic airgun sound are so low compared to the natural mortality that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

Evidence for airgun sound-related damage to adult fish ears has resulted from studies using caged pink snapper (*Pagrus auratus*) (McCauley et al. 2000a,b, 2003). In some individual fish, the sensory epithelium of the inner ear sustained extensive damage as indicated by ablated hair cells. Damage was more extensive in fish examined 58 days post-exposure compared to those examined 18 hours post-exposure. There was no evidence of repair or replacement of damaged sensory cells up to 58 days post-exposure. McCauley et al. (2000a,b, 2003) included the following *caveats* in the study reports: (1) fish were caged and unable to swim away from the seismic source, (2) only one species of fish was examined, (3) the impact on the ultimate survival of the fish is unclear, and (4) airgun exposure specifics required to cause the observed damage were not obtained.

In a study examining the effects of exposure to seismic airgun sound on anadromous fishes, Thomsen (2002) exposed rainbow trout and Atlantic salmon held in aquaculture enclosures to recordings of sounds from a small airgun array. No fish mortality was observed during or immediately after exposure.

See Appendix 2 for more details related to the study of the physical effects of exposure to airgun sound on marine fishes.

Behavioural Effects

Considering the lack of scientific evidence for physical effects of exposure to airgun sound on non-captive marine invertebrates and fishes, much of the current research is investigating the behavioural effects of exposure to airgun sound on these biota.

Invertebrates

Christian et al. (2003) investigated the behavioural effects of exposure to airgun sound on snow crabs using both telemetry and underwater video. None of the animals tagged with ultrasonic transmitters left the immediate area after exposure to the airgun sound. Underwater video was used to monitor caged animals placed on the ocean bottom and then exposed to airgun sound from a distance of 50 m. The snow crab did not exhibit any overt startle response during the exposure period.

In their study of the effects of exposure to airgun sound on adult American lobsters, Payne et al. (2007) noted a trend of increased food consumption by the animals exposed to seismic sound.

McCauley et al. (2000a,b) provided the first evidence of the behavioural response of southern calamari squid *Sepioteuthis australis* exposed to seismic survey sound. McCauley et al. (2000a, b) reported on the exposure of caged cephalopods (50 squid and two cuttlefish) to sound from a single 20 in^3 airgun. The cephalopods were exposed to both stationary and mobile sound sources. Some of the squid fired their ink sacs apparently in response to the first shot of one of the trials and then moved quickly away from the airgun. In addition to the above-described startle responses, some squid also moved towards the water surface as the airgun approached. McCauley et al. (2000a,b) reported that the startle and avoidance responses occurred at a received SPL of 174 dB re 1 μPa_{rms}. They also exposed squid to a ramped approach-depart airgun signal whereby the received SPL was gradually increased over time. No strong startle response (i.e., ink discharge) was observed, but alarm responses, including increased swimming speed and movement to the surface, were observed once the received SPL reached a level in the 156 to 161 dB re 1 μPa_{rms} range.

Although not demonstrated in the invertebrate literature, masking can be considered a potential effect of anthropogenic underwater sound on marine invertebrates. Some invertebrates are known to produce sounds (Au and Banks 1998; Tolstoganova 2002; Latha et al. 2005). The functionality and biological relevance of these sounds are not understood (Jeffs et al. 2003, 2005; Lovell et al. 2006; Radford et al. 2007). If some of the sounds are of biological significance to some invertebrates, then masking of those sounds or sounds produced by predators could potentially have adverse effects on marine invertebrates. However, even if masking does occur in some invertebrates, the pulsed nature of airgun sound is expected to result in less masking effect than would occur with continuous sound.

Invertebrate Fisheries

Christian et al. (2003) investigated the pre- and post-exposure catchability of snow crabs during a commercial fishery. Catch-per-unit-effort did not decrease after the crabs were exposed to seismic survey sound. Note that there was considerable variability in set duration due to poor weather conditions. Anecdotal information from Newfoundland suggested that catch rates of snow crabs showed a reduction immediately following a pass by a seismic survey vessel (G. Chidley, Newfoundland fisherman, pers. comm.). Additional anecdotal information from Newfoundland indicated that a school of shrimp observed via a fishing vessel sounder shifted downwards and away from a nearby seismic airgun sound source (H. Thorne, Newfoundland fisherman, pers. comm.). These observed behaviours were temporary.

Andriguetto-Filho et al. (2005) evaluated the impact of seismic survey sound on artisanal shrimp fisheries off Brazil. Results of that study did not indicate any significant impact on shrimp catches.

Parry and Gason (2006) statistically analyzed data related to rock lobster (*Jasus edwardsii*) commercial catches and seismic surveying in Australian waters from 1978 to 2004. They found no evidence that lobster catch rates were affected by seismic surveys. They also noted that due to natural variability and fishing pressure, a large effect on lobster would be required to make any link to seismic surveys.

See Appendix 3 for more details related to the study of the behavioural effects of exposure to airgun sound on marine invertebrates.

Fishes

Pearson et al. (1992) investigated the behavioural effects of seismic airgun sound on the behaviour of captive rockfishes (*Sebastes* spp.). The authors reported that rockfishes reacted to the airgun sounds by exhibiting varying degrees of startle (classic C-turn response) and alarm (e.g., darting movements, flash school expansion, fast swimming) responses, depending on the species of rockfish and the received sound pressure level. Skalski et al. (1992) also studied the potential behavioural effects of exposure to seismic airgun sound on the rockfishes. During long-term stationary seismic airgun discharge, there was an overall downward shift in fish distribution. It should be noted that this experimental approach was quite different from an actual seismic survey, in that duration of exposure was much longer.

Caged fish exposed to airgun sound in a study by McCauley et al. (2000a,b) exhibited startle and alarm responses. The occurrence of both startle response and alarm responses decreased over time. Other observations included downward distributional shift, increase in swimming speed, and the formation of denser aggregations. Fish behaviour appeared to return to pre-exposure state shortly after the exposures ended.

Hassel et al. (2003, 2004) studied the potential effects of exposure to airgun sound on the behavior of captive lesser sandeel, *Ammodytes marinus*. During seismic airgun discharge, many fish exhibited startle responses, followed by flight from the immediate area. The frequency of occurrence of startle response seemed to increase as the operating seismic array moved closer to the fish. The sandeels stopped exhibiting the startle response once the airgun discharge ceased. During airgun discharge, the sandeels tended to remain higher in the water column and not bury themselves in the soft substrate.

Other studies of fish behavioural effects of exposure to airgun sound have been conducted (Chapman and Hawkins 1969; Dalen and Knutsen 1986; La Bella et al. 1996; Santulli et al. 1999; Wardle et al. 2001; Thomsen 2002; Slotte et al. 2004; Boeger et al. 2006; Jorgenson and Gyselman 2009). Generally, these studies reported results similar to those described above; temporary startle/alarm responses and distributional shifts.

The following section reviews fishery-related studies of fish behavioural effects due to exposure to airgun sound.

Finfish Fisheries

Early experimentation on the effects of seismic airgun sound on catchability of fishes was conducted in the Barents Sea by Engås et al. (1993, 1996). They investigated the effects of exposure to seismic airgun sound on distributions, abundances, and catch rates of cod and haddock using acoustic mapping and experimental fishing with trawls and longlines. They concluded that there were indications of distributional change during and immediately following the seismic airgun discharge. The authors indicated that trawl catches of both cod and haddock declined after the seismic operations. While longline catches of haddock also showed decline after seismic airgun discharge, those for cod increased.

Dalen and Knutsen (1986), Løkkeborg (1991), and Løkkeborg and Soldal (1993) also examined the effects of seismic airgun sound on demersal fish catches. Løkkeborg (1991) examined the effects on cod catches. Catch rate decreases ranging from 55 to 80% were observed within the seismic survey area. This apparent effect persisted for at least 24 hours within about 10 km of the survey area. The effect of exposure to seismic sound on commercial demersal fishes was again studied in 2009 using gillnet and longline fishery methods off the coast of Norway (Løkkeborg et al. 2012). Study results indicated that fishes did react to airgun sound based on observed changes in catch rates during seismic shooting. Gillnet catches increased during the seismic shooting, perhaps as a result of increased fish activity, while longline catches showed an overall decrease.

Skalski et al. (1992) examined the potential effects of airgun sound on the catchability of rockfishes. The catch-per-unit-effort (CPUE) for rockfish declined, on average, by 52% when the airguns were operating. Skalski et al. (1992) concluded that the reduction in catch resulted from a change in behaviour of the fishes. For example, the fish schools descended towards the bottom during airgun discharge. Although lateral fish dispersal was not observed, the authors hypothesized that it could have occurred at a different location with a different bottom type. Skalski et al. (1992) did not continue fishing after cessation of airgun discharge. They speculated that CPUE would quickly return to normal in the experimental area because fish behaviour appeared to normalize within minutes of cessation of airgun discharge. However, in an area where exposure to airgun sound might have caused the fish to laterally disperse, the authors suggested that a lower CPUE might persist for a longer period.

See Appendix 2 for more details related to the study of the behavioural effects of exposure to airgun sound on marine fishes.

Effects of Exposure to Marine Vessel Sound

Numerous papers about the behavioural responses of fishes to marine vessel sound have been published in the primary literature. They consider the responses of small pelagic fishes (e.g., Misund et al. 1996; Vabo et al. 2002; Jørgensen et al. 2004; Skaret et al. 2005; Ona et al. 2007; Sand et al. 2008), large pelagic fishes (Sarà et al. 2007), and groundfishes (Engås et al. 1998; Handegard et al. 2003; De Robertis et al. 2008). Generally, most of the papers indicate that fishes typically exhibit some level of reaction to the sound of approaching marine vessels, the degree of reaction being dependent on a variety of factors including the activity of the fish at the time of exposure (e.g., reproduction, feeding, and migration), characteristics of the vessel sound, and water depth.

Sound Exposure Effects Assessment

The assessment in this and subsequent sections is structured such that the reader should first refer to the interaction table (e.g., see Table 5.3) to determine if there are any interactions with Project activities, secondly to the assessment table (e.g., Table 5.4) which contains ratings for magnitude, geographic extent, and duration, and thirdly to the significance predictions table (e.g., Table 5.5).

It is impossible to assess in detail the potential effects of every type of sound on every species in the Study Area. The best approach, and common practice in EA, is to provide focus by selecting (1) the strongest sound source (i.e., airgun array), and (2) several species that are locally important and representative of the different types of sensitivities, and (3) species or groups that offer a relevant literature base. Snow crab and Atlantic cod best serve this purpose.

The most notable animal-related criteria in the assessment include (1) distance between airgun array and animal under normal conditions (e.g., post-larval snow crabs remain on bottom, post-larval cod occur in the water column, and larvae of both snow crab and cod are planktonic in upper water column), (2) motility of the animal (e.g., post-larval snow crabs are much less motile than post-larval cod, and larvae of both are essentially passive drifters), (3) absence or presence of a swim bladder (i.e., auditory sensitivity) (snow crabs without swim bladder and cod with swim bladder), and (4) reproductive strategy (snow crabs carry fertilized eggs at the bottom until larval hatch, and cod eggs are planktonic).

Potential impacts on other marine invertebrate and fish species are inferred from the assessment using snow crab and Atlantic cod.

As already indicated in this section, many data gaps remain despite the increase in research on the effects of exposure to airgun sound on marine invertebrates and fishes. Available experimental data suggest that there may be physical impacts on the fertilized eggs of snow crab and on the egg, larval, juvenile and adult stages of cod at very close range. Considering the typical source levels associated with commercial seismic airgun arrays, proximate occurrence to the source would result in exposure to very high sound levels. While egg and larval stages are not able to actively escape such an exposure scenario, juvenile and adult cod would most likely avoid it. Developing embryos, juvenile and adult snow crab are benthic and generally far enough from the sound source to receive energy levels well below levels that may have effects. In the case of eggs and larvae, it is likely that the numbers negatively affected by exposure to seismic sound would be within the range of those succumbing to

Table 5.4 Assessment of Effects of Project Activities on the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Vessel Lights	Behavioural effects (N/P)	Reduce lighting (if possible)	0	1	2-3	2	R	2
Sanitary/Domestic Waste	Pathological effects (N); Contamination (N)	Treatment; adherence to regulations and conventions	0-1	1	4	2	R	2
Atmospheric Emissions	Pathological effects (N); Contamination (N)	Use of low-sulphur fuel; Equipment maintenance	0	1	6	2	R	2
Sound								
Airgun Array	Disturbance (N)	Ramp-up of array; Spatial or temporal avoidance [a]	1	1-3	6	2	R	2
Airgun Array	Physical effects (N)	Ramp-up of array; Spatial or temporal avoidance [a]	1	1	6	2	R	2
Seismic Vessel	Disturbance (N)	Spatial or temporal avoidance [a]	0-1	1	6	2	R	2
Picket Vessel	Disturbance (N)	Spatial or temporal avoidance [a]	0-1	1	6	2	R	2
Echosounder	Disturbance (N)	Spatial or temporal avoidance [a]	0	1	6	2	R	2
Accidental Releases	Pathological effects (N); Contamination (N)	Solid streamer [b]; Spill response	0-1	1-2	1	1	R	2

[a] Avoidance of sensitive areas and times, to the extent possible.
[b] A solid streamer will be used for all seismic surveys.

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

Table 5.5 Significance of Potential Residual Environmental Effects of Project Activities on the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood[a]**	
	Significance of Predicted Residual Environmental Effects		**Probability of Occurrence**	**Scientific Certainty**
Vessel Lights	NS	3	-	-
Sanitary/Domestic Waste	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Sound				
Airgun Array	NS	2-3	-	-
Seismic Vessel	NS	2-3	-	-
Picket Vessel	NS	2-3	-	-
Echosounder	NS	2-3	-	-
Accidental Releases	NS	2-3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

natural mortality. Atlantic cod do have swim bladders and are therefore generally more sensitive to underwater sounds than fishes without swim bladders. Spatial and temporal avoidance of critical life history times (e.g., spawning aggregations) to the extent possible as well as ramp-up should mitigate the effects of exposure to airgun sound. Snow crab, sensitive to the particle displacement component of sound only, will be at least 75-100 m from the airguns and will not likely be affected by any particle displacement resulting from airgun discharge.

Limited data regarding physiological impacts on fish and invertebrates indicate that these impacts are both short-term and most obvious after exposure at close range.

The physical effects on marine invertebrates and fishes of exposure to sound with frequencies >500 Hz are *negligible* to *low*, based on the available information from the scientific literature. The behavioural effects on marine invertebrates and fishes of exposure to sound with frequencies >500 Hz appear to be temporary.

Table 5.4 provides the details of the assessment of the effects of exposure to Project-related sound on the Fish and Fish Habitat VEC. As indicated in Table 5.4, sound produced as a result of MKI's proposed Project (airgun array sound being the worst-case scenario) is predicted to have *negligible* to *low* magnitude residual effects on the various life stages of the Fish and Fish Habitat VEC for a duration of *1 to 12 months* over an area of *<1 to 11-100 km²*. Based on these criteria ratings, the *reversible* residual effects of Project-related sound on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *medium* to *high*.

5.8.4.2 Other Project Activities

Vessel Lights

There are potential interactions between vessel lights and certain components of the Fish and Fish Habitat VEC (see Table 5.3). However, other than the attraction of certain species/life stages to the upper water column at night, there will be *negligible* effects of vessel lights on this VEC (see Table 5.4). Therefore, the residual effects of vessel lights associated with MKI's proposed Project on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *high*.

Sanitary/Domestic Waste

There are potential interactions between sanitary/domestic waste and certain components of the Fish and Fish Habitat VEC (Table 5.3). After application of mitigation measures, including treatment of the waste, the residual effects of sanitary/domestic waste on the Fish and Fish Habitat VEC are predicted to be *negligible* to *low* in magnitude for a duration of *1-12 months* over an area of *<1 km²* (see Table 5.4). Based on these criteria ratings, the *reversible* residual effects of exposure to sanitary/domestic waste associated with MKI's proposed Project on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *high*.

Atmospheric Emissions

There are potential interactions between atmospheric emissions and certain components of the Fish and Fish Habitat VEC that occur very near surface (see Table 5.3). Considering that the amount of atmospheric emissions produced during the proposed seismic program will rapidly disperse to undetectable levels, the residual effects of exposure to them on the Fish and Fish Habitat VEC are predicted to be *negligible* (see Table 5.4). Therefore, the *reversible* residual effects of *continuous* atmospheric emissions associated with MKI's proposed Project on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *high*.

Accidental Releases

Planktonic invertebrate and fish eggs and larvae are less resistant to effects of contaminants than are adults because they are not physiologically equipped to detoxify them or to actively avoid them. In addition, many eggs and larvae develop at or near the surface where hydrocarbon exposure may be the greatest (Rice 1985). Generally, fish eggs appear to be highly sensitive at certain stages and then become less sensitive just prior to larval hatching (Kühnhold 1978; Rice 1985). Larval sensitivity varies with yolk sac stage and feeding conditions (Rice et al. 1986). Eggs and larvae exposed to high concentrations of hydrocarbons generally exhibit morphological malformations, genetic damage, and reduced growth. Damage to embryos may not be apparent until the larvae hatch. The natural mortality rate in fish eggs and larvae is extremely high and very large numbers would have to be destroyed by anthropogenic sources before effects would be detected in an adult population (Rice 1985).

There is an extensive body of literature regarding the effects of exposure to hydrocarbons on juvenile and adult fish. Although some of the literature describes field observations, most refer to laboratory studies. Reviews of the effects of hydrocarbons on fish have been prepared by Rice et al. (1986), Armstrong et al. (1995), Payne et al. (2003), and numerous other authors. If exposed to hydrocarbons in high enough concentrations, fish may suffer effects ranging from direct physical effects (e.g., coating of gills and suffocation) to more subtle physiological and behavioural effects. Actual effects depend on a variety of factors such as the amount and type of hydrocarbon, environmental conditions, species and life stage, lifestyle, fish condition, degree of confinement of experimental subjects, and others.

As indicated in Table 5.3, there are potential interactions of accidental releases and components of the Fish and Fish Habitat VEC that occur near surface. The effects of hydrocarbon spills on marine invertebrates and fish have been discussed and assessed in numerous recent environmental assessments of proposed offshore drilling programs and assessments have concluded that the residual effects of accidental hydrocarbon releases on the Fish and Fish Habitat VEC are predicted to be *not significant*. With proper mitigations in place, the residual effects of an accidental release associated with MKI's proposed seismic program on the Fish and Fish habitat VEC would be *negligible* to *low* in magnitude for a duration of *<1 month* over an area of *<1* to *1-10* km^2 (see Table 5.4). Based on these criteria ratings and consideration that the probability of accidental hydrocarbon releases during the proposed seismic program are low, the *reversible* residual effects of accidental releases associated with the proposed program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.5). The level of confidence associated with this prediction is *medium* to *high*.

5.8.5 Fisheries VEC

The potential interactions of Project activities and the Fisheries VEC are indicated in Table 5.6. Traditional fisheries, recreational fisheries, DFO and joint DFO/Industry Research Surveys were included in the assessment of the Fisheries VEC.

The seismic survey vessel and Project-related picket vessel traffic will be present within NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, and 3K. Behavioural changes in commercial species in relation to catchability, and conflict with harvesting activities and fishing gear were raised as potential issues during the consultations and issues scoping for recent EAs (see reviewed EAs in Section 5.2). Additionally, concerns related to concurrent fishing activities and the effects of seismic surveys on fisheries were raised during the consultations for this assessment. Seismic streamers and vessels can conflict with and damage fishing gear, particularly fixed gear (e.g., snow crab pots or gillnets). Such conflicts have occurred in Atlantic Canada in the past when seismic vessels were operating in heavily fished areas. There is also a potential for interference from seismic activities with DFO and DFO/Industry research surveys if both are being conducted in a same general area at the same time. An accidental release of petroleum hydrocarbons may result in tainting (or perceived tainting) thus affecting product quality and marketing.

Table 5.6 Potential Interactions of Project Activities and the Fisheries VEC.

Valued Environmental Component: Fisheries			
Project Activities	Mobile Invertebrates and Fishes (fixed [e.g., gillnet] and mobile gear [e.g., trawls])	Sedentary Benthic Invertebrates (fixed gear [e.g., crab pots])	Research Surveys (mobile gear-trawls; fixed gear-crab pots)
Vessel Lights			
Sanitary/Domestic Waste	X	X	X
Atmospheric Emissions			
Garbage [a]			
Sound			
Airgun Array	X	X	X
Seismic Vessel	X	X	X
Picket vessel	X	X	X
Echosounder	X		X
Helicopter [b]			
Presence of:			
Seismic Vessel	X	X	X
Picket Vessel	X	X	X
Helicopter [b]			
Shore Facilities [c]			
Accidental Releases	X	X	X
Other Projects and Activities			
Oil and Gas Activities in the Labrador Sea	X	X	X
Fisheries	X	X	X
Marine Transportation	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] No helicopter use is planned for 2014 , but helicopters may be used during programs in 2015-2018.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

The chief means of mitigating potential impacts on fishery activities is to avoid active fishing areas, particularly fixed gear zones. For the commercial fisheries, gear damage compensation provides a means of final mitigation of impacts, in case a conflict does occur with fishing gear (i.e., accidental contact of gear with the survey air source array, streamers or seismic vessel).

The document *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) provides guidance aimed at minimizing any impacts of petroleum industry surveys on commercial fish harvesters and other marine users. The mitigations described below are also relevant to DFO and joint DFO/Industry research surveys. Development of the guidelines was based on best practices applied during previous surveys in Atlantic Canada, as well as guidelines from other national jurisdictions.

The relevant guidelines state the following (in Appendix 2 of C-NLOPB [2012] - Environmental Planning, Mitigation and Reporting – II. Interaction with Other Ocean Users):

VSP Programs and Wellsite Surveys

a) The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and the local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained.
b) The operator should publish a Canadian Coast Guard "Notice to Mariners" and a "Notice to Fishers" via the CBC Radio program Fisheries Broadcast.
c) Operators should implement a gear and/or vessel damage compensation program, to promptly settle claims for loss and/or damage that may be caused by survey operations. The scope of the compensation program should include replacement costs for lost or damaged gear and any additional financial loss that is demonstrated to be associated with the incident. The operator should report on the details of any compensation awarded under such a program (i.e., to the C-NLOPB).
d) Procedures must be in place on the survey vessel(s) to ensure that any incidents of contact with fishing gear are clearly detected and documented (e.g., time, location of contact, loss of contact, and description of any identifying markings observed on affected gear). As per Section 5.2 of these Guidelines, any incident should be reported immediately to the 24-hour answering service at (709) 778-1400 or to the C-NLOPB Duty Officer.

2D, 3D and 4D Seismic Programs

In addition to the measures indicated above, the following mitigation measures should also be implemented:

a) Surveys should be scheduled, to the extent possible, to reduce potential for impact or interference with Department of Fisheries and Ocean (DFO) science surveys. Spatial and temporal logistics should be determined with DFO to reduce overlap of seismic operations with research survey areas, and to allow an adequate temporal buffer between seismic survey operations and DFO research activities.
b) Seismic activities should be scheduled to avoid heavily fished areas, to the extent possible. The operator should implement operational arrangements to ensure that the operator and/or its survey contractor and local fishing interests are informed of each other's planned activities. Communication throughout survey operations with fishing interests in the area should be maintained. The use of a 'Fisheries Liaison Officer' (FLO) onboard the seismic vessel is considered best practice in this respect.
c) Where more than one survey operation is active in a region, the operator(s) should arrange for a 'Single Point of Contact' for marine users that may be used to facilitate communication.

The following sections assess the potential effects of Project activities on the Fishery VEC.

5.8.5.1 Underwater Sound

As indicated in the description of commercial fisheries in Section 4.3, there has been substantial harvesting within NAFO Units 2G, 2H, 2J and 3K in the Study Area between 2005 and 2010. Northern shrimp and snow crab accounted for most of the commercial harvest within the Study Area during that period.

The potential for impacts on fish harvesting will, therefore, depend on the location and timing of the surveying activities in relation to these fishing areas, and the type of fishing gear used in any given season. If the survey work is situated away from these fishing areas or occur at different times, the likelihood of any impacts on commercial harvesting will be greatly reduced.

The DFO and joint DFO/Industry research surveys are also conducted using fishing gear. As such, the issues related to potential interference with DFO and joint DFO/Industry research surveys are much the same as for commercial fish harvesting (i.e., potential effects on catch rates and conflicts with research vessel operations).

Potential effects on marine fish behaviour are assessed in Section 5.8.4. While adult fish could be injured by airgun sound if they are within a few metres of a sound source, this is unlikely since fish are likely to disperse during array ramp-up or vessel approach. Therefore, the most likely type of effect will be behavioural. Seismic surveys could cause reduced trawl and longline catches during and following a survey if the fish exhibit behavioural changes (e.g., horizontal and vertical dispersion). There are various research studies on this subject as discussed in Section 5.8.4. While some of the behavioural effects studies report decreases in catch rates near the seismic survey area, there is some disagreement on the duration and geographical extent of the effect.

Mitigations

Mitigations are detailed in a previous section. The primary measures intended to minimize the effects of Project activities on the harvesting success component of the Fishery VEC include:

- Avoidance in time and space of concentrated fishing areas to the greatest extent possible;
- Good communications; and
- Deployment of Fisheries Liaison Officers (FLOs), for 2D/3D seismic programs.

The relevant guidelines state the following with respect to planning seismic surveys (in Appendix 2 of C-NLOPB [2012] - Environmental Planning, Mitigation and Reporting – I. Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment):

> Mitigation Measures
>
> a) Use the minimum amount of energy necessary to achieve operational objectives;
> b) Minimize the proportion of the energy that propagates horizontally; and
> c) Minimize the amount of energy at frequencies above those necessary for the purpose of the survey.

Avoidance

The potential effects of seismic sound on fishery catch success can be mitigated by avoiding heavily fished areas when these fisheries are active (specifically the shrimp and snow crab areas) to the greatest extent possible. As described in this report, most of the domestic fishing in the past has been concentrated in well-defined areas within the Study Area. During any seismic survey, the location of current fishing activities will be monitored by the ship and the FLO (see below), and fishing boats will be contacted by radio as required. Survey personnel (through the Single Point of Contact [SPOC], described below) will also continue to be updated about fisheries near the active survey area. The mapping of fishing activities contained in this EA report will also be an important source of fisheries information for the survey operators.

Communications

During the fisheries consultations for this and other surveys, fisheries representatives noted that good communication is one of the best ways to minimize interference between the seismic operations and fishing activities. Communication will be maintained (both directly at sea and through the survey SPOC) to facilitate information exchange, which includes such groups as DFO managers, independent fishers, representatives of fisheries organizations such as the FFAW, and managers of other key corporate fisheries in the area.

Relevant information about the seismic survey operations will also be transmitted using established communications mechanisms, such as the *Notices to Shipping* (Continuous Marine Broadcast and NavTex), the CBC (Newfoundland) Radio's *Fisheries Broadcast*, by the FFAW in the FFAW *Union Forum* (as suggested during previous consultations), and by direct communication between the seismic survey vessels and fishing vessels via marine radio at sea. This includes seismic survey vessel transit before and after the survey itself.

Fisheries Liaison Officer (FLO)

As a specific means of facilitating at-sea communications, and informing the 2D/3D survey vessel operators about local fisheries, when necessary MKI will have an on-board fisheries industry liaison officer serving as a "fisheries representative." The FLO will remain on the relevant survey vessel for the entire program. This will provide marine radio contact for all fishing vessels in the vicinity of seismic operations to discuss interactions and resolve any problems that may arise at sea. This person will inform the vessel's bridge personnel about any local fishing activities.

Assessment of the Effects of Seismic Survey Sound

Since commercial catches are quota-based, the overlap between fishing activity and seismic activity is unknown at the moment, but will be determined prior to the commencement of the seismic surveys. The best way to prevent overlap between the DFO and joint DFO/Industry research surveys is to exchange detailed locational information and establish a mutually-agreed temporal and spatial separation plan, as was implemented with DFO Newfoundland and Labrador in past seasons. With application of the mitigations discussed above, effects of seismic survey sound on the Fishery VEC are predicted to be a *negligible* to *low* magnitude during *1* to *12 months* over an area of *<1* to *100 km²* (Table 5.7). Based on these criteria ratings, the *reversible* residual effects of seismic survey sound on the Fishery VEC are predicted to be *not significant* (Table 5.8).

Table 5.7 Assessment of Effects of Project Activities on the Fisheries VEC.

Valued Environmental Component: Fisheries								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**[a]	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Sanitary/Domestic Waste	Taint (N); Perceived taint (N)	Treatment	0-1	1	4	2	R	2
Sound								
Airgun Array	Disturbance (N) Effect on catch rate (N)	Spatial or temporal avoidance [b]; communication	0-1	1-3	6	2	R	2
Seismic Vessel	Disturbance (N); Effect on catch rate (N)	Spatial or temporal avoidance [b]; communication	0	1	6	2	R	2
Picket vessel	Disturbance (N); Effect on catch rate (N)	Spatial or temporal avoidance [b]; communication	0	1	6	2	R	2
Echosounder	Disturbance (N); Effect on catch rate (N)	Spatial or temporal avoidance [b]; communication	0	1	6	2	R	2
Presence of Vessels:								
Seismic Vessel	Conflict with gear (N)[c]	Spatial or temporal avoidance [b]; FLOs; SPOC damage/loss compensation	0-1	1-3	6	2	R	2
Picket Vessel	Conflict with gear (N)[c]	Spatial or temporal avoidance [b]; FLOs; SPOC; damage/loss compensation	0-1	1-3	6	2	R	2
Accidental Releases	Taint (N); Perceived taint (N)	Solid streamer [d] Preventative protocols; Spill response plan; Communication	0-1	1-2	1	1	R	2

[a] Use of FLO for 2D/3D seismic programs
[b] To the extent possible.
[c] This is considered negligible since, if a conflict occurs, compensation will eliminate any economic impact.
[d] A solid streamer will be used for all seismic surveys.

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

Geographic Extent:
1 = <1-km²
2 = 1-10-km²
3 = 11-100-km²
4 = 101-1,000-km²
5 = 1,001-10,000-km²
6 = >10,000-km²

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not affected by human activity
2 = Evidence of existing effects

Table 5.8 Significance of Potential Residual Environmental Effects on the Fisheries VEC.

Valued Environmental Component: Fisheries				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood** [a]	
	Significance of Predicted Residual Environmental Effects		**Probability of Occurrence**	**Scientific Certainty**
Sanitary/Domestic Waste	NS	3	-	-
Sound				
Airgun Array	NS	2-3	-	-
Seismic Vessel	NS	3	-	-
Picket vessel	NS	3	-	-
Echosounder	NS	3		
Presence of Vessels				
Seismic Vessel and Streamers	NS	3	-	-
Picket Vessel	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

5.8.5.2 Vessel Presence (including towed seismic equipment)

Commercial fish harvesting activities occur throughout the May to November period being assessed. Of these, the fixed gear (e.g., pot fishery for snow crab, and to a lesser extent the Greenland halibut gillnet fishery) poses the highest potential for conflict, particularly if it is deployed concurrently with seismic survey operations. During 2D/3D seismic surveying, operations will be conducted continuously for 60 to <120 days. In 2014, the seismic survey is anticipated to require at least 90 days. Because of the length of the streamers being towed behind it, the maneuverability of a seismic vessel is restricted and other vessels must give way. As already noted in the EA, the turning radius required between each track line extends the assessment area beyond the actual survey project area (but stays within the Project Area). When gear conflict events occur, that damage gear or result in gear loss due to the survey, they will be assessed and compensation will be paid for losses attributable to the seismic survey.

Mitigation

Mitigations measures intended to minimize the conflict effects of Project activities on the fishing gear component of the Fishery VEC include:

- Avoidance to the extent possible;
- Communications;
- Fisheries Liaison Officers for 2D/3D seismic programs;
- Single Point of Contact; and
- Fishing Gear Compensation.

Avoidance

As discussed above, potential impacts on fishing gear will be mitigated by avoiding active fixed gear fishing areas during the seismic survey to the extent possible. If gear is deployed in a survey area, the diligence of the FLO, good at-sea communications and mapping of current fishing locations have usually proven effective at preventing such conflicts.

The principal mitigation will also be avoidance, based on route selection aimed at deviating around fixed gear fishing areas. Since the patterns of fishing vary by month, a final route, taking into account the avoidance of active areas, will be chosen shortly before the survey work begins. As noted above, a route analysis for this purpose will be prepared and discussions with fishing interests undertaken before the transits.

In addition to avoidance based on route analysis and selection, the onshore SPOC and the at-sea FLO will advise the vessel en-route to ensure fishing gear is avoided. In the case the avoidance mitigative measure fails, a gear damage program will be in place to compensate fishers whose gear is damaged or lost.

As with the commercial fishery, those involved in DFO and joint DFO/Industry research surveys will need to exchange detailed locational information with those involved in the seismic surveying. In 2002 when the plan was first implemented in the eastern Newfoundland Region, positional information was exchanged between DFO and the seismic survey company. A temporal and spatial separation plan was then agreed to with DFO and implemented by the seismic vessel to ensure that seismic operations did not interfere with the research survey. This included adequate "quiet time" before the research vessel arrived at its survey location. The avoidance protocol includes a 30 km (16 nmi) spatial separation and a seven day pre-research survey temporal separation.

Communications

During the fisheries consultations for this and other surveys, fisheries representatives noted that good communication is one of the best ways to minimize interference with fishing activities. Communications will be maintained (directly at sea, and through the SPOC) to facilitate information exchange with fisheries participants. This includes such groups as DFO managers, independent fishers, representatives of fisheries organizations such as the FFAW, and managers of other key corporate fisheries in the area.

Relevant information about the survey operations will also be publicized using established communications mechanisms, such as the *Notices to Shipping* (Continuous Marine Broadcast and NavTex), the CBC (Newfoundland) Radio's *Fisheries Broadcast*, by the FFAW in the FFAW *Union Forum* (as suggested during previous consultations), and by direct communication between the survey vessel and fishing vessels via marine radio at sea. This will also include information about transit routes.

Fisheries Liaison Officer (FLO)

As described above, the on-board fisheries industry FLO will provide a dedicated marine radio contact for all fishing vessels near 2D/3D project operations to help identify gear locations, assess potential interactions and provide guidance to those on the bridge, including during transit to and from St. John’s.

Single Point of Contact (SPOC)

The SPOC has become a standard and effective mitigation for all seismic surveys operating in this sector. MKI’s Environment Advisor/Lead or designate will serve as the survey's SPOC with the fishing industry, as described in the C-NLOPB Guidelines. The SPOC will endeavor to update vessel personnel (e.g. the FLO) about known fishing activities in the area, and will relay relevant information from DFO and fishing companies.

Fishing Gear Compensation

MKI has developed a fishing gear damage compensation policy consistent with C-NLOPB guidelines that will be filed with the Board in support of the *Authorization to Conduct a Geophysical Program* application. In case of accidental damage to fishing gear or vessels, MKI will implement gear damage compensation contingency plans to provide appropriate and timely compensation to any affected fishery participants. The Notices to Shipping, filed by the vessels for surveys and for transits to and from the survey sites, will also inform fishers that they may contact the SPOC if they believe that they have sustained survey-related gear damage.

Assessment of the Effects of Vessel and Seismic Equipment Presence

With application of the mitigations discussed above, effects of vessel presence, including all gear being towed by the seismic vessel, on the Fishery VEC are predicted to be a *negligible* to *low* magnitude during *1* to *12 months* over an area of *<1* to *100* km^2 (Table 5.7). Based on these criteria ratings, the *reversible* residual effects of vessel presence during the seismic program on the Fishery VEC are predicted to be *not significant* (see Table 5.8).

5.8.5.3 Other Project Activities

Sanitary/Domestic Wastes

Impacts related to physical effects on fish and invertebrates, including those potentially resulting from releases of sanitary/domestic wastes, are not discussed any further in this section because earlier assessment of the Fish and Fish Habitat VEC predicted that the residual effects of the wastes on that VEC would be *negligible* to *low* and hence *not significant*.

Accidental Releases

In the event of an accidental release of hydrocarbons (e.g., streamer breakage, fuel spill), there is some possibility of the perception of tainting of invertebrate and fish resources in the proximity of a release, even if there is no actual tainting. Perception alone can have economic effects if the invertebrates and fish lose marketability. Preventative measures/protocols, rapid response plans and good communications are essential mitigations to minimize the effects of any accidental hydrocarbon release. In the event of a release, the length of time that fish are exposed is a determining factor in whether or not their health is substantially affected or if there is actual or perceived tissue tainting. Streamer floatation fluid can be expected to dissipate relatively rapidly. Any effect on access to fishing grounds would be of relatively short duration. In the unlikely event of a substantial hydrocarbon release, the need of compensation for commercial fishers will be determined through the C-NLOPB's guidelines.

With application of the mitigations discussed above, the effect of accidental hydrocarbon releases on the Fishery VEC is predicted have a *negligible* to *low* magnitude during *<1 month* over an area of *<1* to *10* km^2 (see Table 5.7). Based on these criteria ratings, the *reversible* residual effects of accidental releases on the Fishery VEC during the seismic program are predicted to be *not significant* (see Table 5.8).

5.8.6 Marine Birds VEC

There are three main types of potential impacts to seabirds from offshore seismic exploration: (1) attraction to ship lights at night, (2) underwater sound from airgun arrays, and (3) accidental release of fuel. Potential interactions between the Project and seabirds are shown in Table 5.9.

Table 5.9 Potential Interactions between the Project and Seabird VEC.

Project Activities	Valued Environmental Component: Seabirds
Vessel Lights	X
Sanitary/Domestic Waste	X
Atmospheric Emissions	X
Garbage[a]	
Sound	
Airgun Array	X
Seismic Vessel	X
Picket Vessel	X
Echosounder	X

Project Activities	Valued Environmental Component: Seabirds
Helicopter [b]	X
Presence of:	
Seismic Vessel	X
Picket Vessel	X
Helicopter[b]	X
Shore Facilities[c]	
Accidental Releases	X
Other Projects and Activities	
Oil and Gas Activities on Labrador Shelf	X
Oil and Gas Activities on Grand Banks	X
Fisheries	X
Marine Transportation	X

[a] Not applicable as garbage will be brought ashore.
[b] No helicopter use is planned for 2014, but helicopters may be used during programs in 2015-2018.
[c] There will not be any new onshore facilities; existing infrastructure will be used.

5.8.6.1 Vessel Lights

Nocturnally-active seabirds can be attracted to artificial lighting at night. This includes lights at coastal lighthouses and lights on vessels at sea (Montevecchi et al. 1999). Seabirds as well as migrating landbirds have been attracted to lights on offshore oil and gas platforms, especially during foggy or overcast conditions (Montevecchi 2006). Several studies of seabird attraction to artificial lighting on offshore and coastal structures and vessels have been conducted (see Husky 2012 for a review). The birds may become injured by flying directly into, and striking, the source of light or the ship infrastructure (Dick and Donaldson 1978; Telfer et al. 1987; Black 2005; Russell 2005; Poot et al. 2008; Rodríguez and Rodríguez 2009). However, most mortality occurs because these birds enter and become trapped in the partially enclosed areas of ships. On seismic vessels, stranded birds are often found on streamer and airgun decks, where they are unable to find their way out (LGL, unpubl. data). They fly about until exhausted and drop to the deck, after which they succumb to dehydration, starvation, exhaustion, or hypothermia. The latter occurs as a result of falling into the drip trays under winches used to deploy streamers or airgun hoses, where they come into contact with water and hydraulic fluid or streamer fluid. Birds may be attracted to artificial lighting from a distance of up to 5 km in the case of offshore oil/gas installations with 30 kW of lighting (Poot et al. 2008).

Attraction to artificial lighting and attendant grounding appears to be widespread among procellariiform seabird species (i.e., petrels, shearwaters, prions, storm-petrels, and diving-petrels [Pelecanoididae] but not albatrosses Diomedeidae), having been observed in more than 20 species (Imber 1975; Reed et al. 1985; Telfer et al. 1987; Le Corre et al. 2002; Black 2005; Montevecchi 2006; Abgrall et al. 2008a Rodríguez and Rodríguez 2009; Miles et al. 2010; Howell 2012). Leach's Storm-Petrel is the seabird most often attracted to lights at night in Newfoundland and Labrador waters.

Small colonies of nesting Leach's Storm-Petrels occur in Newfoundland not too distant from the Study Area and small numbers of storm-petrels forage offshore. Leach's Storm-Petrels are present in Labrador and northern Newfoundland waters from April to October. The period of greatest risk of attraction to offshore lights is thought to be September when adults and newly fledged chicks are dispersing from nesting colonies and moving to offshore wintering grounds (Williams and Chardine n.d.).

Young-of-the-year birds appear to be more susceptible to light attraction than are adults, but the extent of storm-petrel susceptibility is unclear. Leach's Storm-Petrel and other birds have regularly stranded on previous seismic and controlled source electromagnetic surveys in Newfoundland waters (Moulton et al. 2005, 2006a; Lang et al. 2006; Lang and Moulton 2008; Abgrall et al. 2008a). During seismic monitoring programs conducted in Atlantic Canada (from 2003-2012), LGL MMOs recovered 877 Leach's Storm-Petrels (B. Mactavish, LGL, unpub. data, March 2013). The maximum number of stranded petrels recovered by LGL MMOs in a single night was 46. A detailed review of the issue is contained in the White Rose Extension Project EA (Husky 2012).

Monitoring and mitigation measures to rescue stranded storm-petrels on board the seismic vessel will be the responsibility of the MMO. The MMO will check all open decks daily for stranded birds, and ask ship crew to notify them of any stranded birds that they find. As noted in Section 5.6, procedures developed by the CWS and Petro-Canada (now Suncor) will be used to handle the birds and gently release them (Williams and Chardine, n.d.). Other vessels working on the project will be made aware of the potential problem of storm-petrels stranding on their vessels. Each vessel will have a copy of the manual developed by CWS and Petro-Canada (now Suncor) on proper procedure and handling of stranded storm-petrels (Williams and Chardine, n.d.). MKI acknowledges that a Federal *Migratory Bird Salvage Permit* will be required. Deck lighting will be minimized (if it is safe and practical to do so) to reduce the likelihood of stranding. A report documenting each stranded bird, including the date, global position, and the general condition of the feathers when found, and if releasable, the condition upon release, will be completed and delivered to the CWS by the end of the calendar year. Mitigation and monitoring for stranded birds will reduce effects of attraction to lights to a *low* magnitude, over a geographic extent of *1-10* km^2, and for a duration of *1-12 months* (Table 5.10). Thus, effects are predicted to be *not significant* (Table 5.11).

5.8.6.2 Sanitary/Domestic Waste

Sanitary waste generated by the vessels will be macerated before subsurface discharge, following requirements described in Section 5.6. While it is possible that seabirds (mostly gulls) may be attracted to the sewage particles, the small amount discharged below surface over a limited period of time will be unlikely to increase the far-offshore gull populations. Thus, any increase in gull predation on Leach's Storm-Petrels, as suggested by Stenhouse and Montevecchi (1999), is likely to be minimal. The number of smaller seabirds (e.g., storm-petrels) predated will likely be low and effects are predicted to be *negligible* to *low* magnitude within in area of $<1\ km^2$, for a duration of *1-12 months* (Table 5.10). Thus, effects are predicted to be not significant (Table 5.11).

5.8.6.3 Atmospheric Emissions

Although atmospheric emissions could, in theory, affect the health of some resident marine seabirds, the effects will be *negligible*, because emissions of potentially harmful materials will be small (especially using low 1% sulphur fuel) and they will rapidly disperse to undetectable levels due to their volatility, temperature of emission, and the exposed and often windy nature of the offshore.

Table 5.10 Assessment of Effects of Project Activities on the Seabird VEC.

Valued Environmental Component: Seabirds									
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects						
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Vessel Lights	Attraction (N)	Search/rescue Strandings; reduce lighting (if possible)	1	2	2-3	2	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment / containment	0-1	1	4	2	R	2
Atmospheric Emissions	Air Contaminants (N)	Low sulphur fuel (1%)	0	1	6	2	R	2
Sound								
Airgun Array	Disturbance (N)		0-1	1-2	6	2	R	2
Airgun Array	Physical Effects (N)	Ramp-up	0-1	1	6	2	R	2
Seismic Vessel	Disturbance (N)		0-1	1	6	2	R	2
Picket Vessel	Disturbance (N)		0	1	6	2	R	2
Echosounder	Disturbance (N)		0-1	1	6	2	R	2
Helicopter [a]	Disturbance (N)	Maintain high altitude	0-1	1	1	2	R	2
Presence of:								
Seismic Vessel	Disturbance (N)	Stranding protocol	0	2	6	2	R	2
Picket Vessel	Disturbance (N)	Stranding protocol	0	2	6	2	R	2
Helicopter [a]	Disturbance (N)	Maintain high altitude	0-1	2	1	2	R	1
Accidental Releases	Mortality (N)	Solid streamer[b]; spill response	1	1-2	1	1	R	2

[a] No helicopter use is planned for 2014, but helicopters may be used during programs in 2015-2018.
[b] A solid streamer will be used for all seismic surveys.

Key:

Magnitude:
0 = Negligible, (essentially no effect)
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not affected by human activity
2 = Evidence of existing effects

Table 5.11 Significance of Potential Residual Environmental Effects of the Project on the Seabird VEC.

Valued Environmental Component: Seabirds				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood [a]**	
	Significance of Predicted Residual Environmental Effects		**Probability of Occurrence**	**Scientific Certainty**
Vessel Presence/Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Sound				
Airgun Array	NS	3	-	-
Seismic Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Echosounder	NS	3	-	-
Helicopter	NS	3	-	-
Presence of:				
Seismic Vessel	NS	3	-	-
PicketVessel	NS	3	-	-
Helicopters	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

5.8.6.4 Sound

The effects of underwater sound on birds have not been well studied. Birds have good hearing abilities in air (Fay 1988), but much of what is believed about their hearing ability under water is inferred from mammals. Hearing thresholds (the minimum sound pressure levels at which a sound can be detected) in birds are probably higher in water than in air, as is the case with humans (Dooling and Therrien 2012). In addition, the frequency of best hearing in birds is probably lower in water than air, as it is with humans. However, the feathers that cover birds' ears may affect hearing. The muscles attached to the feather shafts contract during dives, forming a waterproof seal that probably prevents water from entering the auditory meatus.

Stemp (1985) made observations on the reactions of birds to seismic exploration programs in southern Davis Strait over three summer periods. No mortality or effects on distribution were detected in 1982, the only year when an airgun-based program was conducted. John Parsons (*in* Stemp 1985) reported that shearwaters off Sable Island, Nova Scotia, did not respond to underwater explosive charges 30 m away, even though the birds' heads were underwater. Evans et al. *(*1993) made observations from operating seismic vessels in the Irish Sea. They noted that when seabirds were near the seismic boats, "there was no observable difference in their behaviour, birds neither being attracted nor repelled by seismic testing".

Observations of free-ranging moulting Long-tailed Ducks (*Clangula hyemalis*) in the Beaufort Sea showed little effect on the ducks' movements or diving behaviour (Lacroix et al. 2003). However, the study did not monitor potential physical effects on the ducks. The authors suggested caution in interpretation of the data because they were limited in their ability to detect subtle disturbance effects and recommended studies on other species to fully understand the effects of seismic testing. This lack of overt response may be at least partly related to the fact that received levels of underwater sound from airguns are greatly reduced at and immediately below the surface as compared with levels deeper in the water (Greene and Richardson 1988).

Most species of seabirds that are expected to occur in the Study Area typically feed at the surface or at less than one metre below the surface of the ocean (see Table 4.9 in Section 4.4). This includes *Procellariidae* (Northern Fulmar, Great Shearwater, Sooty Shearwater, and Manx Shearwater), *Hydrobatidae* (Leach's Storm-Petrel), *Phalaropodinae* (Red Phalarope and Red-necked Phalarope), *Laridae* (Pomarine Jaeger, Parasitic Jaeger, Long-tailed Jaeger, Herring Gull, Glaucous Gull, Black-legged Kittiwake, and Arctic Tern). These species are under the surface for a few seconds during each dive so would have minimal opportunity to receive underwater sound. Northern Gannet plunge dives deeper, to a depth of 10 m. They are under the surface for a few seconds during each dive so would have minimal exposure to underwater sound. Great Shearwater, Sooty Shearwater, and Manx Shearwater feed mainly at the surface but also chase prey briefly beneath the surface down to a depth of two to ten metres (Brown et al. 1978, 1981).

Diving seabirds are more likely to be affected than are birds that remain at or near the surface of the water. The *Alcidae* are one group of birds that spends considerable time under water at various depths to hunt for food and require a significant length of time to secure food (see Table 4.9 in Section 4.4). This group includes Dovekie, Common Murre, Thick-billed Murre, Razorbill and Atlantic Puffin. From a resting position on the water, they dive under the surface in search of small fish and invertebrates. Alcids use their wings to propel their bodies rapidly through the water. All are capable of reaching considerable depths and spending considerable time under water (Gaston and Jones 1998). An average duration of dive times for the five species of *Alcidae* is 25 to 40 seconds reaching an average depth of 20 to 60 m, but murres are capable of diving to 120 m and have been recorded underwater for up to 202 seconds (Gaston and Jones 1998).

The sound created by airguns is focused downward below the surface of the water. Above the water, the sound is greatly reduced and should have little or no effect on birds that have their heads above water or are in flight. It is possible birds on the water at close range would be startled by the sound, however, the presence of the ship and associated gear dragging in the water should have already warned the bird of unnatural visual and auditory stimuli.

The effects of underwater sounds on *Alcidae* are unknown. Sounds are probably not important to *Alcidae* in securing food. However, all six species are quite vocal at breeding sites indicating auditory capabilities are important in that part of their life cycle. The 'laughing call' of the Thick-billed Murre is shown to cover a frequency range of 1.0 to 4.0 kHz (Gaston and Jones 1998). While supporting data on actual effects are few, it is predicted that there will be *no significant effects* (see Table 5.11) on seabirds from the sound because the magnitude of the effect (if it occurs) will be *negligible* to *low*, the geographic extent will be small (probably *<1 km²* to *1-10 km*^{2}), and duration will be *1-12 months* (see Table 5.10).

There are no specific data on the levels of low-frequency underwater sound that are harmful to seabirds, or that cause temporary hearing impairment (TTS). TTS is known to occur in birds exposed to strong, prolonged sounds in air (Saunders and Dooling 1974). Whether TTS could occur in waterbirds that are exposed relatively briefly to intermittent pulses of airgun sound close to an operating airgun array is unknown. TTS is, by definition, only temporary. Indeed, the auditory systems of birds, unlike mammals, have some capability to recover even from exposure to sounds that are strong enough to cause direct auditory injury (Corwin and Cotanche 1988). The presence of the survey vessel and perhaps the ramp-up period for the airguns will displace birds from the immediate program area. Thus, any effects of seismic exploration sounds (from the airgun array and ships) on birds in the Study Area are expected to be *not significant* (see Table 5.11) because the magnitude of the effect (if it occurs) will be *negligible* to *low*, the geographic extent will be small (probably *<1 km²* to *1-10 km*^{2}), and duration will be *1-12 months* (see Table 5.10).

Helicopter flights are not planned for the 2014 program, but may occur during the 2015-2018 programs. However, even if flights do occur they will be infrequent and of short duration. Seabirds are expected to flush or dive in response to the sounds from helicopter flights to and from the seismic vessel, thus physical damage to seabirds is also not expected as birds will avoid the area near the helicopter. Any effects will be transitory. Helicopter flights will be operated at a minimum altitude of 300-450 m (~1,000-1,500 ft) when in transit to minimize any potential effects on seabirds. Effects on sea-associated birds will be of *negligible* to *low* magnitude within and area *<1 km*^{2}, for a duration of *1-12 months* (see Table 5.10). Thus, effects are predicted to be *not significant* (see Table 5.11).

5.8.6.5 Presence of Vessels and Helicopters

The seismic vessel and picket vessel could potentially affect birds through discharges, lights, noise and physical presence of the structures. The potential effects of discharges, lights and noise from vessels have been discussed in previous sections. Potential effects related to physical presence of structures are likely minimal. Seabirds may be attracted to the seismic or picket vessel while prospecting for fish wastes associated with fishing vessels. Since there is little or no food made available by these vessels seabird have a short term interest in the vessels and soon go elsewhere in search of food. Seabirds sitting on the water in the path of these vessels can readily move out of the way. The physical presence of the vessels will have a *negligible* effect that is *not significant* on seabirds (see Tables 5.10 and 5.11).

5.8.6.6 Accidental Releases

The primary accidental event associated with the seismic program that could have environmental consequences of concern is the unintentional release of fuel from project vessels. Solid streamers will be used during the 2014 2D seismic survey, which will eliminate the risk of streamer leakage. It is expected that solid streamers also will be used during the subsequent 2D and 3D seismic surveys (2015-2018), but details have not been finalized yet. Consequently, spills from broken liquid-filled streamers are not expected. All fuel handling and reporting procedures on board will be consistent with MKI's policy, and handling and reporting procedures. A fuel spill may occur from the seismic ship and/or the picket vessel—both vessels will use marine gas oil. Marine gas oil is a low sulphu, light fuel that persists in the environment for much shorter periods than does crude oil or heavy fuel oils such as Bunker C. In cold water, only about 50% of the spilled gas oil would remain on the water surface after 12 hours (Smith and McIntyre 1971). Thus, a spill of gas oil would not persist for long periods on the water surface. About half of the oil lost from the surface is dispersed in the water column and about half is lost to evaporation (Birchard and Nancarrow 1986). Once in the water column, the half-life of diesel at 0º to 2ºC may be more than 10 days (Gearing and Gearing 1982). Any spills would likely be small and quickly dispersed by wind, wave, and ship's propeller action. The effects of hydrocarbon spills on seabirds were reviewed in Husky (2012) and are not repeated in detail here.

The reported effects of hydrocarbon spills on seabirds vary with species, type of hydrocarbon, weather conditions, time of year and duration of the spill (Gorsline et al. 1981). Exposure to oil causes thermal and buoyancy deficiencies that typically lead to the deaths of affected marine birds. Although some may survive these immediate effects, long-term physiological changes may eventually result in death (Ainley et al. 1981; Burridge and Kane 1985; Frink and White 1990; Fry 1990). For some individual birds, oiling has not had lethal or marked sublethal effects. Among oiled, colour-banded Herring Gulls and Lesser Black-backed Gulls (*Larus fuscus*), most survived and cleaned themselves with a few weeks of oiling, some bred successfully and survived up to 20 years after oiling (Camphuysen 2011).

Exposure to fuel under calm conditions may harm or kill individual birds. Potential spills will likely be small and evaporation and dispersion rapid (particularly given the fuel type). Spill response plans (SOPEPs) and equipment will be in place. Effects of a small accidental spill on seabirds would be of *low* magnitude, over a duration of *<1 month,* in an area *<1* km^2 to *1-10* km^2 and effects are judged to be *not significant* (see Tables 5.10 and 5.11).

Waters off the southeast coast of Newfoundland are a major junction for international marine traffic destined for Canadian and U.S. ports. Analyses of the oil involved in bird strandings show that wastes are composed of mixtures of bunker C and marine diesel, indicating origins in the engine room bilges of ocean-going ships (Lock and Deneault 2000). The illegal discharge of oily bilge water off the southeast coast of Newfoundland is a chronic problem (Wiese and Ryan 1999, 2003). MKI project vessels will not engage in the illegal discharge of oily bilge water.

5.8.7 Marine Mammal and Sea Turtle VEC

The potential effects of seismic activities on marine mammals and sea turtles have previously been reviewed in the Labrador Shelf SEA and recent seismic EAs for the Labrador Sea (LGL and GXT

2013—Section 5.8.7; LGL 2010—Section 5.7.7), as well as for several 3D seismic projects in the Jeanne d'Arc Basin on the Grand Banks (e.g., LGL 2005b—Section 6.5.12; LGL 2007—Section 5.6.6; LGL 2008—Section 5.6.4), and other reviews (e.g., Richardson et al. 1995; Gordon et al. 2004; Stone and Tasker 2006; Southall et al. 2007; Abgrall et al. 2008b). The following review is based largely on these documents with new and relevant literature included.

The assessment of impacts is based on the best available information; however, there are data gaps that limit the certainty of these impact predictions. We have discussed potential impacts separately for toothed whales, baleen whales, seals, polar bears, and sea turtles given their different hearing abilities and sensitivities to sound. Potential interactions between Project activities and marine mammals and sea turtles are shown in Table 5.12.

Table 5.12 Potential interactions between the Project and the Marine Mammal and Sea Turtle VECs.

	Valued Environmental Components				
Project Activities	**Toothed Whales**	**Baleen Whales**	**Seals**	**Polar Bears**	**Sea Turtles**
Vessel Lights					
Sanitary/ Domestic Waste	X	X	X	X	X
Atmospheric Emissions	X	X	X	X	X
Garbage [a]					
Sound					
Seismic Vessel	X	X	X	X	X
Seismic Array	X	X	X	X	X
Picket Vessel	X	X	X	X	X
Echosounder	X	X	X	X	X
Helicopter [b]	X	X	X	X	X
Presence of:					
Seismic Vessel	X	X	X	X	X
Picket Vessel	X	X	X	X	X
Helicopter [b]	X	X	X	X	X
Shore Facilities [c]					
Accidental Releases	X	X	X	X	X
Other Projects and Activities					
Oil and Gas Activities in the Labrador Sea	X	X	X	X	X
Oil and Gas Activities on the Grand Banks	X	X	X	X	X
Fisheries	X	X	X	X	X
Marine Transportation	X	X	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] No helicopter use is planned for 2014, but helicopters may be used during programs in 2015-2018.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

5.8.7.1 Effects of Seismic Sound

The potential effects of sound from airgun arrays on marine mammals and sea turtles are a common concern associated with seismic programs. Airgun arrays used during marine seismic operations introduce strong sound impulses into the water. These sound impulses could have several types of effects on marine mammals and sea turtles and are the main issue associated with the proposed seismic surveys. The effects of human-generated noise on marine mammals are quite variable and depend on numerous factors, including: species, activity of the animal when exposed to the noise, and distance of the animal from the sound source. This section includes a brief summary of the anticipated potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles. More comprehensive reviews of the relevant background information for marine mammals and sea turtles appear in Appendices 4 and 5, respectively. Descriptions of the hearing abilities of marine mammals and sea turtles are also provided in Appendices 4 and 5, respectively.

The potential effects of airgun sounds considered in this assessment include: masking of natural sounds, behavioural disturbance, non-auditory physical or physiological effects, and at least in theory, temporary or permanent hearing impairment (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). Permanent hearing impairment or permanent threshold shift (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not an injury (Southall et al. 2007). Although the possibility cannot be entirely excluded, it is unlikely that the program would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals or sea turtles encounter the survey while it is underway, some behavioural disturbance could result, but this would be localized and short-term.

Masking

Masking is the obscuring of sounds of interest by interfering sounds, generally at similar frequencies. Masking can occur if the frequency of the source is close to that used as a signal by the marine mammal and if the anthropogenic sound is present for a significant fraction of time (Richardson et al. 1995; Clark et al. 2009). Conversely, masking is not expected if little or no overlap occurs between the introduced sound and the frequencies used by the species or if the introduced sound is infrequent. Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, marine mammals and sea turtles can emit and receive sounds in the relatively quiet intervals between pulses. Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the seismic pulses. The sounds important to toothed whales and pinnipeds are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. Based on reviewed research, the potential for masking of marine mammal calls and/or important environmental cues is considered quite low from the proposed seismic program. Thus, masking is unlikely to be a significant issue for either marine mammals or sea turtles exposed to the sounds from seismic surveys.

Disturbance by Seismic Vessels

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007). If a marine mammal or sea turtle does react briefly to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals or sea turtles from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder 2007; Weilgart 2007).

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behaviour appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

Little systematic information is available on reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessel. In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance. The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels. Captive bottlenose dolphins and beluga whales exhibited changes in behaviour when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviours. Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes.

Pinnipeds tend to be less responsive to airgun sounds than many cetaceans and are not likely to show a strong avoidance reaction to the airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behaviour. Based on available data, it is likely that sea turtles would exhibit behavioural changes and/or localized avoidance near a seismic vessel. To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate are likely to have the greatest impact. However, turtles are rare in the Project Area off Labrador.

Hearing Impairment Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed in Southall et al. 2007). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions. Current U.S. NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and 190 dB re 1 μPa_{rms}, respectively (NMFS 2000). Those criteria have been used in establishing the safety (=shut-down) radii planned for numerous seismic surveys conducted under U.S. jurisdiction and in some parts of Canada. However, those criteria were established before there was any information about the minimum received levels of sounds necessary to cause TTS in marine mammals. The 180 dB criterion for cetaceans is probably quite conservative (i.e., lower than necessary to avoid auditory injury), for at least some species including bottlenose dolphin and beluga.

Recommendations for science-based noise exposure criteria for marine mammals were published by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. NMFS is currently moving toward adoption of new procedures taking at least some of the Southall et al. recommendations into account (Scholik-Schlomer 2012; NMFS 2013). The new noise exposure criteria for marine mammals will account for the now-available scientific data on TTS, the expected offset between the TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive (e.g., M-weighting or generalized frequency weightings for various groups of marine mammals, allowing for their functional bandwidths), and other relevant factors.

There is substantial overlap in the frequencies that sea turtles detect vs. the frequencies in airgun pulses. Sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs. However, monitoring studies show that some sea turtles do show localized movement away from approaching airguns. At short distances from the source, received sound levels diminish rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals and sea turtles occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. In addition, many cetaceans and (to a limited degree) pinnipeds and sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid the possibility of hearing impairment.

Non-auditory Physical Effects

Non-auditory physical effects may also occur in marine mammals and sea turtles exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur include stress, neurological effects, and organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, there is no definitive evidence that any of these effects occur even for marine mammals or sea turtles in close proximity to large arrays of airguns. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioural avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, as well as sea turtles, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given animal and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals and sea turtles to sounds strong enough to induce non-auditory physical effects.

Sound Criteria for Assessing Impacts

Impact zones for marine mammals are commonly defined by the areas within which specific received sound level thresholds are exceeded. The U.S NMFS (1995, 2000) has concluded that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa_{rms}. The corresponding limit for seals has been set at 190 dB re 1 μPa_{rms}. These sound levels are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS, one cannot be certain that there will be no injurious effects, auditory or otherwise, to marine mammals. For over a decade, it has been common for marine seismic surveys conducted in some areas of U.S. jurisdiction and in some areas of Canada (Canadian Beaufort Sea and on the Scotian Shelf), to include a "shutdown" requirement for cetaceans based on the distance from the airgun array at which the received level of underwater sounds is expected to diminish below 180 dB re 1 μPa_{rms}. An additional criterion that is often used in predicting "disturbance" impacts is 160 dB re 1 μPa; at this received level, some marine mammals exhibit behavioural effects. There is ongoing debate about the appropriateness of these parameters for impact predictions and mitigation (see Appendix 4).

For marine seismic programs in Newfoundland and Labrador, the C-NLOPB (2012) recommends that seismic operators follow the "*Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*" (hereafter referred to as the *Statement*) issued by the DFO. The *Statement* does not include noise criteria as part of the recommended mitigation measures, rather it defines (see Point 6.a) a safety zone as "a circle with a radius of at least 500 metres as measured from the centre of the air source array (s)".

Assessment of Effects of Sound on Marine Mammals

The marine mammal effects assessment is summarized in Table 5.13 and discussed in detail below.

Toothed Whales

Despite the relatively poor hearing sensitivity of toothed whales (at least the smaller species that have been studied) at the low frequencies that contribute most of the energy in seismic pulses, sounds are sufficiently strong that they remain above the hearing threshold of odontocetes at tens of kilometres from the source. Species of most concern are those that are designated under *SARA* Schedule 1 and that may occur in and near the Project Area (i.e., northern bottlenose whale, Sowerby's beaked whale). Beluga whales, killer whales, and harbour porpoises, all with special status by COSEWIC (the harbour porpoise is also listed as *threatened* under Schedule 2 of *SARA*), are not expected to occur in large numbers in the Project Area. The received sound level of 180 dB re 1 μPa_{rms} criterion is accepted as a level that below which there is no physical effect on toothed whales. It is assumed that disturbance effects for toothed whales may occur at received sound levels at or above 160 dB re 1 μPa_{rms}. However, it is noted that there is no good scientific basis for using this 160 dB criterion for odontocetes and that a 170 dB re 1 μPa_{rms} is a more realistic indicator of the area within which disturbance is likely (see Appendix 4).

Table 5.13 Assessment of Effects of Project Activities on Marine Mammals.

Valued Environmental Components: Marine Mammals								
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment; containment	0-1	1	4	2	R	2
Atmospheric Emissions	Surface Contaminants (N)	Low sulphur fuel	0	1	6	2	R	2
Sound								
Airgun Array	Hearing Impairment (N) Physical Effects (N)	Pre-watch; Ramp-up; Delay Start; Shutdown[a]	0-1	1-2	6	2	R	2
Airgun Array	Disturbance (N)	Pre-watch; Ramp-up; Delay Start; Shutdown[a]	1	3-4	6	2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Picket Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Echosounder	Disturbance (N)		0-1	1	6	2	R	2
Helicopter[b]	Disturbance (N)		0-1	1-2	1	2	R	2
Presence of:								
Seismic Vessel	Disturbance (N)		0-1	1	6	2	R	2
Picket Vessel	Disturbance (N)		0-1	1	6	2	R	2
Helicopter[b]	Disturbance (N)	Maintain high altitude	0-1	1-2	1	2	R	2
Accidental Releases	Injury/Mortality (N)	Solid streamer[c]; Spill Response	1	1-2	1	1	R	2

[a] The airgun arrays will be shutdown if an *endangered* (or *threatened*) marine mammal or sea turtle is sighted within 500 m of the array.
[b] No helicopter use is planned for 2014, but helicopters may be used during programs in 2015-2018.
[c] A solid streamer will be used for all seismic surveys.

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

Hearing Impairment and Physical Effects

Given that whales typically avoid at least the immediate area around seismic (and other strong) noise sources, whales in and near the Project Area will likely not be exposed to levels of sound from the airgun array that are high enough to cause non-auditory physical effects or hearing impairment. It is highly unlikely that toothed whales will experience mortality or strand as a result of Project activities. The mitigation measure of ramping-up the airgun array (over a 30 min period) should allow whales close to the airguns to move away before the sounds become sufficiently strong to have potential for hearing impairment. Also, the airgun array will not be started if a toothed whale is sighted within the 500 m safety zone. There is reduced potential for toothed whales being close enough to the array to experience hearing impairment. If some whales did experience TTS, the effects would likely be quite "temporary". As per Table 5.13, MKI's seismic program is predicted to have *negligible* to *low* hearing impairment/physical effects on toothed whales, over a duration of *1 to 12 months*, in an area *<1 km^2* to *1-10 km^2*. Therefore, hearing impairment and/or physical effects on toothed whales are judged to be *not significant* (Table 5.14).

Table 5.14 Significance of Potential Residual Environmental Effects of the Proposed Seismic Program on Marine Mammals.

Valued Environmental Component: Marine Mammals				
Project Activity	Significance Rating	Level of Confidence	Likelihood [a]	
	Significance of Predicted Residual Environmental Effects		Probability of Occurrence	Scientific Certainty
Vessel Presence/Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Sound				
Array – hearing/physical effects	NS	2	-	-
Array – behavioural effects	NS	3	-	-
Seismic Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Echosounder	NS	3	-	-
Helicopter	NS	3	-	-
Presence of:				
Seismic Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Accidental Releases	NS	3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect
Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence
Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

Disturbance Effects

Based on our review, there could be behavioural effects on some species of toothed whales within the Project Area. Known effects may range from changes in swimming behaviour to avoidance of the seismic vessel. Based on available literature, a 160 dB re 1 μPa_{rms} sound level is used to assess disturbance effects, more specifically potential displacement from the area around the seismic source. This is likely a conservative criterion since some toothed whale species:

- have been observed in other areas relatively close to an active seismic source where received sound levels are greater than 160 dB; and
- individuals which may be temporarily displaced from an area will not be significantly impacted by this displacement.

It is uncertain how many toothed whales may occur in the Study Area at various times of the year. The Study Area is not known to be an important feeding or breeding areas for toothed whales (however, there has been little research to verify this). As per Table 5.13, disturbance effects from Project activity noise on toothed whales would likely be *low*, over *1 to 12 months*, in an area of *11-100* or *101-1,000* km^2. Therefore, potential effects related to disturbance, are judged to be *not significant* for toothed whales (see Table 5.14).

Prey Species

It is unlikely that prey species for toothed whales will be impacted by seismic activities to a degree that inhibits their foraging success. If prey species exhibit avoidance of the seismic ship it will likely be transitory in nature (see Sections 5.7.5 and 5.7.6) and over a small portion of a whale's foraging range within the Project Area. Potential effects of reduced prey availability on toothed whales are predicted to be *negligible*.

Baleen Whales

Baleen whales are thought to be sensitive to low-frequency sounds such as those that contribute most of the energy in seismic pulses. Species of most concern are those that are designated under *SARA* Schedule 1 and that may occur in and near the Project Area (i.e., blue and fin whales). As with toothed whales, the 180 dB re 1 μPa_{rms} criterion is used when estimating the area where hearing impairment and/or physical effects may occur for baleen whales (although there are no data to support this criterion for baleen whales). For all baleen whale species, it is assumed that disturbance effects (avoidance) may occur at sound levels greater than 160 dB re 1 μPa_{rms}.

Hearing Impairment and Physical Effects

Given that baleen whales typically exhibit at least localized avoidance of seismic (and other strong) noise, baleen whales will likely not be exposed to levels of sound from the airgun array high enough to cause non-auditory physical effects or hearing damage. The mitigation measure of ramping-up the airgun array should allow any whales close to the airguns to move away before the sounds become sufficiently strong to have potential for hearing impairment. Also, the airgun array will not be started if a baleen whale is sighted within the 500 m safety zone. Therefore, there is reduced potential for baleen whales being close enough to the array to experience hearing impairment. If some whales did experience TTS, the effects would likely be quite "temporary". As per Table 5.13, MKI's seismic program is predicted to have *negligible to low* hearing impairment effects on baleen whales, over a duration of *1 to 12 months*, in an area *<1* km^2 to *1-10* km^2. Therefore, hearing impairment and/or physical effects on baleen whales are judged to be *not significant* (see Table 5.14).

Disturbance Effects

Based on the above review, there could be behavioural effects on some species of baleen whales within and near the Project Area. Reported effects range from changes in swimming behaviour to avoidance of the seismic vessel. The area where displacement would most likely occur would have a predicted scale of impact at *11-100* km^2 to *101-1,000* km^2. This is likely a conservative estimate given that:

- some baleen whale species have been observed in areas relatively close to an active seismic source; and
- it is unlikely that displacement from an area constitutes a significant impact for baleen whales in the Project Area.

It is uncertain how many baleen whales may occur in the Study Area during the period when seismic activity is most likely to occur (May to November). The Project Area is not known to be an important feeding or breeding area for baleen whales. As per Table 5.13, disturbance effects on species of baleen whales would likely be *low*, over a duration of *1 to 12 months*, in an area of *11-100* km^2 to *101- 1,000* km^2. Therefore, effects related to disturbance, are judged to be *not significant* for baleen whales (see Table 5.14).

Prey Species

It is unlikely that prey species for baleen whales, particularly euphausiids, will be impacted by seismic activities to a degree that inhibits their foraging success. If prey species exhibit avoidance of the seismic ship it will likely be transitory in nature (see Sections 5.7.5 and 5.7.6) and over a small portion of a whale's foraging range within the seismic area. Potential effects of reduced prey availability on baleen whales are judged to be *negligible*.

Seals

Seals are not expected to be abundant within the Study Area, particularly in the time period when seismic operations will likely occur. Harp, hooded, and ringed seals are expected to have a more northerly distribution during the survey period, although they could be moving through the Study Area. Grey and harbour seals are likely not very abundant and would be most common in coastal areas. None of the species of seal that occur within the Study Area are considered at risk by COSEWIC or are designated on a *SARA* schedule (although some are COSEWIC *candidate species*, see Section 4.6).

Hearing Impairment and Physical Effects

Given that seals typically avoid the immediate area around a seismic array, seals are unlikely to be exposed to levels of sound from the airgun array (and other noise sources) high enough to cause non-auditory physical effects or hearing impairment. The mitigation measure of ramping-up the airgun array will allow seals close to the airguns to move away before the sounds become sufficiently strong to have potential for hearing impairment. Also, a ramp-up will not be initiated if a seal is sighted within the 500 m safety zone. Therefore, there is reduced potential for seals being close enough to an array to experience hearing impairment. If some seals did experience TTS, the effects would likely be quite "temporary". As per Table 5.13, MKI's seismic program is predicted to have *negligible* to *low* hearing impairment and/or physical effects on seals, over a duration of *1 to 12 months*, in an area *<1 km^2* to *1-10 km^2*. Therefore, hearing impairment and physical effects on seals are judged to be *not significant* (see Table 5.14).

Disturbance Effects

Based on the above review, there could be behavioural effects on seals within and near the Project Area. Known effects include changes in diving behaviour and localized avoidance of the seismic vessel. It is uncertain how many seals may occur in the Project Area during the period when seismic operations will occur (May to November). There are no available criteria for assessing the sound level most likely to elicit avoidance reactions in seals. It is noteworthy that seals have been sighted inside the radius thought to cause TTS (190 dB) in other areas. A 160 dB re 1 μPa_{rms} sound level has been conservatively used to assess disturbance effects, more specifically potential displacement from the area around the seismic source. Therefore, the area where displacement may occur would have likely a scale of potential effect at *11-100 km^2*. This estimated area around the seismic vessel would be ensonified periodically for a duration of *1 to 12 months*. As per Table 5.13, MKI's proposed seismic program is predicted to have *low* disturbance effects on seals. Therefore, effects related to disturbance, are judged to be *not significant* for seals (see Table 5.14).

Prey Species

It is unlikely that prey species for seals will be impacted by seismic activities to a degree that inhibits their foraging success. If prey species exhibit avoidance of the seismic ship it will likely be transitory in nature (see Sections 5.7.5 and 5.7.6) and over a small portion of the seal's foraging range within the seismic area. Potential effects of reduced prey availability on seals are expected to be *negligible*.

Polar Bears

Airgun effects on polar bears have not been studied. However, polar bears on the ice would be unaffected by underwater sound. Sound levels received by polar bears in the water would be attenuated because polar bears generally swim with their heads out of the water or at the surface, and polar bears do not dive much below 4.5 m. Received levels of airgun sounds are reduced near the surface because of the pressure release effect at the water's surface (Greene and Richardson 1988; Richardson et al. 1995). Measurements of the in-air hearing of polar bears suggest bears have best hearing sensitivity for sounds with frequencies between 11.2 to 22.5 kHz (Nachtigall et al. 2007). Their hearing is presumably adapted for in-air hearing, and—even when submerged—they may not be very sensitive to underwater sound. It is unlikely that many polar bears will be encountered during the proposed seismic program, given that operations will likely occur during ice-free periods. Given the small number of polar bears involved, effects of seismic sound sources on polar bear hearing are predicted to be *negligible*. Similarly, effects of seismic sources on polar bear behaviour are predicted to be low in an area of *11-100* km^2 (see Table 5.13). No significant effects are expected (see Table 5.14).

Prey Species

It is unlikely that seals (polar bear's primary prey) will be impacted by seismic activities to a degree that inhibits the foraging success of polar bears. If seals exhibit avoidance of the seismic ship it will likely be transitory in nature (see above) and over a small portion of a seal's foraging range within the seismic area. Potential impacts of reduced prey availability are predicted to be *negligible*.

Assessment of Effects of Sound on Sea Turtles

The effects assessment for sea turtles is summarized in Table 5.15.

Hearing Impairment and Physical Effects

Based on available data, it is possible that sea turtles might exhibit temporary hearing loss if the turtles are close to the airguns (Moulton and Richardson 2000). However, there is not enough information on sea turtle temporary hearing loss and no data on permanent hearing loss to reach any definitive conclusions about received sound levels that trigger TTS. Also, it is likely that sea turtles will exhibit behavioural reactions or avoidance within an area of unknown size around a seismic vessel. The mitigation measure of ramping-up the airgun array over a 30 min period should permit sea turtles close to the airguns to move away before the sounds become sufficiently strong to have any potential for hearing impairment. Also, ramp-up will not commence if a sea turtle is sighted within the 500 m safety zone, and the airgun array will be shutdown if a sea turtle is sighted within the safety zone.

It is very unlikely that many sea turtles will occur in the Study Area. Therefore, there is likely limited potential for sea turtles to be close enough to an array to experience hearing impairment. If some turtles did experience TTS, the effects would likely be quite "temporary". As per Table 5.15, MKI's seismic program is predicted to have *negligible* to *low* physical effects on sea turtles, over a duration of *1-12 months*, in an area *<1 to 1-10* km^2. Therefore, auditory and physical effects on sea turtles are judged to be *not significant* (Table 5.16).

Table 5.15 Assessment of Effects of Project Activities on Sea Turtles.

Valued Environmental Components: Sea Turtles								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment; containment	0-1	1	4	2	R	2
Atmospheric Emissions	Surface Contaminants (N)	Low sulphur fuel	0	1	6	2	R	2
Sound								
Airgun Array	Hearing Impairment (N); Physical Effects (N)	Pre-watch; Ramp-up; Delay Start; Shutdown[a]	0-1	1-2	6	2	R	2
Airgun Array	Disturbance (N)	Pre-watch; Ramp-up; Delay Start; Shutdown[a]	1	3	6	2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Picket Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Echosounder	Disturbance (N)		0-1	1	6	2	R	2
Helicopter[b]	Disturbance (N)		0-1	1-2	1	2	R	2
Presence of:								
Seismic Vessel	Disturbance (N)		0-1	1	6	2	R	2
Picket Vessel	Disturbance (N)		0-1	1	6	2	R	2
Helicopter[b]	Disturbance (N)	Maintain high altitude	0	1-2	1	2	R	2
Accidental Releases	Injury/Mortality (N)	Solid Streamers[c]; Spill Response	1	1-2	1	1	R	2

[a] The airgun arrays will be shutdown if an *endangered* (or *threatened*) marine mammal or sea turtle is sighted within 500 m of the array.
[b] No helicopter use is planned for 2014, but helicopters may be used during programs in 2015-2018.
[c] A solid streamer will be used for all seismic surveys.

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

Table 5.16 Significance of Potential Residual Environmental Effects of the Proposed Seismic Program on Sea Turtles.

Valued Environmental Component: Sea Turtles				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood [a]**	
	Significance of Predicted Residual Environmental Effects		**Probability of Occurrence**	**Scientific Certainty**
Vessel Presence/Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Sound				
Array – hearing/physical effects	NS	2	-	-
Array – behavioural effects	NS	3	-	-
Seismic Vessel	NS	3	-	-
PicketVessel	NS	3	-	-
Echosounder	NS	3	-	-
Helicopter	NS	3	-	-
Presence of:				
Seismic Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect
Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence
Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

Disturbance Effects

It is possible that sea turtles will occur in the Project Area, although the cooler water temperatures likely preclude some species from occurring there. If sea turtles did occur near the seismic vessel, it is likely that they would exhibit avoidance within a localized area. Based on observations of green and loggerhead sea turtles, behavioural avoidance may occur at received sound levels of 166 dB re 1 μPa_{rms}. Based on available evidence, the area where displacement would most likely occur would have a scale of impact at *11-100 km^2*. As per Table 5.15, MKI's seismic program is predicted to have *low* disturbance effects on sea turtles, over a duration of *1 to 12 months*, in an area *11-100 km^2*. Therefore, effects related to disturbance, are judged to be *not significant* for sea turtles (see Table 5.16).

Prey Species

Leatherback sea turtles are expected to feed primarily on jellyfish. It is unknown how jellyfish react to seismic sources, if these invertebrates react at all. Leatherbacks are also known to feed on sea urchins, tunicates, squid, crustaceans, fish, blue-green algae, and floating seaweed. It is possible that some prey species may exhibit localized avoidance of the seismic array but this is unlikely to impact sea turtles, which are also likely to avoid the seismic vessel and are known to search for aggregations of prey. Potential effects of reduced prey availability are predicted to be *negligible*.

5.8.7.2 Effects of Helicopter Overflights

Available information indicates that single or occasional aircraft overflights will cause no more than brief behavioural responses in baleen whales, toothed whales and seals (summarized in Richardson et al. 1995). As per Table 5.13, disturbance impacts are assessed as *negligible* to *low* impact, over a duration of *1-12 months*, in an area *<1* km^2 to *1-10* km^2. Therefore, effects related to disturbance, are judged to be *not significant* for marine mammals (see Table 5.14).

To the best of our knowledge, there are no systematic data on sea turtle reactions to helicopter overflights. Given the hearing sensitivities of sea turtles, they can likely hear helicopters, at least when the helicopters are at lower altitudes and the turtles are in relatively shallow waters. It is unknown how sea turtles would respond, but single or occasional overflights by helicopters would likely only elicit a brief behavioural response. As per Table 5.15, disturbance impacts are assessed as *negligible*, over a duration of *1-12 months*, in an area *<1* km^2 to *1-10* km^2. Therefore, impacts related to disturbance, are judged to be *not significant* for sea turtles (see Table 5.16).

5.8.7.3 Effects of Presence of Vessels

During the proposed seismic program, there will be one seismic ship at all times and a picket vessel on site during most of the program. There is some risk for collision between marine mammals and vessels, but given the slow surveying speed (~4.5 knots; 8.3 km/h) of the seismic vessel (and its picket vessel), this risk is likely to be minimal (e.g., Laist et al. 2001; Vanderlaan and Taggart 2007; Gende et al. 2011; Wiley et al. 2011). Marine mammal responses to ships are presumably responses to noise, but visual or other cues are also likely involved. Marine mammal response (or lack thereof) to ships and boats (pre-1995 studies) are summarized in Richardson et al. (1995), p. 252 to 274. More recent studies are described in Husky (2012). Marine mammal responses to the presence of vessels are variable. Seals often show considerable tolerance to vessels. Like seals, polar bears exhibit variable responses to boats. Some seem to approach vessels while others exhibit avoidance (e.g., Harwood et al. 2005). Toothed whales sometimes show no avoidance reactions and occasionally approach vessels; however, some species are displaced by vessels. Baleen whales often interrupt their normal behaviour and swim rapidly away from vessels that have strong or rapidly changing noise, especially when a vessel heads directly towards a whale. Stationary vessels or slow-moving, “non-aggressive” vessels typically elicit very little response from baleen whales.

There are few systematic studies on sea turtle reactions to ships and boats but it is thought that response would be minimal relative to responses to seismic sound. Hazel et al. (2007) evaluated behavioural responses of green turtles to a research vessel approaching at slow, moderate, or fast speeds (4, 11, and

19 km/h, respectively). Proportionately fewer turtles fled from the approaching vessel as speed increased, and turtles that fled from moderate to fast approaches did so at significantly shorter distances from the vessel than those that fled from slow approaches. The authors concluded that sea turtles cannot be relied on to avoid vessels with speeds greater than 4 km/h. However, studies were conducted in a 6 m aluminum boat powered by an outboard engine, which would presumably be more challenging for a sea turtle to detect than a seismic or picket vessel. Lester et al. (2012) reported variable behavioural responses of a semi-aquatic turtle to boat sounds.

Sea turtles may also become entangled with seismic gear (e.g., cables, buoys, streamers, etc.) or collide with the vessel (Pendoley 1997; Ketos Ecology 2007; Weir 2007; Hazel et al. 2007). Entanglement of sea turtles with marine debris, fishing gear, dredging operations, and equipment operations are a documented occurrence and of elevated concern for sea turtles. Turtles can become wrapped around cables, lines, nets, or other objects suspended in the water column and become injured or fatally wounded, drowned, or suffocated (e.g., Lutcavage et al. 1997; NMFS 2007). Seismic personnel have reported that sea turtles (number unspecified) became fatally entrapped between gaps in tail-buoys associated with industrial seismic vessel gear deployed off West Africa in 2003 (Weir 2007). With dedicated monitoring by trained biological observers, no incidents of entanglements of sea turtles with this gear have been documented in over 40,000 nmi (74,000 km) of NSF-funded seismic surveys (e.g., Smultea and Holst 2003; Haley and Koski 2004; Holst 2004; Smultea et al. 2004; Holst et al. 2005a,b; Holst and Smultea 2008). Towing of the hydrophone streamer or other equipment is not expected to significantly interfere with sea turtle movements, including migration, unless they were to become entrapped as indicated above.

However, the Labrador Sea, including the Project Area, is not a breeding area for sea turtles and it is not known or thought to be an important feeding area, and thus it is not expected that high concentrations of sea turtles could potentially be physically affected.

Effects of the presence of vessels on marine mammals or sea turtles, including the risk of collisions, are predicted to be *negligible to low*, over a duration of *1-12 months*, in an area *1-10* km^2. Therefore, effects related to the presence of vessels, are judged to be *not significant* for marine mammals and sea turtles (see Tables 5.13 to 5.16).

5.8.7.4 Effects of Accidental Releases

All petroleum hydrocarbon handling and reporting procedures on board will be consistent with MKI's policy, and handling and reporting procedures. A fuel spill may occur from the seismic ship and/or the picket vessel. Any spills would likely be small and quickly dispersed by wind, wave, and ship's propeller action. The effects of hydrocarbon spills on marine mammals and sea turtles were reviewed in Section 11.4.3 of Husky (2012) and are not repeated here. Based on multiple studies, whales and seals do not exhibit large behavioural or physiological responses to limited surface oiling, incidental exposure to contaminated food, or ingestion of oil (St. Aubin 1990; Williams et al. 1994). Sea turtles are thought to be more susceptible to the effects of oiling than marine mammals but effects are primarily believed to be sublethal (Husky 2012). Camacho et al. (2013) reported that 88% of loggerhead turtles that stranded due to crude oil in the Canary Islands, Spain, survived; those that died showed signs of ingested oil and internal lesions. Lesions on the skin, carapace, and plastron tend not to be fatal (Camacho et al. 2013).

Effects of a small accidental spill on marine mammals or sea turtles would be *low,* over a duration of *<1 month,* in an area *<1 km^2 to 1-10 km^2* and are judged to be *not significant* (see Tables 5.13 to 5.16).

5.8.7.5 Effects of Other Project Activities

There is potential for marine mammals and sea turtles to interact with domestic and sanitary wastes, and atmospheric emissions from the seismic ship and the picket vessel. Any effects from these interactions are predicted to be *negligible* (see Tables 5.13 to 5.16).

5.8.8 Species at Risk VEC

A biological overview of all species considered at risk under *SARA* and/or by COSEWIC that are likely or may occur in the Study Area was provided in Section 4.6. No critical habitat has been defined for the Study Area. As discussed in previous sections and presented in Table 4.13, *SARA* species of relevance to the Study Area include:

- White shark; northern, spotted, and Atlantic wolffish;
- Ivory Gull, Harlequin Duck, and Barrow's Goldeneye;
- Blue, northern bottlenose, Sowerby's beaked, and fin whale; polar bear; and
- Leatherback sea turtle.

Species not currently designated on Schedule 1 of *SARA* but listed on Schedule 2 or 3 or being considered for addition to Schedule 1 (as per their current COSEWIC listing of *endangered, threatened* or *special concern*), are not included in the Species at Risk VEC here but have been assessed in the relevant VEC in Sections 5.8.4 (Fish), 5.8.6 (Marine Birds) and 5.8.7 (Marine Mammals and Sea Turtles) of this EA. If species not currently designated on Schedule 1 of *SARA* do become listed on this legal list during the remainder of the life of the Project (2014–2018), the Proponent will re-assess these species considering the prohibitions of *SARA* and any recovery strategies or action plans that may be in place. Possible mitigation measures as they relate to Species at Risk will be reviewed with DFO and Environment Canada. Potential interactions between the Project and SAR are shown in Table 5.17.

As per the detailed effects assessment in Section 5.8.4 and shown again in Tables 5.4 to 5.5, physical effects of the Project on the various life stages of wolffishes and the white shark will range from *negligible* to *low* over a duration of *1-12 months*, within an area of *<1 km^2* (Table 5.18). Behavioural effects may extend out to a larger area but are still predicted to be *not significant* (Table 5.19). The mitigation measure of ramping-up the airgun array (over a 30 min period) is expected to minimize the potential for impacts on wolffishes and the white shark.

As per the detailed effects assessment in Section 5.8.6, the predicted effect of the Project on the Ivory Gull, Harlequin Duck, and Barrow's Goldeneye is *not significant.* These species are unlikely to occur in the Study Area, particularly during the summer when seismic surveys are likely to be conducted. In addition, the foraging behaviour (and location of foraging areas) would not likely expose them to underwater sound from the Project (see Tables 5.18 and 5.19). Furthermore, these bird species are not known to be prone to stranding on vessels. The mitigation measure of monitoring the seismic vessel and releasing stranded birds and ramping-up the airgun array will minimize the potential for impacts on these species.

Table 5.17 Potential Interactions between the Project and Species At Risk VEC.

Valued Environmental Components: Species at Risk				
Project Activities	**Wolffishes, White Shark**	**Ivory Gull, Harlequin Duck, Barrow's Goldeneye**	**Blue, Northern Bottlenose, Sowerby's Beaked, and Fin Whales, Polar Bear**	**Leatherback Sea Turtle**
Vessel Lights	X	X		
Sanitary/ Domestic Waste	X	X	X	X
Atmospheric Emissions	X	X	X	X
Garbage [a]				
Sound				
Airgun Array	X	X	X	X
Seismic Vessel	X	X	X	X
Picket Vessel	X	X	X	X
Echosounder	X	X	X	X
Helicopter [b]		X	X	X
Presence of:				
Seismic Vessel		X	X	X
Picket Vessel		X	X	X
Helicopter [b]		X	X	X
Shore Facilities [c]				
Accidental Releases	X	X	X	X
Other Projects and Activities				
Oil and Gas Activities in the Labrador Sea	X	X	X	X
Oil and Gas Activities on Grand Banks	X	X	X	X
Fisheries	X	X	X	X
Marine Transportation	X	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] No helicopter use is planned for 2014, but helicopters may be used during programs in 2015-2018.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

Table 5.18 Assessment of Effects of Project Activities on the Species at Risk VEC.

Valued Environmental Component: Species At Risk								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Vessel Lights	Attraction (N); mortality (N)	Turn off non-essential lighting; release protocols for seabirds	0-1	1-2	2-3	2	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment	0-1	1	4	2	R	2
Atmospheric Emissions	Surface Contaminants (N)	Use of low-sulphur fuel; Equipment maintenance	0	1	6	2	R	2
Sound								
Airgun Array	Hearing Impairment (N) Physical Effects (N)	Ramp-up; delay start[a]; shutdown [b]	0-1	1-2	6	2	R	2
Airgun Array	Disturbance (N)	Ramp-up; delay start[a]; shutdown [b]	0-1	1-4	6	2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Picket Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Echosounder	Disturbance (N)		0-1	1	6	2	R	2
Helicopter[c]	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1	R	2
Presence of:								
Seismic Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Picket Vessel	Disturbance (N)		0-1	1-2	6	2	R	2
Helicopter[c]	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1	R	2
Accidental Releases	Injury/Mortality (N)	Solid streamer[d]; spill response	0-2	1-2	1	1	R	2

[a] Ramp-up will be delayed if any marine mammal or sea turtle is sighted within the 500 m safety zone.
[b] The airgun arrays will be shutdown if an *endangered* (or *threatened*) marine mammal or sea turtle is sighted within 500 m of the array.
[c] No helicopter use is planned for 2014, but helicopters may be used during programs in 2015-2018.
[d] A solid streamer will be used for all seismic surveys.

Key:

Magnitude:
0 = Negligible, essentially no effect
1 = Low
2 = Medium
3 = High

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

Reversibility:
R = Reversible
I = Irreversible
(refers to population)

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

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

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects

Table 5.19 Significance of Potential Residual Environmental Effects of the Proposed Seismic Program on the Species At Risk VEC.

Valued Environmental Component: Species At Risk				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood [a]**	
	Significance of Predicted Residual Environmental Effects		**Probability of Occurrence**	**Scientific Certainty**
Vessel Presence/Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Sound				
Array – hearing/physical effects	NS	2	-	-
Array – behavioural effects	NS	3	-	-
Seismic Vessel	NS	3	-	-
PicketVessel	NS	3	-	-
Echosounder	NS	3	-	-
Helicopter	NS	3	-	-
Presence of Vessels				
Seismic Vessel and Streamer	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect
Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

[a] Considered only in the case where 'significant negative effect' is predicted.

Based on available information, the blue whale, Sowerby's beaked whale, and leatherback sea turtle are not expected to occur regularly in the Study Area. It is extremely unlikely that a north Atlantic right whale would occur in the Study Area. Northern bottlenose whales, designated as *endangered* (Scotian Shelf population), are expected to occur regularly in the Study Area during summer months and perhaps also at other times of the year. The polar bear, designated as *special concern*, also occurs in the Study Area primarily during the winter and spring. There are finalized recovery strategies for leatherback sea turtles (ALTRT 2006), blue whales in Atlantic Canada (Beauchamp et al. 2009), the Scotian Shelf population of northern bottlenose whales (DFO 2010e), and north Atlantic right whales for which critical habitat has also been designated (Brown et al. 2009). Mitigation and monitoring designed to minimize potential effects of airgun array noise on *SARA*-listed marine mammals and sea turtles will include those detailed in Section 5.6. These include:

- Prewatch of the safety zone before the array is activated;
- Ramp-up of the airgun array over a 30 min period;
- Monitoring by MMO(s) during daylight hours that the airgun array is active;
- Shutdown of the airgun array when an *endangered* or *threatened* marine mammal or sea turtle is sighted within the 500 m safety zone; and
- Delay of ramp-up if any marine mammal or sea turtle is sighted within the 500 m safety zone.

With these mitigation measures in place and as per the detailed effects assessment in Section 5.8.7, the Project is predicted to have *no significant effect* (hearing impairment/physical or behavioural) on SAR marine mammals and sea turtles (see Table 5.14 and 5.16, respectively).

In summary, potential effects of the proposed 2D and 3D seismic program are not expected to contravene the prohibitions of *SARA* (Sections 32(1), 33, 58(1)).

5.8.9 Sensitive Areas VEC

An overview of sensitive areas overlapping the Study Area was provided in Section 4.7. The habitual preferences of biota potentially inhabiting these sensitive areas, including invertebrates, fishes, marine mammals, sea turtles and seabirds, were detailed in Sections 4.2 to 4.5, and species at risk were described in Section 4.6.

Based on the conclusions of Sections 5.8.4 to 5.8.8, the Project is predicted to have *no significant effect* on sensitive habitat or the species therein within the Study Area.

6.0 Cumulative Effects

This EA has assessed cumulative effects within the Project and thus the residual effects described in preceding sections include any potential cumulative effects from the MKI seismic survey activities in the Project Area.

It is also necessary to assess cumulative effects from other activities outside the Project that are planned for the Regional Area. These activities may include:

- Fishing (e.g., commercial, traditional, recreational);
- Vessel traffic (e.g., transportation, defense, recreational vessels);
- Hunting (e.g., seabirds, seals); and
- Offshore oil and gas industry.

Commercial fishing has been discussed and assessed in detail in Section 5.8.5. Commercial fishing activities, by their nature, cause mortality and disturbance to fish populations and may cause incidental mortalities or disturbance to seabirds, marine mammals, and sea turtles. It is predicted that the seismic surveys will not cause any mortality to these VECs (with the potential exception of small numbers of storm-petrels) and thus, there will be no or negligible cumulative effect from mortalities. There is some potential for cumulative effect from disturbance (e.g., fishing vessel noise) but there will be directed attempts by both industries to mitigate effects and to avoid each other's active areas and times. Any gear damage attributable to the Project will be compensated, and thus any effects will be *not significant*.

Shipping activity in the Labrador Sea involves vessels travelling to and from Labrador ports, and to other ports in the province, and vessels that are travelling through the zone mostly to and from ports in the Canadian High Arctic (see Labrador Shelf SEA; Sikumiut 2008). Shipping is mostly seasonal, beginning in June when ice conditions permit and ending in November at the onset of winter. There are exceptions; for example, the offshore fishing activities and freighters travelling between Greenland and eastern North American ports continue throughout the year. The shipping of concentrated ore from the mining operations in Voisey's Bay also continues during the winter months at the rate of one vessel trip every three weeks on average. The Canadian Coast Guard operates several Marine Communications and Traffic Services centres including in St. Anthony and Happy Valley-Goose Bay. It records the activities of vessels that are 500 gross tonnage and greater.

The Labrador traffic relevant to the Study Area during the shipping season involves scheduled ferry and freight services as follows (Labrador Shelf SEA, with updates):

- Ferry services from Happy Valley-Goose Bay to Black Tickle and northern Labrador communities to Nain. The *MV Northern Ranger* begins operations in early June and ends by mid-November. Services include passengers and freight. The schedule is on a five-day cycle (Monday to Friday) to the northern ports and a two-day cycle to the southern ports (Saturday and Sunday).

- Ferry services between Charlottetown, Norman Bay, William's Harbour and Port Hope Simpson. The *MV Marine Eagle* begins operations in early June and ends by mid-November. Services include passengers and freight. It alternates between ports on a daily operation.
- Freight services by the *MV Sir Robert Bond* to northern Labrador as needed.

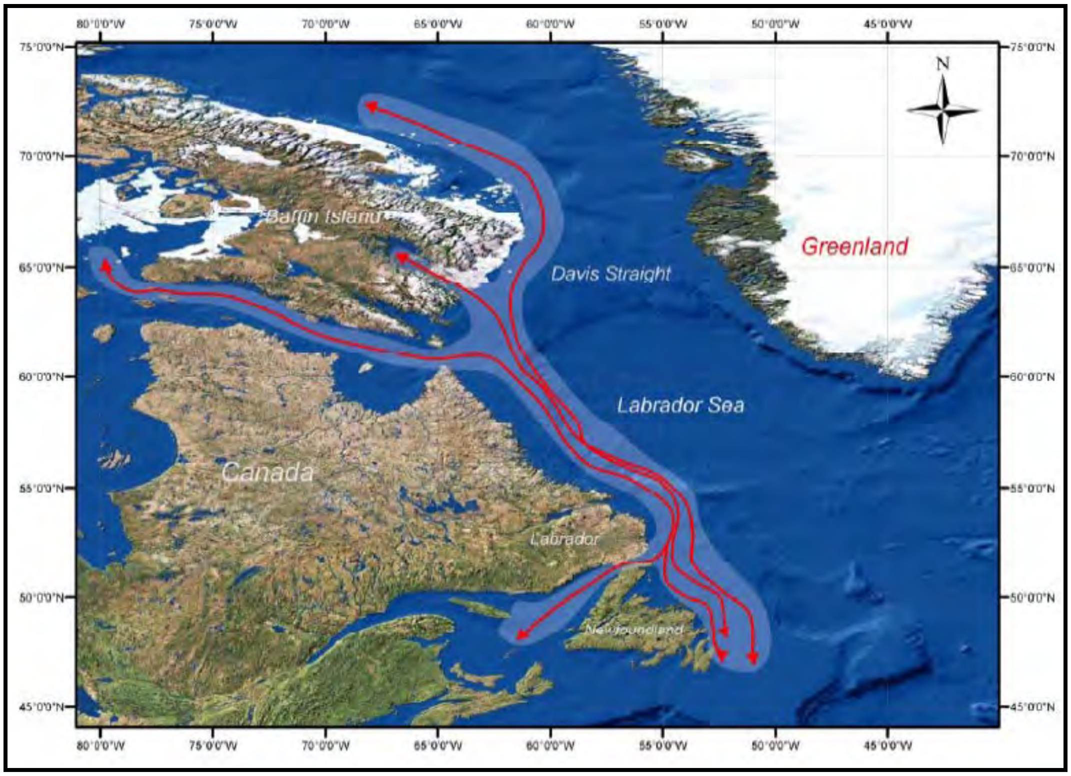
Oil tankers operate regularly during the shipping season, delivering fuel to ports along the Labrador coast (Labrador Shelf SEA). Oil companies such as Imperial Oil Ltd., Ultramar, Irving and Petro-Nav supply various types of fuels to Labrador and the far north. Tankers operated by several companies transport these fuels. Coastal Shipping Ltd., a subsidiary of the Woodward Group, operates five tankers which supply fuel to Labrador communities and the Canadian Arctic. Groupe Desgagnes in Quebec, Algoma Tankers in Ontario, and Rigel Shipping in New Brunswick are tanker-operating companies that transport fuel to Labrador and ports in the far north. General routing to the Arctic through the Labrador Sea is shown in Figure 6.1.

Other vessels transport cargo to various community and industry projects in Labrador and farther north (Labrador Shelf SEA). These shipping companies include Miller's Shipping in St. John's, Berkshire Shipping in Arnold's Cove, Davis Shipping in Wesleyville, McKeil Marine Limited in Hamilton, Ontario, and Groupe Ocean in Quebec. These companies also provide barge towing services that carry heavy construction equipment and supplies to remote areas.

The mining operations in Voisey's Bay have approximately 20 vessel trips per year to the mine wharf site in Edward's Cove, Anaktalak Bay (Labrador Shelf SEA). It involves the transport of ore to other processing plants in Canada and the supply of fuel and general freight to the site. The Labrador Inuit Development Corporation (LIDC) operates an anorthosite mine in Ten Mile Bay near Nain. A portion of the ore is shipped to Hopedale by barge while the larger amount is exported directly to Italy by cargo ship, which is usually one vessel trip per year.

Shipping is likely to have an effect on the behaviour of fish and marine mammals. Seismic noise will contribute a minor percentage to the overall noise generated by other vessel sources, and will be of temporary and short duration in most areas. Traffic by two additional ships, travelling at slow speeds, is also not likely to add much congestion. Ships may need to divert around the immediate seismic survey area, but this will not prevent or impede the passage of either vessel as the *Shipping Act* and standard navigation rules will apply.

Analyses of the oil involved in bird strandings in the region show that wastes are composed of mixtures of bunker C and marine diesel, indicating origins in the engine room bilges of ocean-going ships (Lock and Deneault 2000). The illegal discharge of oily bilge water off the southeast coast of Newfoundland is a chronic problem (Wiese and Ryan 1999, 2003) and may also be an issue off Labrador. Vessels chartered by MKI will not engage in the illegal discharge of oily bilge water. It is expected that the additional effects of seismic noise or vessel discharge with existing shipping effects are *not significant*. It is also possible that some species habituate to ship noise.



Source: Labrador Shelf SEA.

Figure 6.1 Shipping Transportation to the Canadian Arctic through the Labrador Sea.

The vast majority of hunting of seabirds (mostly murres) in Newfoundland and Labrador waters occurs near shore from small boats and thus, there is little or no potential for cumulative effects on this VEC. Similarly, most, if not all, seal hunting would occur outside of the Project Area in the Gulf of St. Lawrence or off northeast Newfoundland.

Potential offshore oil and gas industry projects listed on the C-NLOPB public registry (www.cnobp.nl.ca as viewed 29 January 2014) for offshore Labrador in 2014 and beyond include:

- GX Technology Canada Ltd. 2D Seismic, Gravity, and Magnetic Survey for the Labrador Shelf Area, 2013-2015;
- Husky Energy 2D/3D Seismic Labrador Shelf Program, 2009-2017;
- Investcan Energy Corporation 2D/3D seismic program including geohazard and VSP surveys on Labrador Shelf, 2010-2017; and
- Chevron Canada Resources 3D/2D Seismic Labrador Program, 2010-2017.

In addition, ARKex Ltd and TGS-NOPEC have a Labrador Sea Gravity Gradient Survey planned for 2014-2018; this project does not include seismic surveys.

While the above list suggests potential for many programs to run concurrently it should be noted that east coast operators tend to coordinate their logistics. As a result, based on historical levels of activities, there typically would be no more than two or three seismic programs operating off Newfoundland and Labrador during any one season.

There is potential for cumulative effects with other seismic programs, as these Projects will add to the underwater noise offshore Labrador. It will be in the interests of the different parties for good coordination between programs in order to provide sufficient buffers and to minimize acoustic interference. Different seismic programs could potentially be operating in close proximity. During these periods, marine mammals may be exposed to noise from several seismic survey programs. However, potential effects on VECs are not expected to occur beyond a localized area from the sound source. In addition, all geophysical programs will use mitigation measures such as ramp-ups, delayed startups, and shutdowns of the airgun arrays. Thus, while some animals may receive sound from one or more geophysical programs and possibly from commercial or other vessels transiting through the Project Area, the current judgement is that any cumulative disturbance will be over a short-term duration of *1-12 months* and a geographic extent ranging from *101-1,000 km*^{2} to *1,001-10,000 km*^{2} and that residual effects will be *not significant*.

If offshore operations are conducted in separate survey areas, it is expected that the overall impacts of each project would be independent and as predicted. In addition, multiple seismic and drilling programs are proposed or ongoing in the Jeanne d'Arc Basin, Orphan Basin, Flemish Pass, or offshore of Newfoundland's west coast. Also, there are three existing offshore production developments (Hibernia, Terra Nova, and White Rose), some with satellite fields, on the northeastern part of the Grand Banks. A fourth platform, Hebron, is expected to be in production in 2017. However, offshore oil and gas activity on the Grand Banks (and other areas outside of the Labrador Sea) should be far enough away to avoid any disturbance effects. Any cumulative effects (i.e., disturbance), if they occur, will be additive (not multiplicative or synergistic) and are predicted to be *not significant*.

All vessels (supply vessels, fishing vessels, cargo vessels and seismic vessels) and offshore rigs on the east coast, including Labrador, have navigation and warning lights. In some instances, work areas are lit by floodlights. As discussed in the preceding paragraphs, some seabirds may be attracted to these lights and, consequently, become stranded on picket vessels, drill rigs, or other offshore structures. However, cumulative effects are not expected to exceed those expected for individual vessels in the area. There will be *no significant* cumulative effects of lights on marine birds triggered by the exploration program.

7.0 Residual Effects of the Project

A summary of the Project's residual effects on the environment, that is those effects that remain after mitigations have been instituted, are shown in Table 7.1. MKI's seismic program is predicted to have *no significant effects* on VECs.

Table 7.1 Significance of Potential Residual Environmental Effects of the Proposed Seismic Program on VECs in the Study Area.

Valued Environmental Component: Fish and Fish Habitat, Fisheries, Birds, Turtles, Marine Mammals, Species at Risk				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood (Significant Effect Only)**	
	Significance of Predicted Residual Environmental Effects		**Probability of Occurrence**	**Scientific Certainty**
Vessel Presence/Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Sound				
Array – physical effects	NS	2-3	-	-
Array – behavioural effects	NS	2-3	-	-
Seismic Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Echosounder	NS	3	-	-
Helicopter	NS	3	-	-
Presence of Vessels				
Seismic Vessel and Streamer	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:

Residual environmental Effect Rating:
S = Significant Negative Environmental Effect
NS = Not-significant Negative Environmental Effect
P = Positive Environmental Effect

Probability of Occurrence: based on professional judgment:
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Significance is defined as a medium or high magnitude (2 or 3 rating) and duration greater than 1 year (3 or greater rating) and geographic extent >100 km^2 (4 or greater rating).

Level of Confidence: based on professional judgment:
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

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List of Appendices