

Environmental Assessment of Multiklient Invest Labrador Offshore Seismic Program, 2018–2023

Prepared by



Prepared for

Multiklient Invest AS

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TGS-NOPEC Geophysical Company ASA

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Environmental Assessment of Multiklient Invest Labrador Offshore Seismic Program, 2018–2023

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1.0 Introduction

Multiklient Invest AS (MKI), a wholly-owned subsidiary of Petroleum Geo-Services ASA (PGS), and TGS-NOPEC Geophysical Company ASA (TGS) are proposing to conduct two-dimensional (2D), three-dimensional (3D), and/or four-dimensional (4D) seismic surveys in offshore Labrador (the Project). MKI will serve as the Operator. This document is the Environmental Assessment (EA) of the Project. The Project Area identified in Figure 1.1 includes the shelf region off Labrador, as well as offshore slope and deep water regions associated with the shelf (e.g., parts of the Labrador basin). MKI and TGS are proposing to conduct seismic surveys, sometimes two or more operations, during one or more years within the 2018–2023 timeframe.

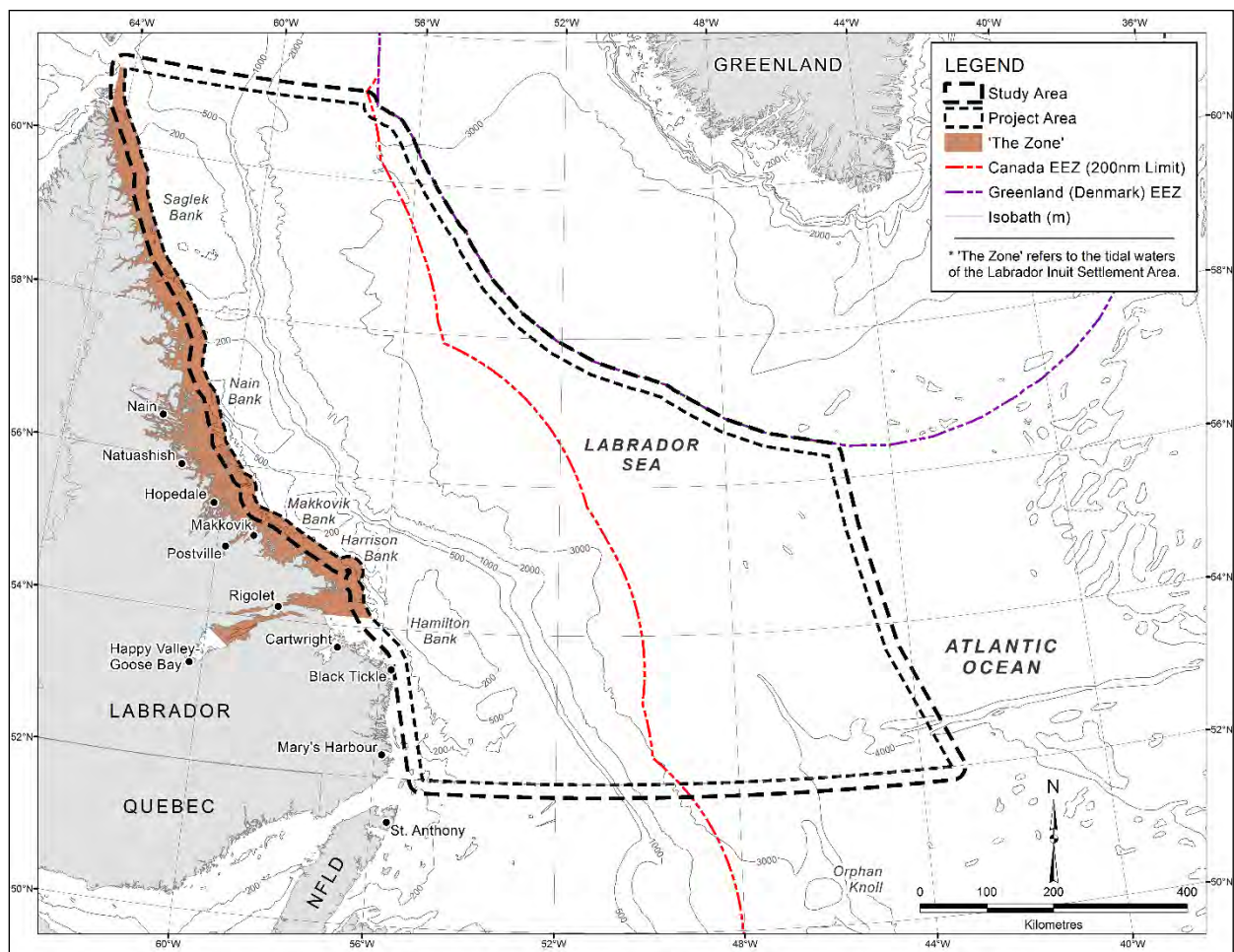


Figure 1.1 Locations of Project Area and Study Area for MKI's Proposed Labrador Offshore Seismic Program, 2018–2023.

This EA is intended to enable the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) to fulfill its responsibilities under § 138 (1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Act* and § 134(1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (Accord Acts). An EA and associated Addendum were submitted to the C-NLOPB for the Project with a 10-year temporal scope (2017–2026) and spatial scope inclusive of offshore Newfoundland and Labrador (LGL 2017a,b). The C-NLOPB recently reviewed the temporal and spatial scopes of the Accord Acts, and made the decision to reduce the temporal scope of geophysical/geological EAs to six years to better align with Period I of an exploration licence. It was also determined that the spatial scope of EAs in the Labrador Shelf offshore area will have a southern boundary of 52°N, and EAs not offshore Labrador will have a northern boundary of 52°N (C-NLOPB 2018). This EA reflects these decisions and includes the offshore Labrador portion of the Project. This EA addresses Addendum comments (LGL 2017b; C-NLOPB 2018) associated with the original EA (LGL 2017a). This EA has been guided by the C-NLOPB's Final Scoping Document (C-NLOPB 2017a) posted on its website on 24 January 2017, as well as by advice and information received (including consolidated comments for the Addendum; C-NLOPB 2018), and issues identified through various communications and consultations with other agencies, interest groups, stakeholders and beneficiaries. An EA Update document will be submitted to the C-NLOPB each year that MKI plans to conduct seismic surveying.

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 Accord Acts. 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 fish and fish habitat, fisheries, marine mammals, sea turtles and marine-associated birds, Fisheries and Oceans Canada (DFO) and Environment and Climate Change Canada (ECCC) are the government agencies that have most involvement in the EA process. Legislation that is relevant to the environmental aspects of the Project includes:

- *Canada-Newfoundland and Labrador Atlantic Accord Implementation Act*;
- *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*;
- *Oceans Act*;
- *Fisheries Act*;
- *Navigation Protection Act*;
- *Canada Shipping Act*;
- *Migratory Birds Convention Act*;
- *Species at Risk Act (SARA)*; and
- *Canadian Environmental Protection Act*.

MKI will follow guidelines issued by the C-NLOPB, the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2017b), which include DFO's *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*. The Project will also consider other relevant advice received during the consultations for this Project.

1.2 The Operator

The Operator, Multiklient Invest AS (MKI), is a wholly-owned subsidiary of Petroleum Geo-Services ASA (PGS). MKI has entered into a cooperative agreement with TGS-NOPEC Geophysical Company AS to conduct this work.

1.3 Canada-Newfoundland and Labrador Benefits

In full appreciation of the requirements of the Accord Acts, MKI is committed to providing maximum benefits associated with East Coast operations to Canadians, and in particular, to individuals and companies from Newfoundland and Labrador that are commercially competitive in accordance with MKI's requirements.

MKI will manage the seismic operations from St. John's, Newfoundland and Labrador. MKI agrees that first consideration will be given to personnel, support and other services that can be provided from within Newfoundland and Labrador, and to goods manufactured in Newfoundland and Labrador, as long as the goods and services can be delivered at a high standard of Health, Safety and Environmental competency, are of high quality, and are competitive in terms of fair market price. All contractors and subcontractors working for MKI in Newfoundland and Labrador must also apply these principles in their operations.

1.4 Contacts

1.4.1 Multiklient Invest AS

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2.0 Project Description

The official name of the Project is Multiklient Invest Labrador Offshore Seismic Program, 2018–2023. MKI is proposing to conduct one or more 2D, 3D and/or 4D seismic surveys within its proposed Project Area (see Figure 1.1) between 2018 and 2023; however, no surveys are planned for 2018. There is the possibility that MKI will concurrently conduct two or more 2D, 3D and/or 4D surveys in any given year during 2018–2023. The maximum number of simultaneous seismic surveys in a given year would be three 3D surveys and one 2D survey. The timing of the surveys is subject to MKI priorities and circumstances, weather conditions, contractor availability and regulatory approvals. Specific details of MKI's seismic survey plans for 2019 and onward will be included in an EA Update.

2.1 Spatial and Temporal Boundaries

The Study Area includes the Project Area plus a 20 km buffer around the Project Area to account for the propagation of seismic survey sound that could potentially affect marine biota (see Figure 1.1). The proposed Project Area includes space to account for ship turning and streamer deployment. The areal extents of the Project Area and the Study Area are 654,060 km² and 731,955 km², respectively. As indicated in Figure 1.1, the eastern portion of the Project Area and Study Area extends outside of Canada's Exclusive Economic Zone (EEZ) (~38% of the total area). Water depths within the Project Area range from approximately 100 to 4,000 m (see Figure 1.1).

The Study Area and Project Area for this proposed Project are essentially a modification of the study and project areas, respectively, associated with the following MKI project: Labrador Sea Seismic Program, 2014–2018 (C-NLOPB File No. 45006-020-003). MKI has been conducting 2D and 3D seismic surveys in the Project Area during recent years.

The coordinates that delineate the proposed Project Area (decimal degrees, WGS84 Datum) are as follows:

- 61.000°N, 64.253°W (western extreme);
- 61.003°N, 57.587°W (northern extreme);
- 60.700°N, 56.743°W;
- 57.818°N, 52.301°W;
- 56.307°N, 45.504°W;
- 53.644°N, 44.547°W;
- 52.000°N, 43.348°W (eastern extreme);
- 52.000°N, 54.913°W (southern extreme);
- 53.601°N, 55.428°W;
- 54.601°N, 56.623°W;

- 55.614°N, 59.281°W;
- 57.254°N, 60.938°W; and
- 59.421°N, 63.041°W.

The coordinates that delineate the proposed Study Area (decimal degrees, WGS84 Datum) are as follows:

- 61.108°N, 64.546°W (western extreme);
- 61.128°N, 57.321°W (northern extreme);
- 60.835°N, 56.501°W;
- 57.970°N, 52.121°W;
- 56.426°N, 45.262°W;
- 53.703°N, 44.260°W;
- 51.909°N, 43.098°W (eastern extreme);
- 51.865°N, 55.105°W (southern extreme);
- 53.681°N, 55.852°W;
- 54.543°N, 56.919°W;
- 55.584°N, 59.593°W;
- 57.220°N, 61.262°W; and
- 59.380°N, 63.382°W.

The temporal boundaries of the Project are 1 May–30 November during 2018–2023; no seismic surveys will occur in 2018.

2.2 Project Overview

The proposed Project is a ship-borne geophysical program. Specific data acquisition plans for 2D, 3D and/or 4D surveys during 2019–2023 are not yet determined; however, the maximum annual amount of 2D and 3D/4D combined that will be acquired during 2019–2023 are 10,000 km and 15,000 km², respectively. No seismic surveys will occur in 2018.

It is anticipated that the PGS vessels *Ramform Tethys*, *Ramform Titan*, *Ramform Sterling* and/or *Sanco Atlantic* (formerly the *Atlantic Explorer*) will be used during the surveys; however, other vessels may also be used. All vessels will be approved for operation in Canadian waters and will be typical of the worldwide fleet. Details on airgun arrays and streamers are provided in § 2.2.6 and § 2.2.7, respectively.

In addition to the airgun arrays, underwater sound will also be generated by navigational, operational and safety equipment on board the vessels, such as echosounders and sonars. A seismic survey will use an industry-standard echosounder/fathometer instrument (i.e., Kongsberg Simrad EA600 echosounder or equivalent) for navigational purposes by obtaining information

on water depths and potential navigation hazards for vessel crews during routine navigation operations. Navigation echosounders direct a single acoustic signal focussed in a narrow beam directly downward to the sea floor. The reflected sound energy is detected by the echosounder, which calculates and displays water depth to the user.

The C-NLOPB's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2017b) will be used as the basis for the marine mammal monitoring and mitigation program for the seismic surveys. Section III of Appendix 2 of the Guidelines (C-NLOPB 2017b) states that "Operators are expected to implement a seabird and marine mammal observation program throughout all C-NLOPB authorized program activities. Such a program should involve a designated observer trained in marine mammal and seabird observations". Qualified and experienced Marine Mammal Observers (MMOs) will monitor for marine mammals and sea turtles and implement mitigation measures as appropriate throughout all of MKI's authorized program activities. Visual monitoring and passive acoustic monitoring (PAM) will be used. The aspects of the monitoring and mitigation plan include the use of the ship's bridge for MMOs from which to conduct observations (i.e., good sight lines all around the vessel), and the use of reticle binoculars and other distance estimators to accurately estimate the location of the animal with respect to the safety zone. The airgun array will be ramped up, and ramp ups will be delayed if a marine mammal or sea turtle is detected within the appropriate safety zone (minimum of 500 m as noted in DFO's *Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment*). The airgun array will be shut down any time a marine mammal or sea turtle with *endangered* or *threatened* status on Schedule 1 of the SARA is detected within the safety zone. These measures are designed to minimize effects on marine life, particularly marine mammals and other species considered at risk under the SARA. In addition, the MMOs will conduct a monitoring and release program for seabirds which may strand on board Project vessels. A Fisheries Liaison Officer (FLO) will be on board the seismic vessel to ensure implementation of communication procedures intended to minimize conflict with the commercial fishery.

2.2.1 Objectives and Rationale

The primary objective of the Project is to determine the presence and likely locations of geological structures that might contain hydrocarbon deposits. Existing seismic data in the area do not provide sufficient detail or coverage to serve the needs of the energy companies in their exploration, development and production activities. Acquisition of more 2D, 3D and/or 4D 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 Scheduling

As indicated in § 2.1, the seismic surveys will be conducted between 1 May and 30 November of any given year during 2018–2023.

2.2.3 Site Plans

No seismic surveys are anticipated for 2018. For 2D surveys beyond 2018, there will be an approximate 3–50 km separation between adjacent survey lines. The survey line lengths may vary from 50–250 km. MKI anticipates acquiring 3D seismic data within the Project Area in the future but specific survey plans have not yet been set.

2.2.4 Personnel

A typical seismic vessel can accommodate ~55–60 personnel. Personnel on a seismic vessel include ship's officers and marine crew as well as technical and scientific personnel. The seismic vessel will also have MMOs and a FLO on board. All project personnel will have the required certifications as specified by the relevant Canadian legislation, the C-NLOPB, and MKI's Health, Safety, Environment, and Quality (HSEQ) agreement.

2.2.5 Seismic Vessel

As noted earlier, it is anticipated that the PGS vessels *Ramform Tethys*, *Ramform Titan*, *Ramform Sterling* and/or *Sanco Atlantic* (formerly the *Atlantic Explorer*) will be used during the surveys. The MV *Ramform Tethys* was built in 2016 and is a Bahamian flagged vessel (Figure 2.1). It is 104.2 m long, with a beam of 70 m and a draft of 6.9 m. The *Ramform Tethys* has cruising and maximum speeds of ~28 km/h (15 knots) and ~30 km/h (16 knots), respectively, but will travel at a speed of ~9 km/h (5 knots) while conducting seismic surveying. The vessel is equipped with state of the art navigation, radar, communication and depth sounding equipment, bow and stern thrusters, and a Dynamic Positioning (DP) system. It has a fuel capacity of 5,800 m³ of heavy fuel oil (HFO) and uses three diesel-electric engines. Three variable pitch propellers provide 1.8 Megawatts of power, which is more than sufficient to tow the very wide spread streamers. The *Ramform Tethys* operates two work boats that permit streamer maintenance.

The *Ramform Tethys* belongs to the PGS Titan class and has 24 streamer reels; 16 abreast with a further 8 in a second row; and 22 tow points. The back deck layout is augmented by six independent airgun array handling booms.

The *Ramform Titan* is a sister ship to the *Tethys*, launched in 2013 with virtually identical specifications (with the exception of a 6.4 m draft). The *Ramform Sterling* was launched in 2009; this Bahamian flagged vessel has a length of 102.2 m, beam of 40.0 m and draft of 7.3 m. The *Sterling* can tow up to 20–22 streamers (Figure 2.2).

For seismic surveys during 2019–2023, vessel specifics will be provided once the vessels have been identified.



Figure 2.1 *MV Ramform Tethys.*



Figure 2.2 *MV Ramform Sterling.*

2.2.6 Seismic Energy Source Parameters

The sound sources for the proposed 2D/3D/4D survey program will consist of one, two or three airgun arrays. For any sound source that consists of either two or three airgun arrays, the arrays will be discharged alternately (i.e., multiple airgun arrays will not be discharged simultaneously). Examples of source parameters for 2D and 3D surveys are as follows. Two-dimensional seismic surveys could be conducted using a single 40-airgun array, with a total volume of 4,880 in³. The airgun array(s) would be deployed at a depth of 9 m and will be operated with compressed air at a pressure of 2,000 psi. The peak-to-peak sound source level would be ~175 bar-m (~238 dB re 1 $\mu\text{Pa} \cdot \text{m}_{\text{p-p}}$). Three-dimensional seismic surveys could be conducted using two airgun arrays, each with 32 airguns, and a total volume of 4,130 in³. The airgun array(s) would be deployed at depths ranging from 7–9 m and operated with compressed air at a pressure of 2,000 psi. The peak-to-peak sound source level would be ~140 bar-m (~237 dB re 1 $\mu\text{Pa} \cdot \text{m}_{\text{p-p}}$).

Detailed specifications of the airgun array to be used each year will be provided in future EA updates, once the project design has been completed and parameters have been selected.

2.2.7 Seismic Streamers

The maximum streamer length in a given year will be 10,050 m; streamers will be towed at depths ranging from 15–30 m. A maximum of 24 streamers will be towed during 3D surveying

over the 2019–2023 period, with a maximum streamer footprint width of 2 km and distance between adjacent streamers of 25–150 m. Details will be provided in future EA Updates.

2.2.8 Logistics/Support

2.2.8.1 Vessels

MKI's primary support and supply will be provided by either the PGS vessel MV *Thor Magni*, or similar vessel. In addition, it is anticipated that at least one local escort vessel will accompany each operating seismic vessel. When necessary (i.e., when fishing vessels and gear or other hazards such as ice and floating debris are thought to be in the immediate path of the seismic vessel), escort vessels will be used to scout ahead of the seismic vessels. If a seismic survey is being conducted in an area known to be without fishing vessels and gear, the escort vessel could be sent to scout out another area where the seismic vessel would be working next.

2.2.8.2 Crew Changes

Crew changes will be conducted by either ship-to-ship transfer or ship-to-shore transfer. Although the *Ramform Tethys*, *Ramform Sterling*, *Ramform Titan* and the *Sanco Atlantic* are equipped with a helicopter deck, it is unlikely that crew changes will be conducted by helicopter. Helicopters will likely be used for emergencies only.

2.2.8.3 Shore Base, Support and Staging

MKI will have a shore representative based in St. John's for the duration of the seismic program. No new shore-based facilities will be established as part of the Project.

2.2.9 Waste Management

Waste management will be consistent with industry best practices in offshore Newfoundland and Labrador. Any garbage generated will be collected and separated into items that are either dischargeable to the sea, non-dischargeable to the sea or reusable according to MARPOL 73/78 Annex IV: Pollution by Sewage from Ships, and Annex V: Pollution by Garbage from Ships. Some waste will be incinerated at sea. According to MARPOL 73/78 Annex V, liquid waste discharge is not considered to be 'garbage'; see § 5.7.3 for further description of vessel discharges.

2.2.10 Air Emissions

Air emissions will be those associated with standard operations for marine vessels, including the seismic vessel, the support vessel and the escort vessel. MKI follows MARPOL 73/78 Annex VI: Regulations for the Prevention of Air Pollution from Ships.

2.2.11 Accidental Events

In the unlikely event of the accidental release of hydrocarbons during the Project, the measures outlined in MKI's oil spill response plan will be implemented. The oil spill response plan will be filed with the C-NLOPB. In addition, MKI will have an emergency response plan in place.

2.3 Mitigation and Monitoring

Project mitigation measures are detailed in the EA, some of which follow the guidelines outlined in the *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*. Mitigation procedures will include ramp-ups, implementation of ramp-up delays and airgun array shutdowns for designated marine mammal and sea turtle species, use of qualified and dedicated MMOs and FLOs, and a fisheries compensation program. PAM for cetaceans is planned; details will be provided in EA Update(s). In addition, the MMOs will conduct a monitoring and release program for seabirds that may strand on Project vessels. Seabird monitoring will include systematic counts based on protocols issued by the ECCC-Canadian Wildlife Service (CWS).

2.4 Project Site Information

The Project is located in the offshore area east of Labrador. It includes the shelf region off Labrador, as well as offshore slope and deep water regions associated with the shelf (e.g., parts of the Labrador basin) (see Figure 1.1).

2.4.1 Environmental Features

The physical and biological environments of the general area have been described in the Labrador Shelf Strategic Environmental Assessment (SEA) (C-NLOPB 2008)¹, as well as in two project-specific EAs: (1) MKI's Labrador Sea Seismic Program, 2014–2018 (LGL 2014)²; and (2) Seitel Canada Ltd.'s East Coast Offshore Seismic Program, 2016–2025 (LGL 2016)³. Reviews of the physical and biological environments, based on the SEA, the two project-specific EAs and newly available information, are provided in § 3.0 and § 4.0 of this EA, respectively.

Figure 2.3 shows the extent to which the proposed MKI Study Area overlaps the study areas associated with the SEA and the Seitel EA. The proposed Study Area lies entirely within the Seitel EA Study Area.

¹ Available at <http://www.cnlopb.ca/sea/labrador.php>

² Available at <http://www.cnlopb.ca/assessments/mkilabsseareport.php>

³ Available at <http://www.cnlopb.ca/pdfs/seitel/eareport.pdf?lbisphpreq=1>

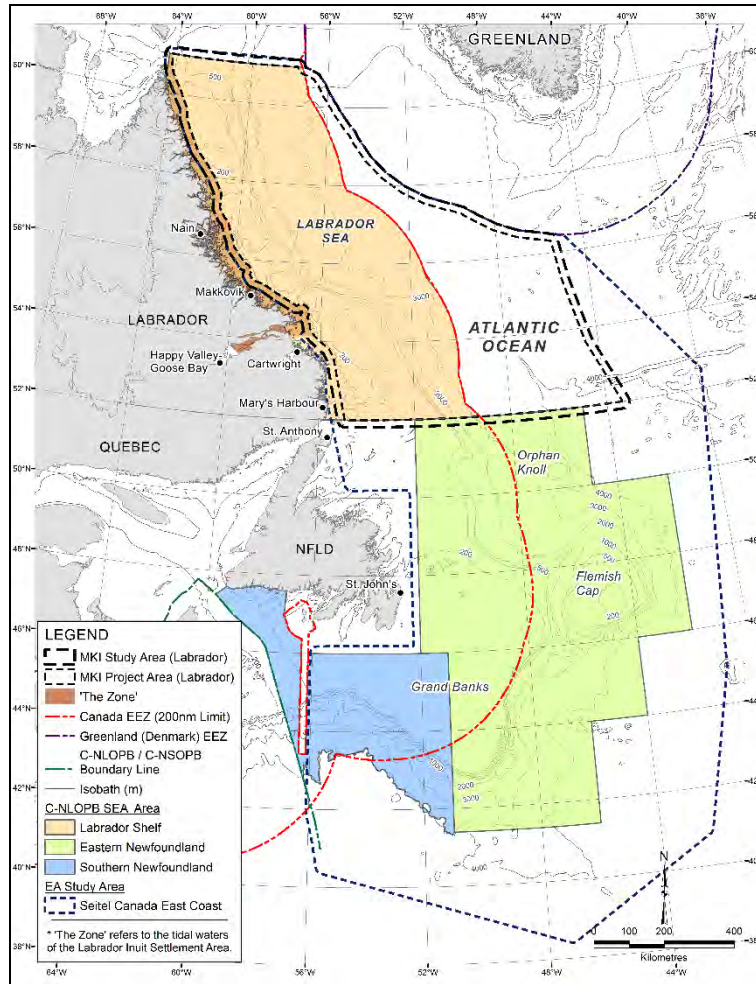


Figure 2.3 Location of MKI’s Study Area Relative to Study Areas Associated with the SEA and Seitel EA.

2.4.1.1 Physical Environment and Potential Effects on the Project

As indicated above, descriptions of the general physical environment of the Study Area are contained in the aforementioned SEA (C-NLOPB 2008) and project-specific EAs (LGL 2014, 2016). The proposed seismic surveys could be conducted in areas with water depths ranging from approximately 100–4,000 m. Extreme wind, wave and ice conditions can slow or even halt survey operations, and accidents are more likely to occur during extreme conditions than during calm conditions. The scheduling of 2D, 3D and/or 4D seismic surveys during a period (May 1 to November 30) when NW Atlantic operating conditions are typically less severe compared to the late-fall/winter/early-spring period, should decrease the risk of potential effects of the environment on the Project.

A summary of the potential effects of the physical environment on the Project, based on information in the SEA (C-NLOPB 2008), the relevant project-specific EAs (LGL 2014, 2016), and any new available information, is provided in § 5.6.

2.4.1.2 Biological Environment

Considering the size of the Study Area for the proposed Project, the biological environment within it is varied and complex. The description of the biological environment is presented in § 4.0 on the basis of the following six Valued Environmental Components (VECs):

- Fish and fish habitat;
- Fisheries;
- Marine-associated birds;
- Marine mammals and sea turtles;
- Species at risk; and
- Sensitive areas.

The potential effects of routine Project activities and accidental events (e.g., unplanned hydrocarbon release) associated with Project activities are assessed in this EA. Cumulative effects on the VECs are also considered in this EA. Other marine users typically considered in the discussion on cumulative effects includes fishing, cargo and passenger vessels, other oil industry-related vessels, transport and military vessels, or other commercial work.

2.5 Consultations

During preparation of the EA, MKI consulted with stakeholders in several communities in Labrador. A summary of the results of those consultations are presented in § 5.1.1, and a full report on the in-person consultation meetings and public meetings is provided Appendix 1. In addition, the Nunavik Marine Region Impact Review Board (NMRIRB) was contacted in July 2018 to discuss the Project.

In January 2017, various stakeholders in Labrador were contacted and provided a link to the MKI Project Description posted on the C-NLOPB website. The groups contacted are listed below. During 24–27 January, an MKI team conducted consultations in Mary's Harbour and Happy Valley-Goose Bay (HV-GB); the groups consulted in late-January are noted below. Other consultations in Labrador were held in Nain with the Nunatsiavut Government and a public meeting during the weeks of the 6th and 20th of March 2017. Recent consultation meetings, focused on fishing, were held with the Fish, Food and Allied Workers (FFAW) and DFO. Following these, MKI attended a meeting with the crab fleet representatives to discuss and answer question about the forthcoming season. Further meetings are planned with FFAW, Ocean Choice and DFO to review the more detailed plans for the 2018 season offshore Newfoundland. In addition, MKI has distributed the annual newsletter to the established list of

stakeholders, which in part informs these groups that seismic surveying offshore Labrador is not planned for 2018 (see Appendix 2).

- Labrador Fishermen's Union Shrimp Company Ltd. (LFUSCL) in Mary's Harbour - meeting on 24 January 2017;
- Mayor of Mary's Harbour - meeting on 24 January 2017;
- Public Information Session in Mary's Harbour - meeting on 24 January 2017;
- Torngat Secretariat in HV-GB - meeting on 25 January 2017;
- Torngat Fish Producers Co-op in HV-GB - meeting on 26 January 2017;
- Public Information Session in HV-GB - meeting on 26 January 2017;
- Innu Nation in HV-GB - meeting on 27 January 2017;
- Cartwright Town Council;
- Town of Charlottetown;
- Labrador Choice Seafoods Inc., Charlottetown;
- Forteau Town Council;
- Town of Happy Valley-Goose Bay (HV-GB);
- NunatuKavut Community Council, HV-GB;
- Nunacor Development Corporation, HV-GB;
- Town of L'Anse au Loup;
- Nunatsiavut Government (Department of Lands and Natural Resources), Nain;
- Nain Inuit Community Government, Nain;
- Town of North West River;
- Community of Pinsent's Arm;
- Town of Port Hope Simpson;
- Innu Nation, Sheshatshiu; and
- Sheshatshiu First Nation Innu Band Council.

2.6 Effects of the Project on the Environment

The proposed Project is within the scope of other seismic programs routinely conducted offshore Newfoundland and Labrador and elsewhere in eastern Canada. Potential environmental effects are examined with focus on the VECs listed above in § 2.4.1.2 and the cumulative effects associated with other marine users. The assessment of the effects of the Project on the environment also rely on information presented in the Labrador Shelf SEA (C-NLOPB 2008), and the two relevant project-specific EAs (LGL 2014, 2016).

2.7 Environmental Monitoring

MMOs will be on board the seismic vessel(s) to monitor for and implement mitigation measures specific to marine mammals and sea turtles, and to collect systematic data on marine mammal/sea turtle behaviour and distribution with and without airguns operating. MKI will also

use PAM for cetaceans. Systematic seabird counts will also be conducted during the seismic surveys. As per the most up-to-date ECCC protocols, seabird surveys will be conducted two to three times daily, each survey period consisting of at least five, consecutive, 10-minute units, the units being separated by the time needed for the vessel to travel 300 m (2:00 minutes at 5 knots). ECCC-CWS now has a mobile version of the Eastern Canadian Seabirds at Sea (ECSAS) database, which can be used by observers to facilitate data entry with little to no need for post-processing. The decision as to whether to use the mobile version will be made by MKI in conjunction with observer provider; regardless, the ECCC-CWS ECSAS protocols will be followed and the required data fields will be collected. The seabird observations will be conducted by an experienced MMO, during which time, ideally, a second experienced MMO is observing for marine mammals and sea turtles. Therefore, marine mammal and sea turtle observations are continuous throughout the daytime period.

Weekly reports from the seismic vessel to the C-NLOPB during operations will also include information related to commercial fishing (e.g., FLO reports of gear and/or fishing vessels encountered during the seismic survey).

3.0 Physical Environment

The Final Scoping Document (C-NLOPB 2017a) requires that the EA include a review of the meteorological and oceanographic characteristics of the Study Area, including extreme conditions, in order to provide a basis for assessing the effects of the environment on the Project. The physical environment of the Study Area has been described in the Labrador Shelf SEA (§ 3.0 of C-NLOPB 2008), and two relevant EAs (§ 3.0 of LGL 2014, 2016). An overview of the physical environment of the Study Area, based primarily on information in the aforementioned documents, is provided below. The overview also contains new and relevant information since publication of the SEA and the site-specific EAs.

3.1 Bathymetry and Geology

The bathymetry and geology of the Study Area is highly variable. For example, the Labrador Shelf contains deep saddles (>200 m) which separate several shallow offshore banks (<200 m), and depths increase to >3,000 m in the Labrador Basin beyond the outer shelf.

The surficial geology of the Study Area ranges from fine (mud and clay) to extremely coarse (boulders and bedrock) (C-NLOPB 2008). Surficial sediments in the area are primarily hemi-pelagic, ice-rafted, and from glacial plume deposits (Toews and Piper 2002).

Five surficial sedimentary formations are recognized within the Study Area (C-NLOPB 2008):

- 1) Qeovik Silt – proglacial and subglacial sediments;
- 2) Makkaq Clay – stratified clay and silt, with minor amounts of sand and gravel;
- 3) Sioraq Silt and Gravel – post glacial marine sediments;
- 4) Sioraq Sand – fine muddy sand to gravelly sand; and
- 5) Lower Till and Upper Till – clayey and sandy silt, with scattered shells and pebbles throughout.

3.2 Climatology

All marine seismic surveys are influenced by weather conditions, from both routine operational and environmental safety perspectives. During routine activities, data quality can be affected by weather, particularly by wind and wave conditions. This subsection, based on the Labrador Shelf SEA (C-NLOPB 2008) and recent EAs (LGL 2014, 2016), provides a general overview of climatic conditions in the Study Area, including wind, waves, temperature, precipitation, visibility, and weather systems. More detailed descriptions are provided for extreme events.

The wind and wave climatology of the Study Area was prepared using the most recent data from the Meteorological Service of Canada 50 year (MSC50) hindcast wind and wave database for the North Atlantic. The MSC50 data set was determined to be the most representative of the

available data sets, as it provides a continuous 57-year period of hourly data for the Study Area. The analyses were conducted using two grid points to represent the Study Area: (1) grid point 14710 near Saglek Bank; and (2) grid point 13643 in Hopedale Saddle (Table 3.1, Figure 3.1).

Table 3.1 MSC50 Grid Point Locations.

Region	Grid Point	Latitude	Longitude
Saglek Bank	14710	59.0°N	60.0°W
Hopedale Saddle	13643	55.0°N	55.0°W

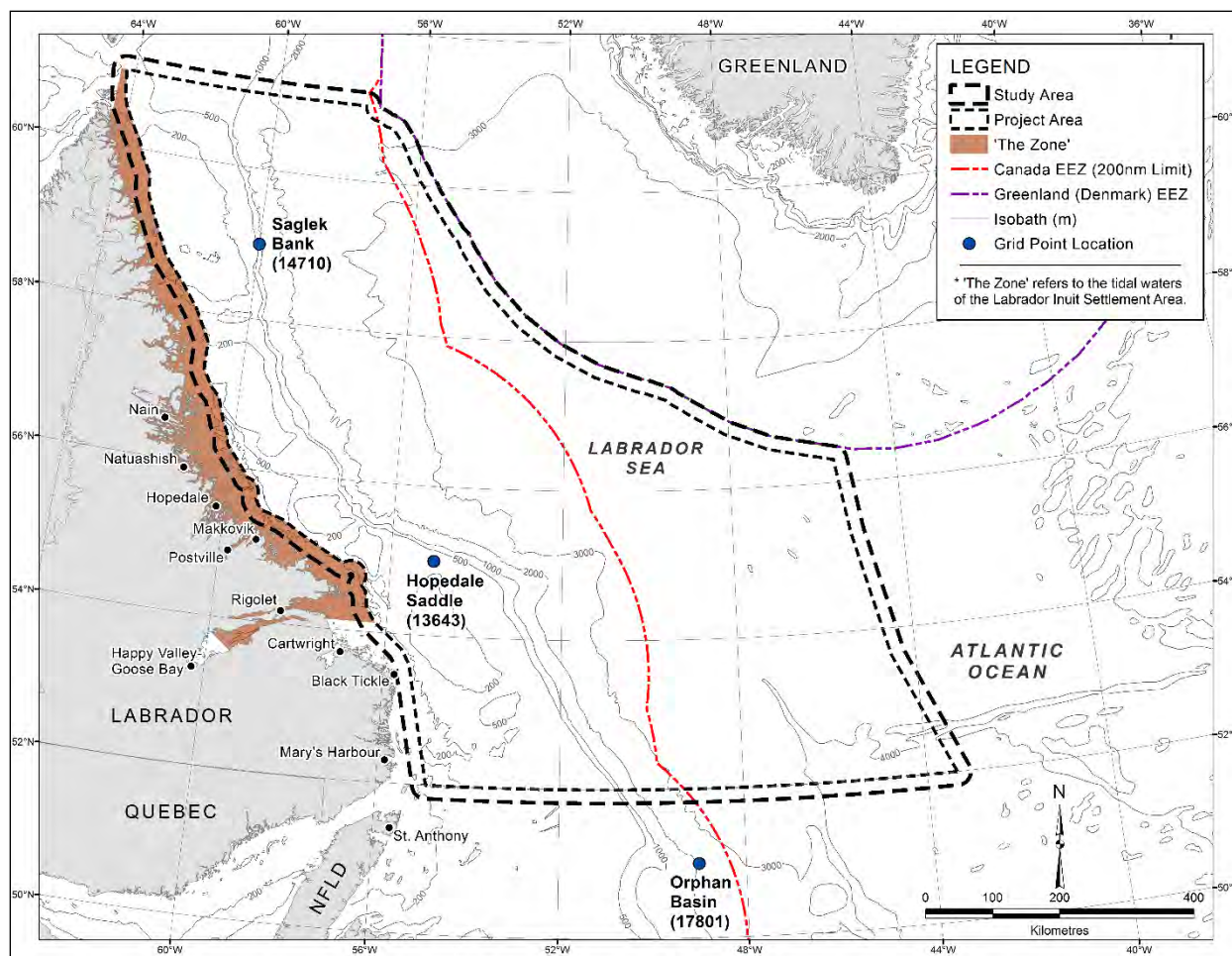


Figure 3.1 Location of MSC50 Grid Points and Regions used in the Physical Environment Analyses.

Hindcast data for grid points 14710 and 13643 are one-hour time steps from January 1954 to December 2005 (C-NLOPB 2008).

3.2.1 Wind

Mean wind speeds are low during the summer and peak during the winter in all regions of the Study Area (Table 3.2). From May–November, the highest mean wind speeds occur during November (9.6 m/s) and the lowest during July (4.8 m/s). While much of the Study Area experiences primarily southwest to west winds throughout the year, there is a strong annual cycle in wind directions. The Labrador Shelf most frequently experiences west to northwest winds during the winter months. However, they begin to shift counter-clockwise during March and April, resulting in mainly southwest winds during the summer months. During autumn, the tropical-to-polar gradient strengthens, and the winds shift slightly, becoming predominately westerly by late autumn.

Table 3.2 Mean Hourly Wind Speed Statistics for Offshore Labrador.

Month	Mean Wind Speed (m/s)	
	Saglek Bank (14710)	Hopedale Saddle (13643)
Jan	9.7	10.3
Feb	8.5	9.4
Mar	8.2	8.9
Apr	7.3	7.7
May	6.1	6.2
Jun	5.4	5.5
Jul	4.8	4.8
Aug	5.4	5.4
Sep	7.0	7.1
Oct	8.6	8.6
Nov	9.6	9.6
Dec	10.3	10.5

Source: C-NLOPB 2008.

3.2.2 Waves

Within the majority of the Study Area, the predominant direction of the combined significant wave heights is from the west during autumn and winter, primarily due to a high frequency of occurrence of wind waves during these seasons. During March and April, the wind waves remain primarily westerly while the swell begins to move southerly. During the summer, southwesterly wind waves and southwesterly swell contribute to produce combined significant wave heights in the southwest direction. During September and October, the wind waves deviate again to the west and become the predominant component of the combined significant wave heights. Extratropical storms can occur in the Study Area, predominantly during October through to March. Hurricanes are generally reduced to tropical or post-tropical storms by the

time they reach the Study Area but may still produce gale force winds and high waves. Tropical storms have the greatest possibility of occurring from late-August through October. Extratropical storms are discussed in more detail in § 3.2.5 of this EA.

Wave conditions are characterized by significant wave height and maximum wave height (described below), as well as peak spectral period and characteristic period. Significant wave height is defined as the average height of one-third of the highest waves. Its value approximates the characteristic height observed visually. From May–November, the highest significant wave heights occur during November and the lowest during July in all regions, ranging from 2.9–3.4 m and 1.2–1.3 m, respectively (Table 3.3).

Table 3.3 Combined Significant Wave Height Statistics for Offshore Labrador.

Month	Significant Wave Height (m)	
	Saglek Bank (14710)	Hopedale Saddle (13643)
Jan	2.8	3.2
Feb	2.2	3.1
Mar	2.1	2.7
Apr	1.9	2.4
May	1.5	1.7
Jun	1.4	1.5
Jul	1.2	1.3
Aug	1.3	1.4
Sep	1.8	2.0
Oct	2.3	2.6
Nov	2.7	3.0
Dec	2.9	3.4

Source: C-NLOPB 2008.

Maximum wave height is defined as the greatest vertical distance between a wave crest and adjacent trough. From May–November, the most severe sea states occur from September through November based on maximum wave heights (Table 3.4).

3.2.3 Wind and Wave Extreme Value Analysis

The occurrence of severe wind and waves associated with extreme storm events is of particular importance for the planning and execution of marine seismic surveys. An analysis of extreme wind and waves was performed using the two grid points already indicated to represent the Study Area (see Table 3.1, Figure 3.1). Extreme value analyses were performed to determine the highest expected values for wind speed and significant wave height for each of the MSC50 grid points (C-NLOPB 2008).

Table 3.4 Combined Maximum Wave Height Statistics for Offshore Labrador.

Month	Maximum Wave Height (m)	
	Saglek Bank (14710)	Hopedale Saddle (13643)
Jan	10.0	12.6
Feb	11.2	11.1
Mar	9.0	11.4
Apr	6.5	10.4
May	5.5	8.5
Jun	6.9	7.0
Jul	4.3	4.5
Aug	4.9	5.7
Sep	6.6	10.0
Oct	9.4	10.5
Nov	11.2	11.6
Dec	12.1	10.7

Source: C-NLOPB 2008.

3.2.3.1 Extreme Value Estimates for Winds from the Gumbel Distribution

Extreme wind speed estimates were calculated using Oceanweather's Osmosis software for return periods of 1-year, 10-years, 50-years, and 100-years, using hourly mean wind speeds for a reference height of 10 m above sea level (C-NLOPB 2008). A storm with a return period of 100 years means that the calculated extreme wind speed will occur once every 100 years, averaged over a long period of time. The calculated annual 100-year extreme 1-hour wind speed ranged from 29.9 to 30.3 m/s (Table 3.5).

Table 3.5 Extreme Wind Speed Estimates for Offshore Labrador.

Return Period (years)	Wind Speed (m/s)	
	Saglek Bank (14710)	Hopedale Saddle (13643)
1	nd	nd
10	26.5	27.0
50	29.0	29.4
100	29.9	30.3

Source: C-NLOPB 2008.

3.2.3.2 Extreme Value Estimates for Waves from a Gumbel Distribution

Monthly extreme significant wave height estimates for return periods of 1-year, 10-years, 50-years, and 100-years for grid points within the Study Area are presented in Table 3.6.

Table 3.6 Extreme Significant Wave Height Estimates for Offshore Labrador.

Return Period (years)	Significant Wave Height (m)	
	Saglek Bank (14710)	Hopedale Saddle (13643)
1	nd	nd
10	10.6	11.2
50	12.1	12.6
100	12.7	13.1

Source: C-NLOPB 2008.

3.2.4 Weather Variables

For offshore Labrador, data related to air temperatures were compiled using the National Climate Data and Information Archive for two weather stations located along the Labrador coast, Nain and Cartwright, covering the period from 1981–2010 (ECCC 2015). Data related to sea surface temperatures were compiled using the Bedford Institute of Oceanography (BIO) hydrographic database (BIO 2017). A subset of data from hydrographic bottles, CTD casts, Batfish tows, and bathythermographs, covering the period from 1910–2009, was used in the analysis for the Labrador Shelf (Husky 2010). Data related to visibility were extracted from over water observations of shipping weather in the Labrador Sea (McClintock and Davidson 1995 *in* Husky 2010).

3.2.4.1 Temperature

The moderating influence of the ocean serves to limit both the diurnal and the annual temperature variation in the Study Area. Diurnal temperature variations due to the day/night cycles are very small. Short-term, random temperature changes are due mainly to a change of air mass following a warm or cold frontal passage. In general, air mass temperature contrasts across frontal zones are greater during the winter than during the summer months. Mean monthly air temperatures and sea surface temperatures for the Study Area are presented in Tables 3.7 and 3.8, respectively, and are the mean of all recorded temperatures for the Labrador Shelf during that month.

The temperature data indicate that from May–November, the air is warmest during August and coldest during November. Sea surface temperature is warmest during August and coldest during the spring.

Table 3.7 Mean Monthly Air Temperatures for the Labrador Shelf.

Month	Air Temperature (°C)	
	Nain	Cartwright
Jan	-17.6	-14.3
Feb	-17.4	-13.5
Mar	-12.5	-8.7
Apr	-4.6	-1.8
May	1.5	3.3
Jun	6.4	8.6
Jul	10.1	12.3
Aug	11.0	12.7
Sep	7.5	9.0
Oct	2.1	3.7
Nov	-4.4	-2.0
Dec	-11.8	-8.8

Source: ECCC 2015.

Table 3.8 Mean Monthly Sea Surface Temperatures for the Labrador Shelf.

Month	Sea Surface Temperature (°C)
Jan	-0.6
Feb	0.7
Mar	-0.4
Apr	-1.4
May	nd
Jun	1.7
Jul	4.6
Aug	6.0
Sep	3.4
Oct	2.3
Nov	1.0
Dec	-0.6

Source: Husky 2010.

3.2.4.2 Visibility

Visibility is defined as the greatest distance at which objects of suitable dimensions can be seen and identified. Horizontal visibility may be reduced by any of the following conditions, either alone or in combination: fog, mist, haze, smoke, liquid precipitation (e.g., drizzle), freezing precipitation (e.g., freezing rain), frozen precipitation (e.g., snow), and blowing snow. Reduced visibility can affect crew changes and work boat operations as well as increase the risk of interactions of the seismic vessel and its towed gear with obstructions in the water. The ability of MMOs to effectively monitor the safety zone is also affected by reduced visibility.

The frequency distribution of visibility states for the Study Area is presented in Table 3.9. The visibility states have been defined as very poor (less than 1 km), poor (1–2 km), fair (2–10 km), and good (>10 km).

Table 3.9 Frequency of Occurrence of Visibility States for the Labrador Sea.

Month	Frequency of Occurrence (%)			
	Very Poor (<0.5 km)	Poor (0.5–2 km)	Fair (2–10 km)	Good (>10 km)
January	6	4	23	67
February	7	3	21	69
March	5	6	22	67
April	5	2	11	82
May	17	6	9	68
June	20	2	11	67
July	15	6	12	67
August	14	2	12	72
September	6	2	9	83
October	5	3	14	78
November	4	3	19	74
December	4	3	23	70
Annual	6	4	23	67

Source: Husky 2010.

During the winter months, the main obstruction is snow, although mist and fog may also reduce visibility at times. As spring approaches, the reduction in visibility attributed to snow decreases. As air temperature increases, the occurrence of advection fog also increases. Advection fog, which forms when warm moist air moves over cooler waters, may persist for days or weeks. The month of July has the highest percentage of obscuration to visibility, most of which is in the form of advection fog, although frontal fog may also contribute to the reduction in visibility. During August, the temperature difference between the air and the sea begins to decrease, and by September the air temperature begins to fall below the sea surface temperature and the occurrence of fog decreases.

Throughout the May–November period, September, October and November have the lowest occurrences of reduced visibility within the Study Area because the air temperature has, on average, decreased below the sea surface temperature but is not cold enough for snow. Reduction in visibility during autumn and winter is relatively low and is mainly attributed to the passage of low pressure systems.

3.2.5 Weather Systems

The climate of the Study Area is very dynamic, being largely governed by the passage of high and low pressure circulation systems. These circulation systems are embedded in and steered by

the prevailing westerly flow that typifies the upper levels of the atmosphere in the mid-latitudes and arises because of the normal tropical to polar temperature gradient. The mean strength of the westerly flow is a function of the intensity of this gradient, and as a consequence, is considerably stronger in the winter months than during the summer months due to an increase in the south to north temperature gradient.

The passage of high and low pressure circulation systems yield a climate within the Study Area that can be highly variable. Conversely, intense low pressure systems also frequently slow down or stall off the coasts of Newfoundland and Labrador. This may result in an extended period of little change in conditions that may range, depending on the position, overall intensity, and size of the system, from relatively benign to heavy weather conditions. Prevailing winds are from the west in the Study Area, typical of such mid-latitudes due to the normal tropical to polar temperature gradient. The intensity of this gradient directly affects the mean strength of the westerly flow, resulting in a much stronger flow during the winter than the summer with the increase in the south-to-north temperature gradient.

Major storms travelling west-to-east across Canada generally pass through St. Lawrence and move seaward over the Grand Banks and Labrador Sea (CCG 2012). During the winter months, an upper level trough and upper ridge typically occur over central Canada and the North Atlantic, respectively, causing three primary storm tracks which affect the Study Area: (1) from the Great Lakes Basin; (2) from Cape Hatteras, North Carolina; and (3) from the Gulf of Mexico. These storm tracks bring an average of eight low pressure systems per month to the Study Area. The storms can range in intensity from relatively weak to major winter storms.

Low pressure systems that form in moisture-abundant southern latitudes are carried northward to Labrador by the jet stream, resulting in blizzard conditions with snow and strong winds during the winter months. As these low pressure systems move away, the wind shifts back to the northwest, resulting in extreme wind chills as the winds bring bitter arctic air to the Study Area (Barney n.d.). Cold air temperatures result in freezing precipitation such as snow showers and squalls over open water in the Labrador Sea throughout the winter months, along with super-cooled fog which is most frequently reported between February and March (CCG 2012). Freezing precipitation generally occurs in the Study Area when the air temperature is -10°C , the westerly wind speed is 30 knots, and wave heights are 4–5 m (CCG 2012). As solar radiation increases during the spring months, a general atmospheric warming occurs, that is relatively greater at higher latitudes. This results in a decreased north-south temperature contrast, thereby lowering the kinetic energy of the westerly flow and decreasing the potential energy available for storm development. In the Study Area, this often results in grey skies, frequent drizzle or freezing drizzle and temperatures around 0°C (Barney n.d.). In the summer months, the primary storm tracks shift farther north than in the winter. Overall, storms occur less frequently and are much weaker in the Study Area, with decreased significant wave heights and wind speeds. The combination of the more northerly low pressure systems and the northwest sector of the sub-tropical high to the south results in a prevailing wind direction across the Study Area from

the southwest to south, with the northerly low pressure systems resulting in relatively frequent rainfall and coastal fog (Barney n.d.).

The hurricane season in the North Atlantic Basin normally extends from June through November, although tropical storm systems occasionally occur outside this period. A tropical storm will maintain its energy until there is no longer a sufficient supply of warm, moist air available, and typically moves east to west over the warm waters in the southern tropics. If a tropical storm turns northwards and heads toward Newfoundland, it begins to lose some of its tropical characteristics while moving over the colder oceanic waters. Once these weakening storms reach Newfoundland, they are typically embedded into a mid-latitude low and are often down-classified to post-tropical, either as an extratropical cyclone or a remnant low. However, tropical cyclones occasionally encounter favourable conditions as they travel northwards and retain their tropical characteristics long enough to reach the Orphan Basin. Tropical storms do not typically extend into the Study Area, owing to the cold waters of the Labrador Sea.

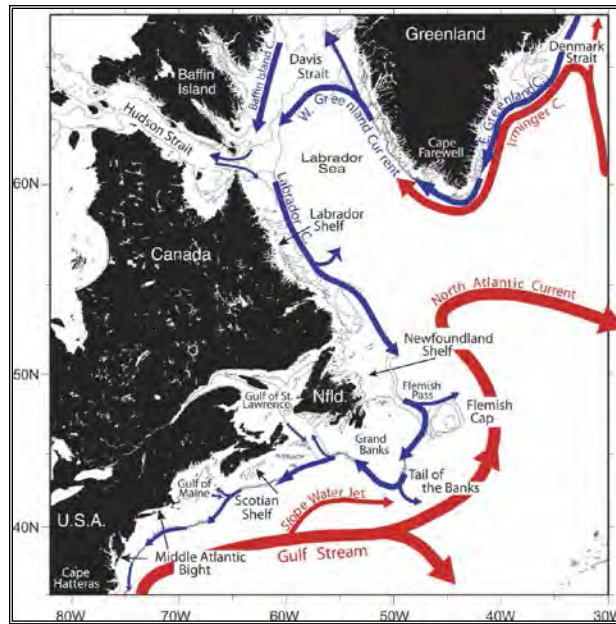
Approximately half of the tropical cyclones formed in the Atlantic that travel into the mid-latitude region transform into extratropical cyclones. During this transformation, the system loses its tropical characteristics but still produces large waves, gale- to hurricane-force winds and intense rainfall. The likelihood of the transformation of a tropical storm to an extratropical storm increases during the latter half of the hurricane season, with the highest probability of transition occurring in October. In the Atlantic, this transition occurs in the early- and late-hurricane season at lower latitudes, and during the peak of the season in higher latitudes.

3.3 Physical Oceanography

A detailed review of the key physical oceanographic conditions and characteristics, including ocean currents, current velocities, and water mass properties (temperature, salinity, density), has been provided in the Labrador Shelf SEA (C-NLOPB 2008). A summary of the major currents in the Study Area is provided below, with additional information from project-specific EAs (LGL 2014, 2016).

3.3.1 Major Currents in the Study Area

The large scale circulation off the coast of Labrador is dominated by well-established currents that flow along the margins of the continental shelf. The major current system in the area is the Labrador Current, influenced by the West Greenland Current, Baffin Island Current and waters from Hudson Bay, with the North Atlantic Current and Gulf Stream to the southeast. The main current patterns are shown in Figure 3.2, with cold shelf break waters shown in blue and warm Gulf Stream waters shown in red.



Source: Fratantoni and Pickart 2007.

Figure 3.2 Major Ocean Currents and Surface Circulation Features in the Northwest Atlantic Ocean.

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. The Labrador Current divides into two major branches on the northern Grand Banks. The inshore branch, which is approximately 100 km wide, is steered by the local underwater topography through the Avalon Channel, and then continues to follow the bathymetry around the Avalon Peninsula and southern Newfoundland. This branch then divides into two parts, one flowing west and around the north side of St. Pierre Bank and the other flowing south in Haddock Channel between Green Bank and Whale Bank.

The stronger offshore branch of the Labrador Current flows along the shelf break over the upper portion of the continental slope. This branch divides east of 48°W, resulting in part of the branch flowing to the east around Flemish Cap and the other part flowing south around the eastern edge of the Grand Banks and through Flemish Pass. Within the Flemish Pass, the width of the Labrador Current is reduced to 50 km with speeds of about 30 cm/s. This flow transports cold, relatively low salinity Labrador Slope water into the region. To the southeast of the Flemish Cap, the North Atlantic Current transports warmer, high salinity water to the northeast along the southeast slope of the Grand Banks and the Flemish Cap. The southward flowing stream of the offshore branch of the Labrador Current splits into two parts south of the Grand Banks. One section continues eastward as a broad flow, part of which breaks off to return southward, while

the other turns offshore at the tail of the Grand Banks to flow northward along the edge of the North Atlantic Current.

The structure of the Gulf Stream changes from a single, meandering front to multiple, branching fronts when it reaches the Grand Banks. Between 65°W and 50°W, the Gulf Stream flows eastward. Shortly after passing east of 50°W, the Gulf Stream splits into two currents. One branch, the North Atlantic Current, curves north along the continental slope, eventually turning east between 50° and 52°N. The other branch, the Azores Current, flows southeastward towards the Mid-Atlantic Ridge. The Gulf Stream transport also varies in time. According to GeoSat altimetry results, the current transports a maximum amount of water in the autumn and a minimum amount in the spring, in phase with the north-south shifts of its position.

There is another major current between the eastward flowing Gulf Stream and the westward flowing Labrador Current, referred to as the Slope Water. This current is described as the northern bifurcation of the Gulf Stream that runs east-northeast along the continental slope south of Newfoundland. The Slope Water has been found to have distinct and unique properties because of mixing with coastal waters and underlying water masses. The Slope Water position varies laterally with the Gulf Stream at 55°W and its transport varies with the transport of the Labrador Current, as well as with changes in the deeper components of the slope water, at about 50°W.

The interaction among the circulations in the Study Area is known to correlate with the behaviour of the North Atlantic Oscillation (NAO) index. The NAO index, the difference in winter sea level atmospheric pressures between the Azores and Iceland, is a measure of the strength of the winter westerly winds over the northern North Atlantic. A high NAO index corresponds to an intensification of the Icelandic Low and Azores High which creates strong northwest winds, cold air and sea temperatures, and heavy ice in the Labrador Sea and Newfoundland Shelf regions. In low index years, the north wall of the Gulf Stream is displaced to the south and the southward transport associated with the Labrador Current is intensified. As a consequence of these north-south displacements of the shelf/slope front, the area is subject to thermal anomaly oscillations.

Throughout the Study Area, the currents vary on different time scales related to factors such as tides, wind stress, atmospheric pressure changes from the passage of storm systems, volume transport of the Labrador Current, seasonal temperature changes and salinity variations. The current variability in the Slope Region is influenced by the intermittent presence of Gulf Stream rings as well as by the relative position of the northern boundary of the Gulf Stream. On an inter-annual scale, the baroclinic transport component of the Labrador Current is negatively correlated with the NAO index. The relative strength of the two pressure systems control the strength and direction of westerly winds and the position of storm tracks in the North Atlantic, which in turn affects the volume transport of the Labrador Current. Similarly, the current variability on a synoptic scale is directly linked to the passage of low pressure systems.

3.4 Ice Conditions

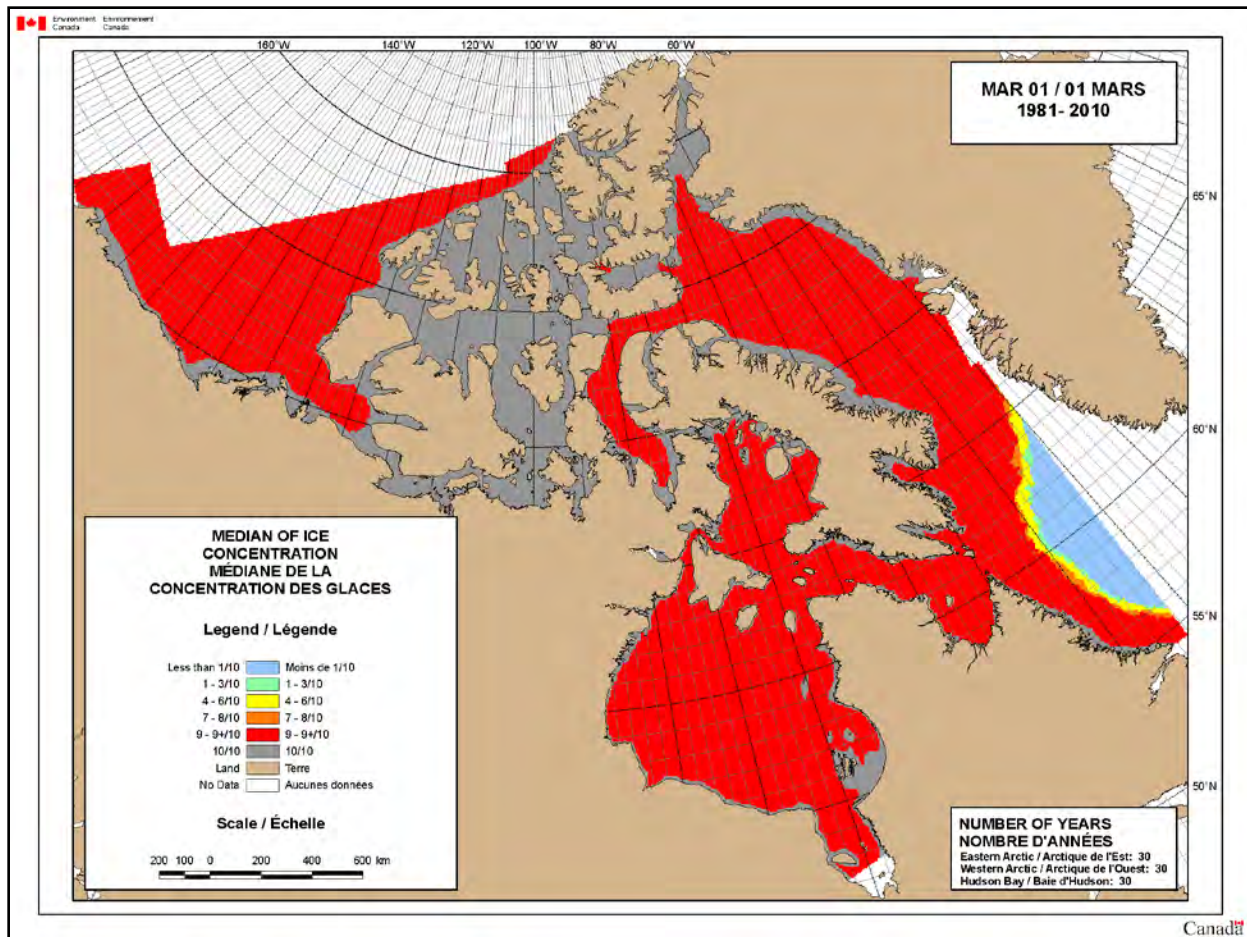
Ice conditions are an important component of the physical environment and can directly affect offshore activities, including seismic surveys, along the coast of Labrador. A review of ice conditions in the Study Area has been provided in the Labrador Shelf SEA (C-NLOPB 2008). A summary of ice conditions is provided below, with updated information on sea ice extent and iceberg sightings for offshore Labrador. The classification of ice commonly found along Canada's eastern seaboard is based on internationally accepted terminology (CIS 2011).

3.4.1 Sea Ice

Sea ice generally begins to form in mid-November to mid-December on the coast of southern Labrador, spreading south to Newfoundland waters by early-January. The 30-year median concentration of sea ice reaches its maximum in the northern Labrador portion of the Study Area (north of 55°N) during the week of 1 March (Figure 3.3), and in the southern Labrador (south of 55°N extending to Newfoundland) during the week of 5 March (Figure 3.4).

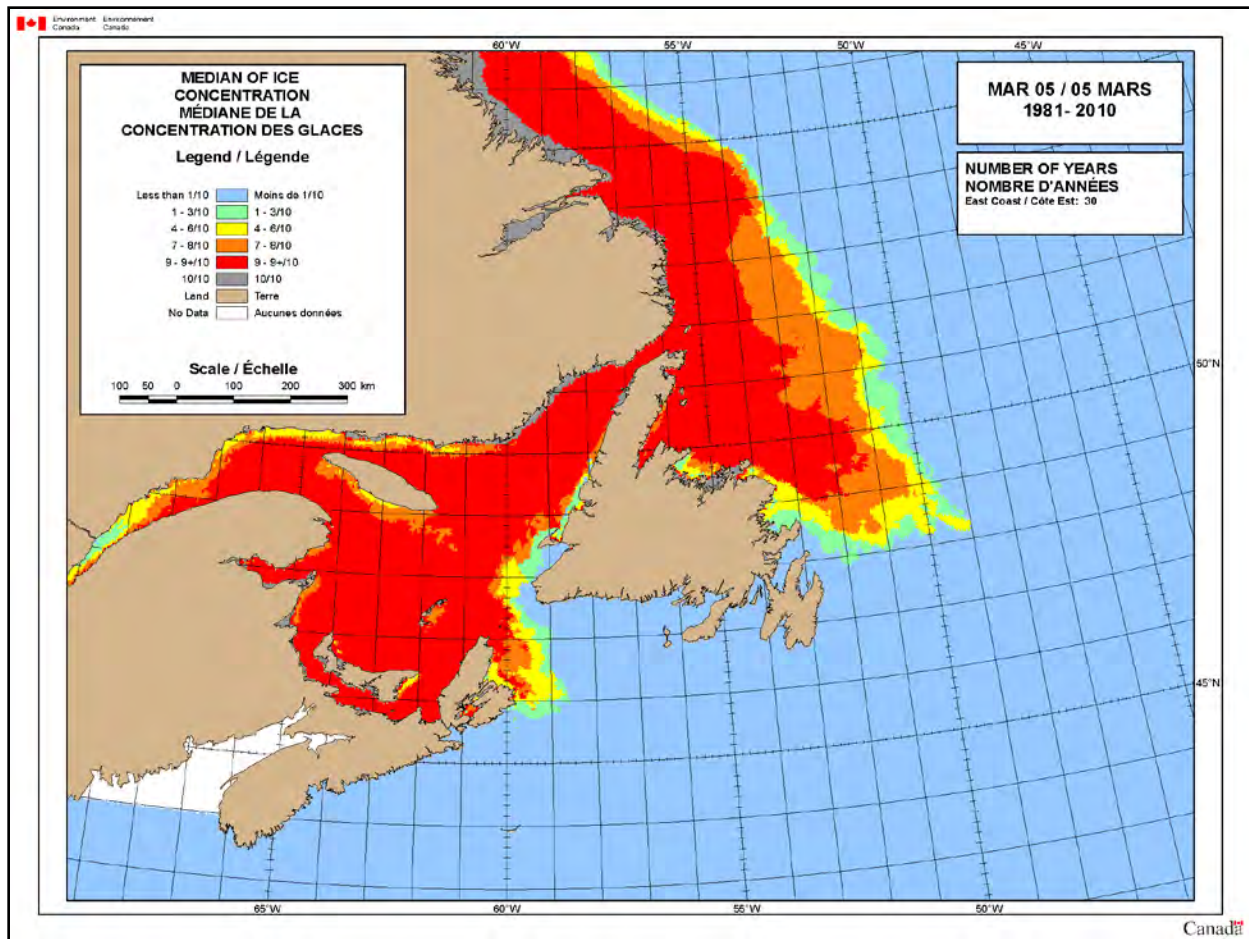
The maximum median sea ice extent reaches beyond the northernmost and southernmost portions of the Study Area, and to 56–59°W and ~51°W in the northern and southern portions of the Study Area, respectively. Based on the 30-year median of data for 1981–2010, only the northern and western portions of the Study Area would have some ice cover (Figures 3.3–3.7). During extreme years, sea ice could occur throughout the southern portion of the Study Area (Figures 3.3–3.7). From mid-August until mid-November, the majority of the Study Area will be free of sea ice. The northern portion of the Study Area is first affected by sea ice beginning the week of 12 November, lasting until the week beginning 27 August (CIS 2011). Figure 3.8 depicts the week of 1 April, the period when the frequency of presence of sea ice is the greatest over the northern portion of the Study Area. The southern portion of the Study Area is first affected by sea ice during the week of 26 November and is ice-free beginning between the weeks of 20 and 27 August. The frequency of presence of sea ice is greatest over the southern portion of the Study Area during the week of 12 March (Figure 3.9).

When sea ice is present, the predominant ice type within the northern portion of the Study Area from 12 November until the week of 1 January is a mixture of new, grey and grey-white, with grey-white ice first appearing the week of 26 November. Some thin first-year ice near the Labrador coast is present as of the week of 1 January. Beginning the week of 1 February, thin first-year ice is present throughout this portion of the Study Area, with remnants of grey-white ice and some medium first-year ice until the week of 1 March. By the week of 1 April, thick first-year ice is present and the grey-white ice has disappeared. Old ice begins to appear the week of 15 May and is the predominant ice type by the week of 30 July (CIS 2011).



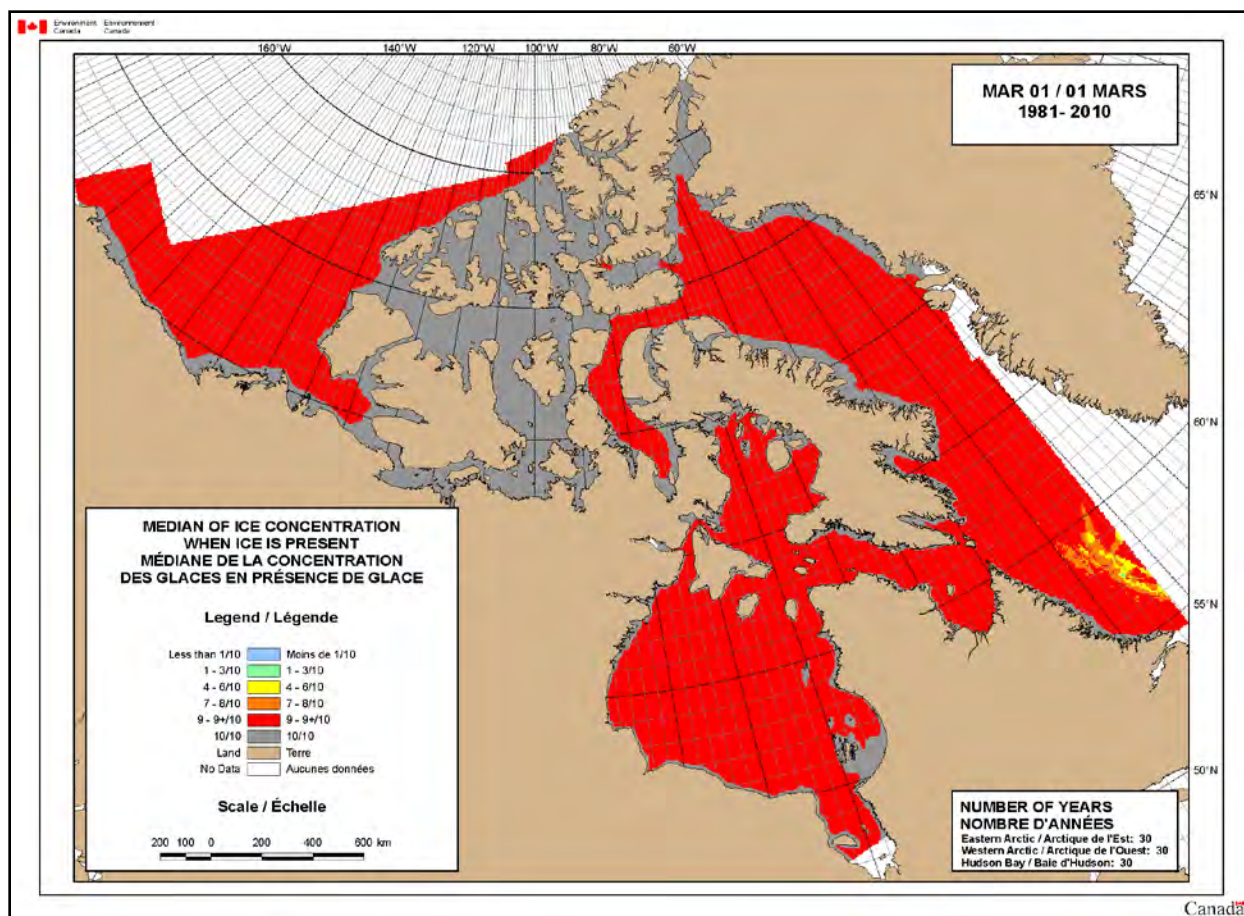
Source: Canadian Ice Service 30-Year Ice Atlas. (<http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en>), accessed April 2018.

Figure 3.3 30-Year Median Concentration of Sea Ice in Northern Canadian Waters, 1981–2010 (1 March).



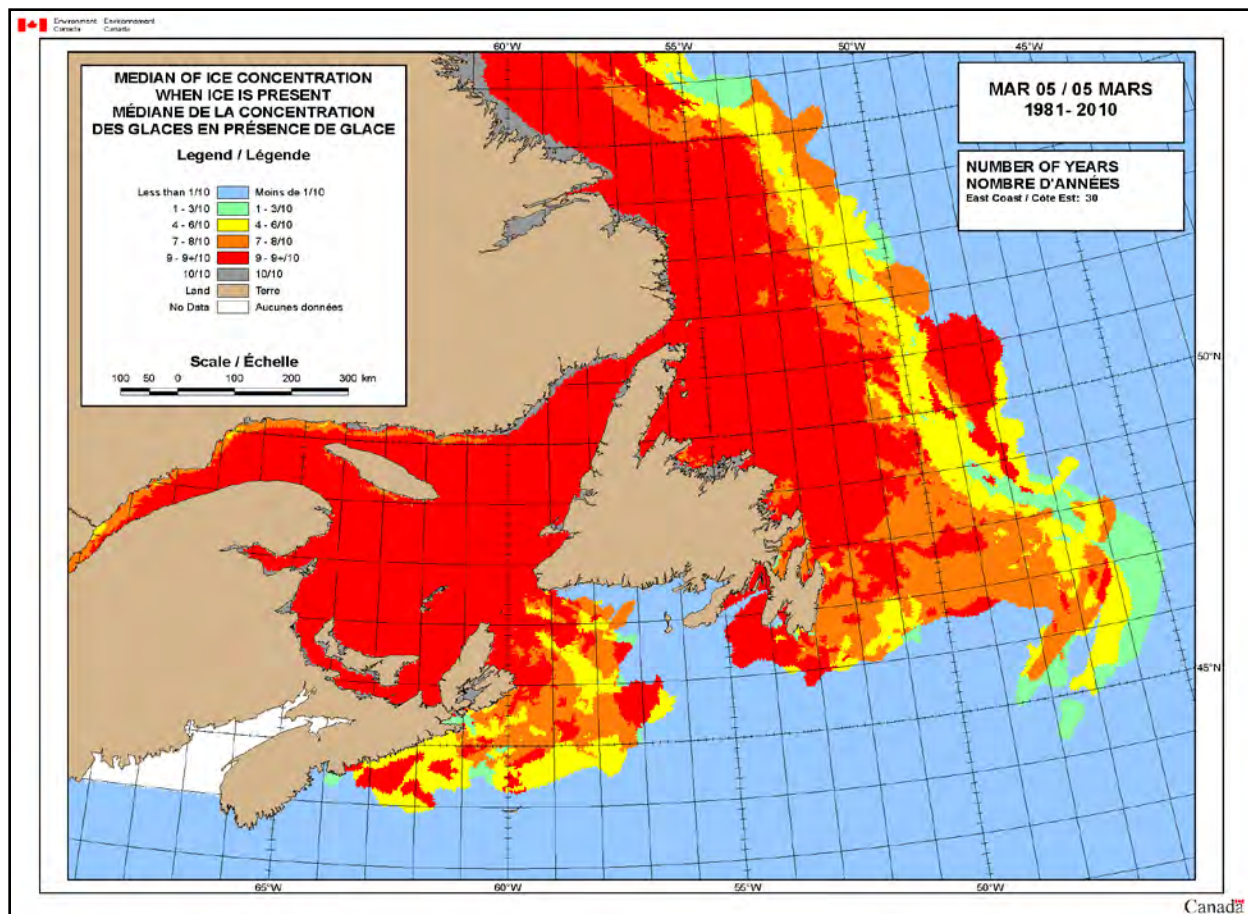
Source: Canadian Ice Service 30-Year Ice Atlas. (<http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en>), accessed April 2018.

Figure 3.4 30-Year Median Concentration of Sea Ice in East Coast Waters, 1981–2010 (5 March).



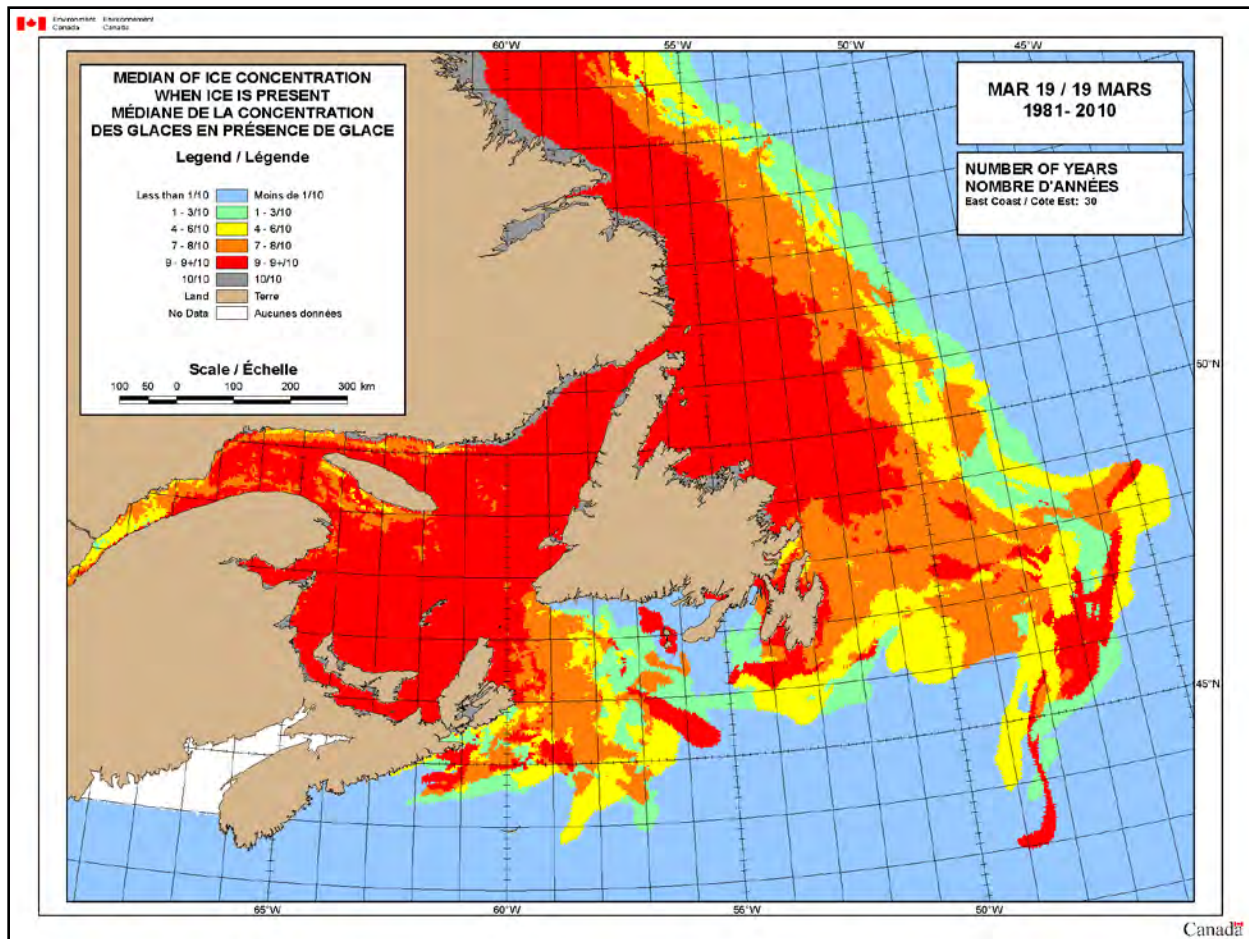
Source: Canadian Ice Service 30-Year Ice Atlas. (<http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en>), accessed April 2018.

Figure 3.5 30-Year Median Concentration of Sea Ice when Ice is Present in Northern Canadian Waters, 1981–2010 (1 March).



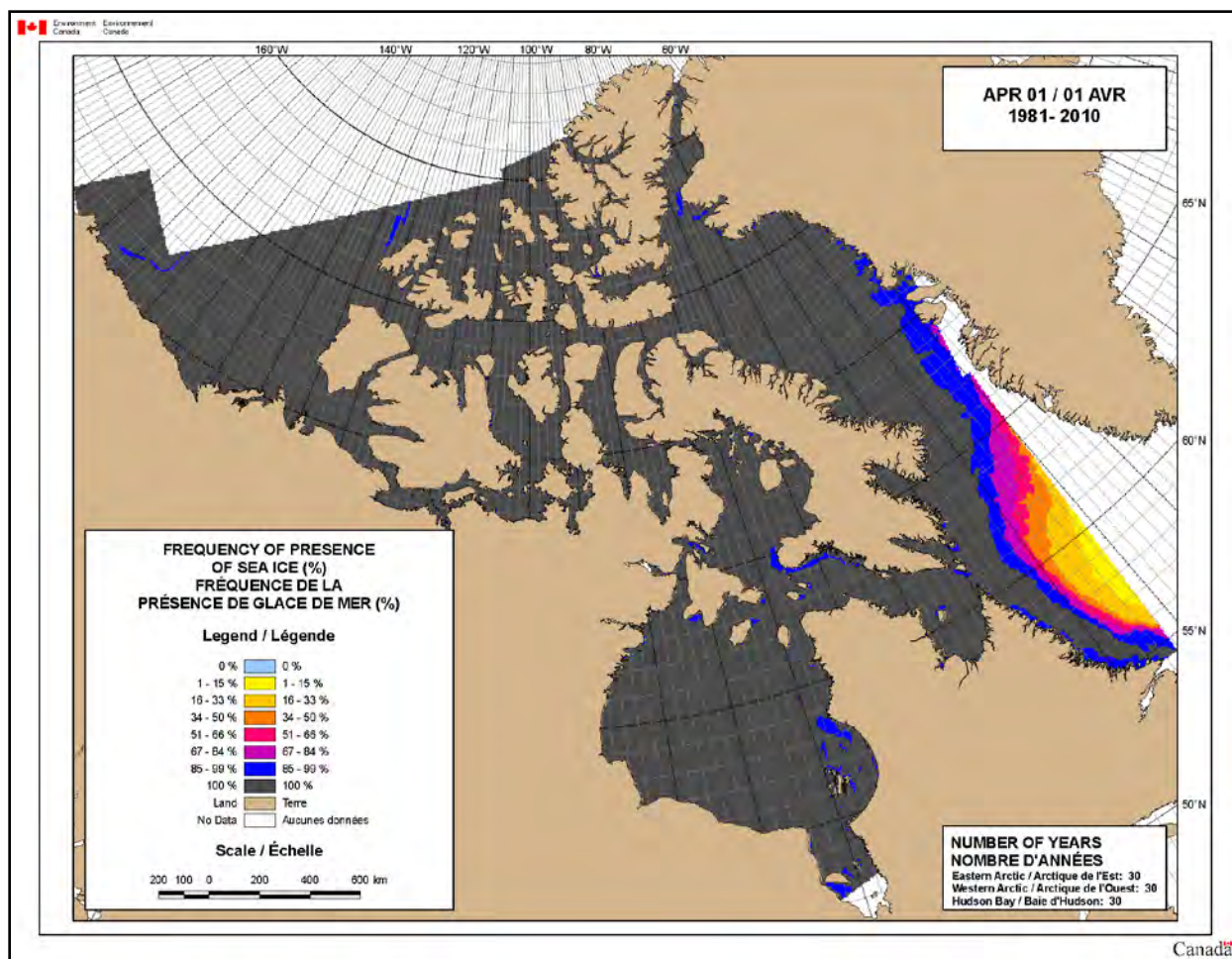
Source: Canadian Ice Service 30-Year Ice Atlas. (<http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en>), accessed April 2018.

Figure 3.6 30-Year Median Concentration of Sea Ice when Ice is Present in East Coast Waters, 1981–2010 (5 March).



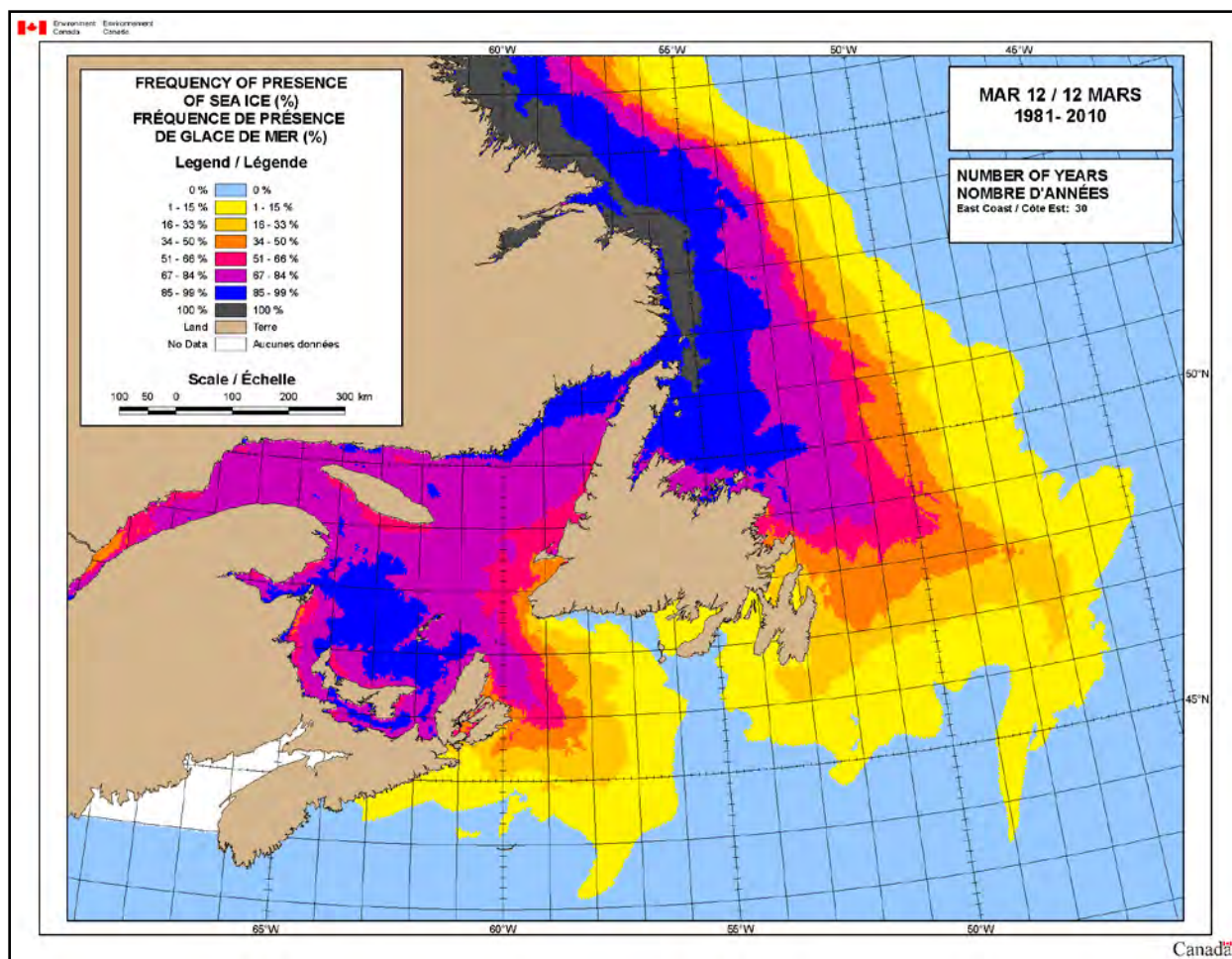
Source: Canadian Ice Service 30-Year Ice Atlas. (<http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en>), accessed April 2018.

Figure 3.7 30-Year Median Concentration of Sea Ice when Ice is Present in East Coast Waters, 1981–2010 (19 March).



Source: Canadian Ice Service 30-Year Ice Atlas. (<http://icweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en>), accessed April 2018.

Figure 3.8 30-Year Frequency of Presence of Sea Ice in Northern Canadian Waters, 1981–2010 (1 April).



Source: Canadian Ice Service 30-Year Ice Atlas. (<http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en>), accessed April 2018.

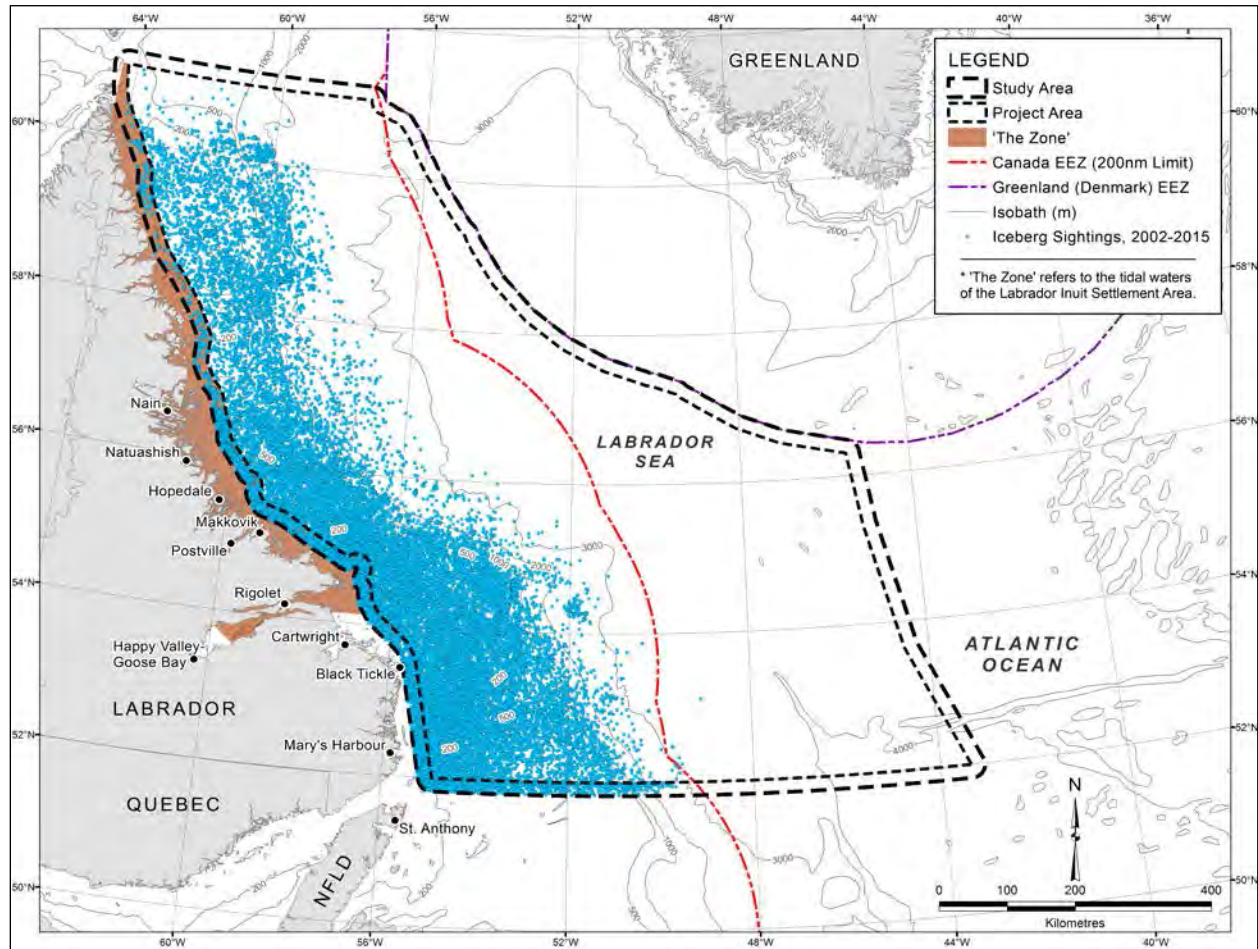
Figure 3.9 30-Year Frequency of Presence of Sea Ice in Canadian East Coast Waters, 1981–2010 (12 March).

New ice begins to form near the coast in the week of 19 November within the Study Area, with grey and grey-white ice also present as of the weeks of 4 and 18 December, respectively. Thin first year-ice begins to form near the Labrador coast by the week of 1 January and extends eastwards over the next month, with medium first-year ice also present as of the week of 5 February. Thick first-year ice is observed by the week of 12 March, with some old ice present by the week of 4 June, and these two ice types consist of the majority of sea ice present by the week of 2 July, after which much of the ice begins to recede (CIS 2011).

3.4.2 Icebergs

Icebergs often cause concern with regard to navigation and offshore activities (including seismic surveys) along the coast of Labrador. The major sources, contributing ~90% of icebergs in Canadian waters, are glaciers along the west coast of Greenland. Prevailing northwest winds and

the strong Labrador Current move icebergs south along the coast of Labrador. The presence of easterly and northeasterly winds strongly influences the number of icebergs that move into the coast or remain offshore. Major iceberg drift patterns flow southward from offshore Labrador to Newfoundland, branching eastward towards the Flemish Cap (Figure 3.10).



Source: NSIDC 1995, IIP Iceberg Sightings Database, accessed April 2018.

Figure 3.10 Iceberg Sightings in the Study Area, 2002–2015.

An analysis was performed to determine the threat posed by icebergs in the Study Area. The International Ice Patrol (IIP) Iceberg Sightings Database was used as the primary data source in this analysis (NSIDC 1995, updated annually). As shown in Table 3.10, during the period from 2002–2015, a total of 31,297 icebergs were observed in the Study Area. Sightings may not include all icebergs passing through the Study Area but indicate the relative abundance by month. Of the 31,297 icebergs sighted, 69.3% were observed during the period of May–November. Most were sighted in May, June and July (14.3, 30.1 and 20.3%, respectively), followed by March (12.7%) and April (13.6%). All remaining months contributed <4% each to the total number of iceberg sightings. Additionally, there was a great deal of inter-annual

variability in the numbers of iceberg sightings. For example, during May–November of 2009, there were 1,451 icebergs observed in the Study Area. During the same time period of 2010, there were only 641 icebergs observed.

Table 3.10 Annual and Monthly Iceberg Sightings within the Study Area, 2002–2015.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	6	150	108	64	303	60	-	-	-	-	-	691
2003	-	5	93	101	144	49	17	-	-	-	-	-	409
2004	-	1	39	318	104	3	1	5	-	-	-	-	471
2005	-	-	5	15	3	17	-	-	-	-	-	3	43
2006	6	133	105	638	469	2,075	-	-	-	-	3	6	3,435
2007	40	21	522	79	203	594	1,189	272	124	-	3	5	3,052
2008	33	92	221	91	292	484	251	16	16	-	-	2	1,498
2009	38	19	745	419	279	604	411	141	16	-	-	2	2,674
2010	2	37	121	997	157	331	111	37	4	-	1	-	1,798
2011	1	47	161	96	740	837	713	192	5	1	-	-	2,793
2012	12	111	58	302	84	420	336	70	52	18	15	2	1,480
2013	16	187	84	282	636	603	669	135	24	2	3	5	2,646
2014	100	252	1,138	556	285	2,902	695	174	10	-	4	11	6,127
2015	14	174	522	268	1,008	188	1,909	56	41	-	-	-	4,180
Total	262	1,085	3,964	4,270	4,468	9,410	6,362	1,098	292	21	29	36	31,297
% of Total	0.8	3.5	12.7	13.6	14.3	30.1	20.3	3.5	0.9	0.0	0.0	0.0	-

Source: NSIDC 1995, IIP Iceberg Sightings Database, accessed April 2018.

Iceberg size is typically characterized by waterline length, defined as the maximum dimension of the iceberg along the waterline, with a growler being defined as <5 m, a bergy bit as 5–14 m, small as 15–60 m, medium as 61–122 m, large as 123–213 m, and very large as >213 m. During the period from 2002–2015, 38.6% of the 31,297 icebergs with a defined sized classification recorded in the Study Area were classified as medium, large, or very large-sized.

4.0 Biological Environment

The biological environment in and near the Study Area has been described in the Labrador Shelf SEA (C-NLOPB 2008) and two project-specific EAs (LGL 2014, 2016). In addition to updated information, overviews of relevant information are presented in the following subsections for fish and fish habitat, fisheries, marine-associated birds, marine mammals, sea turtles, species at risk and sensitive areas. Data gaps identified in the SEA (C-NLOPB 2008) have also been examined for any change in status.

4.1 Ecosystem

An ecosystem is an inter-related complex of physical, chemical, geological, and biological components that can be defined at many different scales from a relatively small area that may only contain one primary habitat type (e.g., a shelf) to a relatively large regional area ecosystem which is topographically and oceanographically complex with shelves, slopes, valleys and several major water masses and currents (e.g., the NW Atlantic). This EA focuses on components of the ecosystem such as selected species and stages of fish, marine-associated birds, marine mammals and sea turtles, that are important ecologically, economically, and/or socially, with potential to interact with the Project. This is the VEC approach (see § 2.4.1.2) to environmental assessment and this approach is described in § 5.0. The VECs and/or their respective groups are discussed in the following subsections.

4.2 Fish and Fish Habitat VEC

This subsection provides a description of the existing fish and fish habitat in the Study Area. Fish habitat is considered first, followed by a discussion of macro-invertebrates and fishes in the Study Area.

4.2.1 Fish Habitat

In this EA, ‘fish habitat’ includes physical and biological aspects of the marine environment used by macro-invertebrate and fish species in the Study Area. The physical and chemical nature of the water column (i.e., water temperature, depth, salinity) and bottom substrate (i.e., surficial sediment) are critical factors affecting the characterization of associated marine biological communities. Subsection 3.1 of this EA discusses both the bathymetry and geology of the Study Area. The biological component of fish habitat refers to phytoplankton, zooplankton and benthos (i.e., infaunal and epibenthic invertebrates, such as polychaetes and echinoderms, not typically harvested during commercial fisheries in the Study Area).

4.2.1.1 Plankton

Plankton is composed of free-floating organisms that form the basis of the pelagic ecosystem. Plankton constituents include bacteria, fungi, phytoplankton, and zooplankton (mostly invertebrates, but may also include eggs and larvae of fishes, known as ichthyoplankton). In simplest terms, phytoplankton species produce carbon compounds through the utilization of sunlight, carbon dioxide, and nutrients (e.g., nitrogen, phosphorus, silicon). This process is called primary production. Herbaceous zooplankton (e.g., calanoid copepods, the dominant component of NW Atlantic zooplankton) feed on phytoplankton, a growth process known as secondary production. The herbivores in turn are ingested by predators (i.e., tertiary production) such as predatory zooplankton (e.g., chaetognaths, jellyfish, etc.), all of which may be grazed by higher predators such as fish, marine-associated birds, marine mammals and sea turtles. 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 fish, seabirds, and marine mammals congregate to feed.

Phytoplankton distribution, productivity and growth regulation in high-latitude ecosystems constitute a complex system in which light, nutrients and herbivore grazing are the principal factors limiting phytoplankton regulation (Harrison and Li 2008). In the NW Atlantic, there is generally a spring plankton bloom (May/June) which is typically followed by a smaller bloom in the fall (September/October). This general pattern likely applies to the Study Area. There are regions of enhanced production in the Study Area, similar to other slope areas that have been studied. For example, Moderate Resolution Imaging Spectroradiometer (MODIS) chlorophyll ‘a’ concentration images from 2015 and 2016 (DFO 2016a) indicate the highest chlorophyll ‘a’ concentrations occurred on the shelf and along the slope areas between June and late August. A second smaller peak occurred in late September and October, primarily in slope areas. The spring/summer bloom of phytoplankton is typically the driving force of high-latitude marine ecosystem dynamics, at least in offshore areas. Sunlight has been considered the limiting factor for development of the spring bloom, but other factors such as nutrients, latitude and water column stratification are also important (Wu et al. 2008).

Zooplankton reproduction is tied to the phytoplankton bloom and 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 is the foremost link between primary production and higher-level organisms in the offshore marine ecosystem. They transfer organic carbon from phytoplankton to fish, marine mammals and seabirds higher in the food chain. Zooplankton, a food source for a broad spectrum of species, contribute carbon via faecal matter and dead zooplankton to benthic food chains. Pepin et al. (2011) noted that plankton distribution in the Study Area is primarily influenced by local advective transport and mixing processes, with several species of *Calanus* copepods acting as key contributors to the regional secondary production.

The information on plankton within the Study Area has been reviewed extensively in the Labrador Shelf SEA (§ 4.5 of C-NLOPB 2008) and is summarized in this subsection. Some of the key points concerning the various components of planktonic communities for the Labrador Shelf area are highlighted below.

- In the North Atlantic, there is strong seasonal variability in primary production, typically characterized by a peak phytoplankton bloom in early-spring (April or May) that is dissipated over the summer by the formation of a summer thermocline that prevents the movement of nutrients throughout the water column (Maillet et al. 2004; Harrison et al. 2013);
- Another smaller phytoplankton bloom is created when fall winds and cooler temperatures break down the thermocline, allowing nutrients to be circulated in the water column and utilized by phytoplankton (Maillet et al. 2004);
- Nitrate and silicate are considered limiting nutrients to phytoplankton and their relative abundance can affect community structure;
- In general, larger microplankton are dominated by diatoms (e.g., *Chaetoceros* sp.), but dinoflagellates (*Ceratium* sp.) become more abundant in fall/winter (Harrison et al. 2013);
- Copepods account for a majority of the zooplankton abundance, followed by cladocerans;
- The copepod *Calanus finmarchicus* is considered a keystone species in the region due to its importance to higher trophic levels;
- Euphausiids, such as krill, are important prey for marine mammals and have the highest densities in slope waters and offshore regions;
- Spawning periods for many fish species are synchronized with plankton blooms to provide larvae access to seasonally abundant food supplies, thereby increasing survivorship;
- Microbiota consisting of bacteria, mould and yeast are ubiquitous in the marine environment. These microflora occupy a unique niche in marine ecosystems in that they both serve as a food source and degrade organic matter (Bunch 1979). Typically, microflora are most abundant in the upper layers and their numbers decrease with depth (Li and Harrison 2001);
- The vertical distributions of many zooplankton species exhibit diurnal variability, resulting in higher concentrations in the surface waters during the day;
- Arctic water masses that influence the Labrador Current are dominated by calanoid copepods (*C. finmarchicus*, *C. glacialis*, and *C. hyperboreus*) and the cyclopoid *Oithona similis* (Huntley et al. 1983);

- Sea ice biota are fauna and flora of all trophic levels that live in, on or associate 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 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. The blooms occur earlier in both the north and south Labrador Sea areas compared to its initiation in the central Labrador Sea (Wu et al. 2008);
- 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); and
- The role of sea-ice dynamics with respect to 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 (Wu et al. 2007).

The Atlantic Zone Monitoring Program (AZMP) was implemented by DFO in 1998 in order to better understand, describe and forecast the state of the marine ecosystem. A critical element of the AZMP is an observation program designed to assess the variability in nutrients, phytoplankton and zooplankton (DFO 2016a). The AZMP findings in relation to oceanographic conditions in the Study Area for 2015 are summarized below.

- In the southern regions of the zone, sea-surface temperatures were above normal in January and February of 2015 and generally near normal until June across the zone. The sea-surface temperatures for Labrador were below normal to normal, and normal to above normal everywhere else in the zone for the remainder of the year. Bottom temperatures were generally normal or above normal across the zone;
- Overall abundance of copepods throughout much of the Atlantic Zone has increased compared to levels observed in 2014;
- Chlorophyll ‘a’ inventories were near or above normal throughout much of the Atlantic Zone; and
- Timing indices of the spring bloom was substantially delayed on the northern Labrador and northeast Shelf compared to those in the Flemish Pass and Flemish Cap area (Pepin et al. 2015).

Planktonic organisms are so ubiquitous and abundant, and typically have such rapid generation times, that there will be negligible effect on planktonic communities from the proposed seismic program. Therefore, no further assessment of the potential effects of the Project on phytoplankton and zooplankton will be discussed in this section. However, planktonic stages of commercial invertebrates (e.g., northern shrimp *Pandalus borealis*, snow crab *Chionoecetes opilio*) and fishes (e.g., Atlantic cod *Gadus morhua*) are described in the following subsections because of their VEC status.

4.2.1.2 Benthic Invertebrates

Benthic invertebrates are bottom-dwelling organisms that can be classified into three categories: (1) infaunal organisms; (2) sessile organisms; and (3) 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 include barnacles, tunicates, bryozoans, holothurians and some anemones. The epibenthic organisms are active swimmers that remain in close association to the seabed and include mysids, amphipods and decapods.

Benthic invertebrate communities can be spatially variable because of variability associated with 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 latitudes are water mass differences, sediment characteristics and ice scour (Carey 1991). The wide range of these characteristics within the Study 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 invertebrate communities of the Study Area have been described in the Labrador Shelf SEA (§ 4.6 and 4.7 of C-NLOPB 2008) and two project-specific EAs (§ 4.2 of LGL 2014, 2016). It is important to note that beyond the Canadian 200 nm limit, there is a substantial deficiency in data related to the benthos. The information presented in this subsection pertains to studies completed on the continental shelf and slope of the Study Area.

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. = 4.0°C; silt and clay substrate). The dominant species at the shallower site, in terms of standing crop and abundance, were the molluscs *Tachyrhynchus erosus* and *Macoma loveni*; the polychaetes *Rhodine gracilior*, *Maldane sarsi* and *Chaetozone setosa*; the echinoderm *Ophiura robusta*; and the crustacean *Unciola leucopis*. The deeper site was dominated by the molluscs *Yoldiella lucida*, *Thyasira gouldi* and *Dentalium occidentale*; the polychaetes *Glycera capitata*, *Ophelina cylindrocaudatus*, *Lumbrineris impatiens* and an unidentified species; and the echinoderms *Amphipholis squamata* and *Amphiura fragilis*. 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.

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 only in this region. Dense congregations of coral off Labrador are referred to as coral “forests” or “fields”. Most grow on hard substrate (Gass 2003), including the large gorgonian corals (Breeze et al. 1997). Others, such as small gorgonians, cup corals and sea pens prefer sand or mud substrate (Edinger et al. 2007). The distribution of various corals along the continental shelf and slope regions of the Study Area based on data collected by fisheries observers are provided in Figure 3 of Wareham and Edinger (2007) and Map 1 of Wareham (2009). In total, 30 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 studies present information on the ecology of deep cold-water corals of Newfoundland and Labrador waters, including information on biogeography, life history, biochemistry and their relation to fishes (e.g., Wilkinson and Edinger 2009; Kenchington et al. 2010a,b, 2016; 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 (2000–2007), DFO Arctic multispecies surveys (2006–2007), a northern shrimp survey (2005) and information provided by fisheries observers aboard commercial fishing vessel (2004–2007). The maps in 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 (*Paragorgia arborea* and *Paramuricea* spp.), small gorgonians (*Acanthogorgia armata* and *Acanella arbuscula*) and soft corals (*Anthomastus grandiflorus*, *Duva florida*, *Gersemia rubiformis* and *Nephtheid* spp.). Also noted were scleractinian species (*Flabellum alabastrum* and *Vaughanella margaritata*) and several pennatulacean species (*Anthoptilum grandiflorum*, *Halipteris finmarchica*, *Pennatula grandis* and unspecified sea pen species). Antipatharian species were also observed within the Study Area along the Labrador shelf. The majority of coral species observed occurred on the continental slope, with the exception of several soft corals (*Gersemia rubiformis* and *Nephtheid* spp.) found distributed on the shelf.

The patterns of association between deep-sea corals, fish and invertebrate species, based on DFO scientific surveys and ROV surveys, are discussed by Edinger et al. (2009). Although there were no obvious relationships between corals and abundance of the ten groundfish species studied, there was 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, roughhead grenadier (*Macrourus berglax*) with large gorgonians/antipatharians and soft corals, and 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*), a lanternfish (*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 significant 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 NW Atlantic were characterized by a significantly higher biodiversity and abundance of associated megafauna compared to non-sponge habitat.

In a recent DFO report by Guijarro et al. (2016), sponge and coral distributions based on research vessel survey data and associated environmental data contributed to the development of a species distribution modelling approach called “random forest” to identify significant benthic areas and predict the probable occurrence of sponges, sea pens (*Pennatulacea*), large gorgonians, and small gorgonians within the entire Newfoundland and Labrador region. Random forest modelling can be used to predict the probability of species occurrence in an unsampled area. Data were collected from DFO research vessel multispecies trawl surveys, DFO/industry northern shrimp surveys and Spanish research vessel groundfish trawl surveys. All tows followed a stratified random trawl design using Campelen trawl gear. Data concerning sponges were drawn from trawl data conducted from 1995–2015 and from 2003–2015 for all other species. Figures 5, 20, 35, and 50 in Guijarro et al. (2016) display the probability of species’ distributions in unsampled areas overlaying known presence/absence of species from survey tows for sponges, sea pens, large gorgonians and small gorgonians. This modelling approach is useful for filling data gaps in survey coverage and extrapolating probable significant benthic areas for unsampled areas.

Kenchington et al. (2016) provided maps displaying the locations of significant coral and sponge concentrations on the Newfoundland and Labrador Shelf and Slope. Using DFO research vessel trawl survey data and an updated kernel density estimation analysis, they modeled the distribution of sponges, small and large gorgonian corals, and sea pens throughout the Study Area; identifying sponge and coral concentrations and significant benthic areas (SBAs). Updated locations of high concentration areas of sponge, sea pen, large gorgonian and small gorgonian corals can be seen in Figures 37, 42, 47, and 52, respectively, of Kenchington et al. (2016). Also, SBAs were identified within the Study Area for the above sponge and coral groups on the Northeast Newfoundland Shelf and Slope regions (see Figure 99 of Kenchington et al. [2016]).

Since 2008, the NAFO Scientific Council has been identifying various areas of significant coral and sponge concentrations within the NAFO Regulatory Area. These areas have been closed to fishing with bottom gear and are shown in § 4.7, Sensitive Areas (NAFO 2018).

DFO recently published a report that discusses its coral and sponge conservation strategy for Eastern Canada (DFO 2015a). The report includes discussion of the current status of coral and sponge conservation in Eastern Canada, research on corals and sponges in Eastern Canada, and other aspects of corals and sponges in both Canadian and international contexts.

DFO RV survey data collected in the Study Area during May–November 2014 indicate that sponges and corals were caught primarily in the slope areas off Labrador although some were also caught on the shelf (see Figures 4.27 and 4.31 in § 4.3.7).

4.2.2 Fish

For the purposes of this EA, ‘fish’ includes macro-invertebrates that are targeted in the commercial fisheries and all fishes, either targeted in the commercial fisheries or otherwise. The focus is on key commercially- and ecologically-important fishes.

4.2.2.1 Principal Macro-invertebrates and Fishes Commercially Harvested

This subsection 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 and Greenland halibut *Reinhardtius hippoglossoides*) and other species caught incidentally (e.g., wolffishes [*Anarhichas* spp.]).

Northern shrimp, snow crab, and Greenland halibut have dominated directed commercial fishery landings for the Study Area in recent years. Some of the ‘incidental catch’ species and key ecologically-important fishes are also discussed in this subsection.

Macroinvertebrates

Northern Shrimp

Aspects of the northern shrimp life history, including information on distribution, are discussed in § 4.2.2.1 of LGL (2014, 2016). Subsection 4.8.3 of the Labrador Shelf SEA (C-NLOPB 2008) also provides life history information on northern shrimp.

The fishable biomass in Shrimp Fishing Area (SFA) 4 (NAFO Div. 2G) decreased by 13% in 2015 relative to 2014, and was estimated at 91,000 mt. The fishable biomass in SFA 5 (NAFO Div. 2HJ) has been relatively stable since 2010, at an estimated 148,000 mt in 2015 (DFO 2016b). The Total Allowable Catch (TAC) for northern shrimp in SFAs 4, 5, and 6 for 2018 is 15,725 mt, 25,630 mt and 8,730 mt, respectively (DFO 2018a).

In the commercial fishery conducted within the Study Area, northern shrimp harvesting during May–November 2015 took place primarily in the area off southeastern Labrador and at various

slope areas off Labrador (see Figure 4.8 in § 4.3.3.2 and Figure 4.24 in § 4.3.7). Fishing effort distribution for northern shrimp within the Study Area during 2013–2014 is provided in Figure 4.10 in § 4.3.3.2 of LGL (2016).

Snow Crab

Aspects of the snow crab life history, including information on distribution, are discussed in § 4.2.2.1 of LGL (2014, 2016). Subsection 4.8.2 of the Labrador Shelf SEA (C-NLOPB 2008) also provides life history information on snow crab.

Snow crab landings in NAFO Div. 2HJ have been low since 2011, with less than 2,000 mt landed annually. Fishing effort has been substantially reduced in recent years. While recruitment increased dramatically in 2014, it was assessed at a much lower level in 2015. Long-term recruitment prospects in these NAFO Divisions are considered unfavourable based on a recent warming oceanic regime and a low abundance of young crabs in the past decade (DFO 2016c). The TAC for snow crab in Div. 2HJ and 3K are 1,865 mt and 5,932 mt, respectively (DFO 2018a).

In the commercial fishery conducted within the Study Area during May–November 2015, snow crab harvesting was conducted off southeastern Labrador (see Figure 4.11 in § 4.3.3.2). Fishing effort distribution for snow crab within the Study Area during 2013–2014 is provided in Figure 4.13 in § 4.3.3.2 of LGL (2016).

Striped Shrimp

The distribution and life history of striped shrimp (*P. montagui*) are described in § 4.2.2.1 of LGL (2014). Striped shrimp are taken as by-catch in the SFA 4 northern shrimp fishery (DFO 2018b). The 2017/2018 commercial catch (as of January 2018) of 2,500 mt was the highest striped shrimp catch observed in SFA 4 since 2012 (4,700 mt), although the by-catch limit of 4,033 mt has not been taken since it was implemented during 2013/2014 (DFO 2018b). During 2017, the fishable biomass of striped shrimp in SFA 4 was estimated at 45,500 mt, a 90% increase from 2016 (DFO 2018b). There is no Integrated Fisheries Management Plan for striped shrimp, and the current status of this resource is unknown due to the large fluctuations in biomass observed from year to year, likely owing to the influence of currents and tides (DFO 2018b). The striped shrimp bycatch limit in the northern shrimp fishery in SFA 4 is 4,033 mt for 2018 (DFO 2018a).

Prior to 2012, logbooks were the only source of catch information, with the recording of by-catch in the Canadian Atlantic Quota Report (CAQR) required as of 2013 (DFO 2018b). Striped shrimp harvest locations in the Study Area were not shown in previous relevant EAs (LGL 2014, 2016) or the Labrador Shelf SEA (C-NLOPB 2008). During May–November 2010 and 2015, striped shrimp were primarily harvested in the northwest portion of the Study Area,

with some catch locations also in the central-western and southwestern portions, in water depths <500 m (see Figure 4.17 in § 4.3.3.2). Striped shrimp were caught in the central-western and southwestern portions of the Study Area during DFO RV surveys during May–November 2014 (see Figure 4.29 in § 4.3.7).

Fishes

Greenland Halibut (Turbot)

Life history aspects of Greenland halibut, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2016). Subsection 4.8.6 of the Labrador Shelf SEA (C-NLOPB 2008) also provides life history information on Greenland halibut.

In the commercial fishery conducted within the Study Area during May–November 2015, Greenland halibut harvesting occurred primarily along the slope region off southern Labrador (see Figure 4.14 in § 4.3.3.2). Distribution of fishing effort for Greenland halibut within the Study Area during 2013 and 2014 is provided in Figure 4.16 in § 4.3.3.2 of LGL (2016). Most catch locations for Greenland halibut in the Study Area during DFO RV surveys in May–November 2014 were distributed along the shelf and slope area off Labrador (see Figure 4.26 in § 4.3.7).

Roughhead Grenadier

The distribution and ecology of roughhead grenadier is described in § 4.2.2.1 of LGL (2014) and § 4.3.4 of C-NLOPB (2008). Commercial harvest locations were not shown in previous relevant EAs (LGL 2014, 2016) or the Labrador Shelf SEA (C-NLOPB 2008). During May–November 2010 and 2015, roughhead grenadier were caught in the southern portion of the Study Area, predominantly between the 500 m and 1,000 m isobaths (see Figure 4.18 in § 4.3.3.2).

Redfishes

Life history aspects of redfishes, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2016). Subsection 4.8.4 of the Labrador Shelf SEA (C-NLOPB 2008) also provides life history information on redfishes.

There is limited commercial fishery for catches of redfishes within the Study Area during May–November 2015, as seen in Figure 4.19 in § 4.3.3.2). There has been a moratorium on redfish within NAFO Sub-Area 2 and Div. 1F3K since 2012 (NAFO 2018). Fishing effort distribution for redfishes within the Study Area during 2013 and 2014 are provided in Figure 4.20 in § 4.3.3.2 of LGL (2016). Catch locations for deepwater redfish in the Study Area during DFO RV surveys in May–November 2014 were distributed along the shelf and upper slope off southern Labrador (see Figure 4.25 in § 4.3.7).

Witch Flounder

The distribution and biology of witch flounder were described in § 4.8.14 of C-NLOPB (2008). Commercial catch locations for witch flounder were not previously shown in relevant EAs (LGL 2014, 2016) or the Labrador Shelf SEA (C-NLOPB 2008). Harvest locations in the Study Area during May–November 2010 are provided in Figure 4.20 in § 4.3.3.2 (there were no harvest locations during May–November 2015). Witch flounder were only harvested in the southern portion of the Study Area during this period, between the 500 m and 1,000 m isobaths.

American Plaice

Life history aspects of American plaice *Hippoglossoides platessoides*, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2016). Subsection 4.8.5 of the Labrador Shelf SEA (C-NLOPB 2008) also provides life history information on American plaice.

There is limited commercial fishery data for catches of American plaice within the Study Area. During May–November 2015, American plaice were harvested in the southern region of the Study Area, outside the community of Cartwright (see Figure 4.21 in § 4.3.3.2). Distribution of fishing effort for American plaice within the Study Area during 2013 and 2014 is provided in Figure 4.21 in § 4.3.3.2 of LGL (2016).

Atlantic Cod

Life history aspects of Atlantic cod, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2016). Subsection 4.8 of the Labrador Shelf SEA (C-NLOPB 2008) also provides life history information on Atlantic cod.

Rose and Rowe (2015) discuss the comeback of northern cod. Using data collected during acoustic-trawl surveys of the main pre-spawning and spawning components of the stock, they show that biomass has increased from tens of thousands of tonnes to >200 thousand tonnes during the last decade. The increase was first signalled by the observation of massive schooling behaviour in late winter in 2008 in the southern range of the stock (i.e., Bonavista Corridor) after a 15-year absence. In the spring of 2015, large increases in cod abundance and size composition were observed for the first time since 1992 in the more northerly spawning groups of the stock complex (i.e., outer Notre Dame Channel, southern Hamilton Bank and Hawke Channel).

The latest DFO stock assessments indicate that the “Northern” cod stocks in NAFO Div. 2J3KL have increased considerably over the past decade. Overall biomass increased between 2005 and 2012 but has remained stable in recent years. DFO continues to manage the stock using the precautionary principle, keeping removals at the lowest possible level until assessments indicate the stock has cleared the critical zone (DFO 2016d). During June–November 2017 (with no

harvest permitted during July), weekly harvest limits ranged from 4,000–5,000 mt in Div. 2J and 2,000–5,000 mt in Div. 3KL (DFO 2017b).

There are no commercial fishery data indicating commercial catches of Atlantic cod in the Study Area during May–November 2015. However, DFO RV data collected in the Study Area during May–November 2014 indicated Atlantic cod catches in the shelf and slope areas of most of the Study Area except for the extreme northern portion (see Figure 4.28 in § 4.3.7).

4.2.2.2 Other Fishes of Note

Capelin

Life history aspects of capelin *Mallotus villosus*, including distribution information, are presented in § 4.8.10 of the Labrador Shelf SEA (C-NLOPB 2008).

In the latest DFO CSAS document for capelin, landings in 2013 and 2014 were determined to be 23,755 mt and 23,173 mt, respectively, with a TAC in Divs. 2J3KL of 22,771 mt in 2014 (DFO 2014). Fish harvesters reported increased abundance and distribution for capelin in all NAFO areas, including those that did not support a commercial fishery in 2014. Capelin were noted to be longer, heavier and have higher fat levels (DFO 2015b). TAC levels increased from 96 mt to 120 mt in Div. 2J and from 8,576 mt to 10,720 mt in Div. 3K between 2014 and 2015 and remained at these levels until 2017 (TAC for 2018 are not yet available) (DFO 2018a).

Wolffishes

Three species of wolffish (i.e., northern *Anarhichas denticulatus*, spotted *A. minor* and Atlantic *A. lupus*) are listed on Schedule 1 of SARA. The northern and spotted wolffishes are considered *threatened* under Schedule 1 of SARA and under COSEWIC. The Atlantic wolffish has *special concern* status under Schedule 1 of SARA and under COSEWIC.

Profiles for northern and spotted wolffishes are included in § 4.6, Species at Risk. The profile for Atlantic wolffish is provided below.

Atlantic Wolffish

Life history aspects of Atlantic wolffish, including distribution information, are presented in § 4.2.2.1 of LGL (2014). Subsection 4.2.3 of the Labrador Shelf SEA (C-NLOPB 2008) also provides a life history information on Atlantic wolffish.

DFO RV data collected in the Study Area during May–November 2014 indicated that Atlantic wolffish were caught on the shelf area off southern Labrador (see Figure 4.30 in § 4.3.7).

Arctic Cod

Life history aspects of Arctic cod *Boreogadus saida*, including distribution information, are presented in § 4.2.2.1 of LGL (2014) and 4.8.12 of the Labrador Shelf SEA (C-NLOPB 2008).

Anadromous Fishes

The two predominant anadromous fish species that occurs within the Study Area are Atlantic salmon *Salmo salar* and Arctic char *Salvelinus alpinus*. Subsection 4.2.2.1 of LGL (2014) provides life history information for both species. Subsections 4.8.7 and 4.8.8 of the Labrador Shelf SEA (C-NLOPB 2008) also provide life history information for Atlantic salmon and Arctic char.

4.2.2.3 Macroinvertebrate and Fish Reproduction in the Study Area

Temporal and spatial details of macroinvertebrate and fish reproduction within the Study Area are provided in Table 4.1.

Table 4.1 Reproduction Specifics of Macroinvertebrate and Fish Species Likely to Spawn 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 8–10 months and larvae hatch in the spring	12–16 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	12–15 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	Spring/summer or winter months	Uncertain
Witch Flounder	Throughout the Grand Banks, particularly along slopes >500 m	Late-spring to late-summer/early-fall	Uncertain
Thorny Skate	Throughout distribution range	Year-round Eggs deposited in capsule (one egg per capsule), possibly on bottom	None
Roundnose Grenadier	Uncertain	Year-round Eggs are free-floating	Uncertain
Roughhead Grenadier	Likely along southern and southeastern slopes of Grand Banks	Winter/early-spring	Uncertain
Capelin	Spawning generally on beaches or in deeper waters	Late-June to early-July	Several weeks
American Plaice	Spawning generally occurs throughout the range the population inhabits.	April–May	12–16 weeks

Species	Locations of Reproductive Events	Times of Reproductive Events	Duration of Planktonic Stages
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–June	10–12 weeks
Atlantic Salmon	Spawn in freshwater	October–November	Several weeks in freshwater
Wolffishes	Along bottom in deeper water, typically along continental slope	Summer to early-winter (species-dependent)	Uncertain
Arctic Char	Spawn in freshwater	October–November	Several weeks in freshwater
Cusk	Uncertain	May–August	Presumed to be 4–16 weeks
Sand Lance	On sand in shallow water of the Grand Banks	November–January	Several weeks

4.2.3 Fish and Fish Habitat Data Gaps Identified in Relevant SEAs

The following data gap associated with the Fish and Fish Habitat VEC was identified in the Labrador Shelf SEA (§ 4.8.21 of C-NLOPB 2008).

- There is a lack of regional specific data related to species life history (e.g., spawning locations, abundance, distribution), particularly with respect to non-commercial species;
- Data related to species movements are limited; and
- There is a lack of knowledge about how climate variations affect species and ecosystem interactions.

The data gaps indicated above still exist. The collection of temporal and spatial data with regards to species life history (e.g., spawning locations, abundance, distribution, areas of high productivity) for data-deficient and lesser known non-commercial species would be valuable when considering environmental effects assessments and fisheries resource management. Similarly, addressing these data gaps would aid in assessing cumulative effects from multiple industrial activities, especially in terms of mitigating possible marine ecosystem impacts. Gaps in our knowledge of marine ecosystems are significant, and these deficiencies make it difficult to determine the extent to which humans have influenced and affected marine ecosystems, particularly with the current increase in anthropogenic activities. The interaction between climate change and ecosystem/species specific impacts is a developing research area that will most likely help fill existing data gaps and provide new data on climate change. As stated in § 6.2 of the Eastern Newfoundland SEA (C-NLOPB 2014): “The C-NLOPB, in consultation with advisory agencies within governments and with relevant stakeholders, will promote the planning, prioritizing and undertaking of research (e.g., through research organizations such as the Environmental Studies Research Funds). In addition, Operators may be required to collect data as part of their program operations, either opportunistically during program operations or

prior to the start of program activities. The requirement and nature of the latter will be determined during project-specific assessment.”

4.3 Fisheries VEC

The Fisheries VEC of the Study Area has been previously described in the Labrador Shelf SEA (§ 4.10 of C-NLOPB 2008), and two project-specific EAs (§ 4.3 of LGL 2014, 2016). An overview of the fisheries of the Study Area, based on information within these documents and new information, is provided below. Relevant data gaps identified in the SEA are also discussed in terms of current status.

This subsection describes the commercial fishery in the Study Area during 2010–2015. The Study Area overlaps portions of NAFO Divisions 0B, 1EF, 2GHJ, and 3K (Figure 4.1).

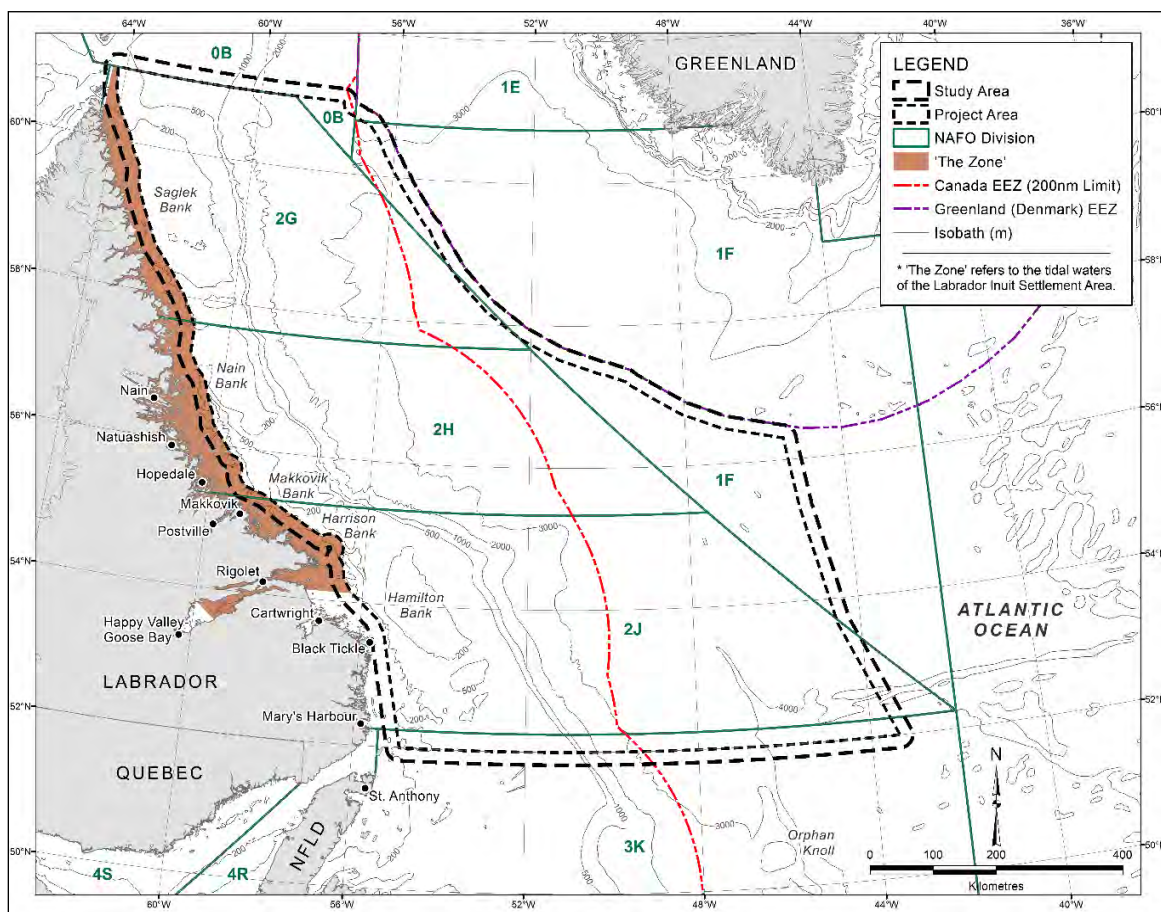


Figure 4.1 Study Area and Project Area in Relation to Regional Fisheries Management Areas (NAFO Divisions).

This subsection also briefly describes historical, recreational and traditional fisheries, aquaculture activity and fisheries research surveys in the Study Area. New information regarding the biology and status of the principal macro-invertebrates and fishes discussed in this section was included in § 4.2, Fish and Fish Habitat.

4.3.1 Information Sources

NAFO catch weight data are used to describe domestic and foreign fisheries conducted beyond the 200 nm EEZ. Less than half of the Study Area is located outside of the 200 nm limit (see Figure 4.1). The NAFO data were obtained from the STATLANT21A dataset for 2010–2015 (Table 4.2). The STATLANT reporting system of questionnaires data are described in § 4.3.1 of LGL (2014). The regional NAFO and historical data analyses in this EA quantify harvesting in NAFO Div. 0B, 1EF, and 2GHJ, beyond the EEZ; 3K is excluded from these analyses as the majority of Div. 3K is beyond and south of the Study Area, and the catch data within it would be more representative of commercial harvests off eastern Newfoundland than offshore Labrador (see Figure 4.1).

Table 4.2 Summary of Information Sources for Commercial Fisheries Data.

Data Source	Domestic/Foreign Fisheries	Temporal Period	Geographic Area	Spatial Resolution
DFO	Domestic	May–November 2010–2015	Within Study Area; mostly within Canadian EEZ but generally within 2,000	Geo-referenced (2010); Gridded 6'x6' cells (2011+)
NAFO	Domestic/Foreign	2010–2015 (1989–2015 for historical overview, § 4.3.3.1	Within/beyond Study Area; beyond Canadian EEZ	NAFO Divisions

The primary fisheries data analyses use all DFO Atlantic Regions georeferenced landings data for the 2010 time period, as well as grid cell landings for 2011–2015 (see Table 4.2). The DFO datasets, analyses and georeferencing/grid methodology of pre- and post-2010 DFO data are described in § 4.3.1 of LGL (2014). Quartile counts are used to present data summaries in tabular format, in order to provide a method by which the individual codes of 1–4 may be directly related to the quartile catch (kg) of value (\$CAD) ranges for a given year. The total number of quartile counts is the same for either catch weight or catch value, as it is the total number of records for a given species, whereby each record contains on catch weight code and one catch value code. Quartile catch/value ranges are not consistent between years; therefore, quartile counts cannot be used to evaluate inter-annual trends. Instead, the sum of quartile codes (range of 1–4) for catch weight for either all species combined or a single species at a time are presented in graphical format (i.e., bar graphs). Using this methodology, inter-annual quartile range variability is accounted for, and the figure is constructed based on summing code

categories (e.g., five instances of Code 1 [i.e., 5x1] equals a sum of quartile codes of 5, and four instances of Code 4 [i.e., 4x4] equals a sum of quartile codes of 16). The more instances of quartile catch weight codes, the greater the overall catch weight during a given year.

References to figures in the Labrador Shelf SEA (C-NLOPB 2008), and two project-specific EAs (LGL 2014, 2016) are provided for commercial harvest locations prior to 2015. Other sources used for this assessment include DFO species management plans, DFO stock status reports and other internal documents.

4.3.2 Regional NAFO Fisheries

The stocks and species managed by NAFO are described in § 4.3.2 of LGL (2014). During the 2010–2015 period, commercial harvesting within the Study Area beyond the 200 nm EEZ, in terms of catch weight, was dominated by northern shrimp (59% of total catch weight; primarily in NAFO Div. 2GHJ), pink (pandalid) shrimp (16%; primarily in 2GHJ), Greenland halibut (13%; primarily in 0B and 2J), Atlantic cod (4%; primarily in 1EF), Aesop shrimp (*P. montagui*; 4%; primarily in 2G), snow crab (2%; primarily in 2J), and deepwater redfish (2%; primarily in 1F). Proportional catch weights in the Study Area during the six-year period, in descending order of magnitude, were 35% in NAFO Div. 2J, 20% in 2H, 19% in 2G, 16% in 0B, 5% in 1F, and 5% in 1E.

Canadian vessels accounted for 90% of the commercial catch weight reported for this area during 2010–2015. While Canadian vessels accounted for the majority of catches in NAFO Div. 0B and 2GHJ, foreign vessels dominated catches in Div. 1EF. Catches in Div. 1E were dominated by northern shrimp and Atlantic cod, and in 1F by Atlantic cod, deepwater redfish and northern shrimp.

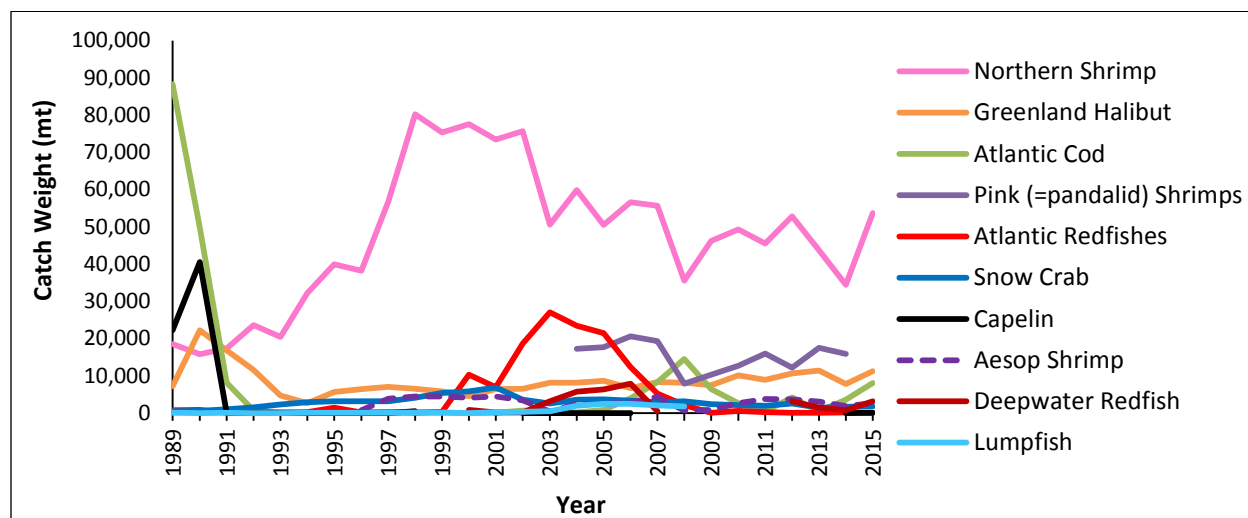
4.3.3 Domestic Fisheries

The following subsection provides an overview of the commercial fisheries within and/or adjacent to the Study Area. Traditional historical fishing activity during the last 20 years, including abundance data for historically principal species, are presented. Statistical summaries of the commercial catch data specific to the Study and Project areas, based on the georeferenced (lat/long) data for 2010 and annual gridded cell (6' x 6') data for 2011–2015, are also provided in this subsection.

4.3.3.1 Historical Fisheries

A historical overview of fisheries was given in § 4.3.3.1 of LGL (2014, 2016). In the late 1980s, species such as Atlantic cod, capelin, and, to a lesser extent, northern shrimp were the primary species harvested in NAFO Divisions 0B, 1EF and 2GHJ beyond the 200 nm limit. The Atlantic cod and capelin fisheries were considerably reduced in the early 1990s during the moratorium,

after which northern shrimp and Greenland halibut became the predominant target species (Figure 4.2). During recent years, northern shrimp has comprised the majority of harvest within the Study Area beyond the EEZ, followed by Greenland halibut and, less so, by Atlantic cod. Much lower quotas have been allocated in recent years for various species, based on scientific advice and other relevant considerations (see § 4.3.3.1 of LGL [2015a] for a description of Integrated Fisheries Management Plans for priority groundfish species).



Source: NAFO STATLANT21A Data Extraction Tool.

Figure 4.2 Historical Catch Weights for Predominant Species in the Commercial Fisheries in NAFO Divisions 0B, 1EF and 2GHJ, All Countries, 1989–2015.

Northern shrimp stocks have recently declined offshore southeastern Labrador and eastern Newfoundland (see § 4.3.3.1 of LGL 2015a), resulting in a shrimp fishing moratorium in Shrimp Fishing Area (SFA) 7 since 2015 (NAFO 2015b,d in LGL 2016; NAFO 2018) and a considerable reduction in TAC in SFA 6 from 48,196 mt in 2014 to 8,730 mt in 2018 (DFO 2018b). Shrimp stocks within SFAs 4 and 5 have not experienced such declines in recent years, with relatively little change to their respective TACs (DFO 2018a). Greenland halibut is caught as bycatch in shrimp fisheries. The use of the Nordmore grate ensures that large halibut are not caught in shrimp trawlers, although no such protection yet exists for small halibut. A pilot project is underway for the Gulf of St. Lawrence Greenland halibut stock investigating the use of an on-board separator on shrimpers to facilitate shrimp sorting. To date, no difference in Greenland halibut bycatch has been observed between shrimping vessels that did or did not use the separator (DFO 2017a). Greenland halibut are managed by DFO (Div. 4RST) and NAFO (Div. 3LMNO) south of the Study Area (DFO 2017b; NAFO 2018). The Atlantic cod fishery within Canada's Territorial Limit (12 nm) in Div. 2J3KL is managed by DFO (DFO 2017b). Recently, the duration of the commercial harvest season for Atlantic cod within the 12 nm limit was extended (mid-June to November [excluding July] during 2017 versus mid-August to end of season during 2016), and the total allowable catch weight for Atlantic cod and bycatch was

increased (ranging up to ~2.3 mt/week during 2017 versus up to ~1.4 mt/week during 2016) (DFO 2017b).

4.3.3.2 Study Area Catch Analysis, 2010–2015

Information on domestic harvests in the Study and Project areas during May–November 2010 are shown in Table 4.3 and in the Study Area during May–November 2011–2015 in Tables 4.4–4.8. Overall, the commercial fisheries for all enterprises combined, in descending order of catch weight magnitude, principally targeted northern shrimp, snow crab and Greenland halibut, accounting for ~97% of the total annual catch weight during May–November 2010 (36,329 mt; see Figure 4.4). Other notable species harvested in the 2010–2015 commercial fisheries in the Study Area include striped shrimp, roughhead grenadier, redfish sp., witch flounder, and American plaice.

During May–November 2010–2015, northern shrimp was predominantly harvested by vessels >45', while snow crab and Greenland halibut were principally caught by vessels of the 45–64.9' length class (Greenland halibut was also mainly caught by vessels >100' during 2010 and 2012) (Tables 4.3–4.8). Vessels <35' were dedicated to the snow crab fishery, and no vessels >100' harvested snow crab. Few vessels <35' also fished for Greenland halibut, and striped shrimp were only taken by vessels >100'. At least 64 vessels of the 35–44.9' length class were recorded as participants in the redfish fishery during the May–November 2010 period, but no catch weights were reported in the DFO database (see Table 4.3).

During May–November 2011–2015, the sum of quartile catch ranges in the Study Area steadily decreased each consecutive year during 2011–2014, for a total decrease of ~43% between 2011 and 2014, and then increased by 14% between 2014–2015 (see Figure 4.3).

Commercial Harvest Locations in the Study Area

Georeferenced harvest locations for all species, May–November 2005–2010 for offshore Labrador are shown in Figure 4.3 of LGL (2014). Grid cell harvest locations (6' x 6' cells) during May–November 2011–2012 for offshore Labrador are shown in Figures 4.4–4.5 of LGL (2014), and for offshore Labrador and eastern and southern Newfoundland during May–November 2013 and 2014 in Figure 4.5 of LGL (2016). Year-round harvest locations are indicated in Figure 4.32 of the Labrador Shelf SEA (C-NLOPB 2008). Figure 4.4 shows grid cell harvest locations for all species within the Study Area, May–November 2015. Minimal fish harvesting occurred in the eastern portion of the Study Area. Most harvesting occurred on the shelf and slope off Labrador out to the 1,000 m isobath. These locations are consistent from year to year.

Table 4.3 Study Area and Project Area Annual Catch Weight and Value by Species and Vessel Length Class, May–November 2010.

Species	Study Area				Project Area									
	Quantity		Value		Quantity		Value							
	mt	% of Total	\$	% of Total	mt	% of Total	\$	% of Total						
All Vessel Length Classes Combined														
Northern Shrimp	30,870	85	54,071,531	79	26,533	84	47,961,382	79						
Snow Crab	2,676	7	7,974,693	12	2,147	7	6,402,293	11						
Greenland Halibut	1,651	5	4,120,201	6	1,632	5	4,079,475	7						
Striped Shrimp	1,122	3	2,411,766	4	1,117	4	2,401,456	4						
Roughhead Grenadier	6	<0.1	3,564	<0.1	6	<0.1	3,564	<0.1						
Redfish sp.	4	<0.1	2,626	<0.1	4	<0.1	2,626	<0.1						
Witch Flounder	1	<0.1	342	<0.1	1	<0.1	342	<0.1						
Total	36,329	100	68,584,723	100	31,439	100	60,851,138	100						
Individual Vessel Length Classes (Study Area)														
Species	Quantity (mt)							Number of Vessels						
	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	Total	% of Total	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	Total	% of Total
Northern Shrimp	0	13	8,976	895	20,986	30,870	85	0	6	3,095	389	2,884	6,374	64
Snow Crab	231	81	2,097	266	0	2,676	7	240	61	1,221	70	0	1,592	16
Greenland Halibut	3	233	600	61	754	1,651	5	2	91	181	24	674	972	10
Striped Shrimp	0	0	0	0	1,122	1,122	3	0	0	0	0	193	193	2
Roughhead Grenadier	0	0	4	2	0	6	<0.1	0	64	53	17	16	150	2
Redfish sp.	0	0	4	0	0.5	4	<0.1	0	8	16	0	605	629	6
Witch Flounder	0	0	0.1	0	1	1	<0.1	0	0	5	0	16	21	0.2
Total	234	327	11,680	1,224	22,863	36,329	100	242	230	4,571	500	4,388	9,931	100

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

Table 4.4 Commercial Catch Weights and Values in the Study Area, May–November 2011 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] or vessel length classes attributed to each species).

Species	Catch Weight Quartile Code Counts ^a				Catch Value Quartile Code Counts ^b				Vessel Length Class Total Quartile Code Counts ^c					Total Counts ^d
	1	2	3	4	1	2	3	4	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	
Northern Shrimp	216	466	691	857	299	520	672	739	0	28	977	175	1,050	2,230
Snow Crab	248	302	135	9	173	292	198	31	135	56	439	64	0	694
Greenland Halibut	66	135	72	0	42	139	85	7	0	39	147	45	42	273
Striped Shrimp	5	18	30	51	6	20	29	49	0	0	0	0	104	104
Roughhead Grenadier	12	10	6	0	7	10	10	1	0	1	14	5	8	28
Redfish sp.	1	7	13	0	1	7	12	1	0	11	10	0	0	21
Atlantic Halibut	4	0	1	0	3	1	1	0	0	0	4	1	0	5
Total	552	938	948	917	531	989	1,007	828	135	135	1,591	290	1,204	3,355

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

Note:

^a Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2011 quartile ranges: 1 = 0 – 2,377 kg, 2 = 2,378 – 11,045 kg, 3 = 11,046 – 45,183 kg, 4 = \geq 45,184 kg.

^b Quartile ranges provided by DFO (Quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2011 quartile ranges: 1 = \$0 – \$7,281, 2 = \$7,282 – \$32,789, 3 = \$32,790 – \$126,294, 4 = \geq \$126,295.

^c Includes the total quartile code count for ranges 1–4, combined; total counts for catch weight and catch value are equal.

^d Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.5 Commercial Catch Weights and Values in the Study Area, May–November 2012 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] or vessel length classes attributed to each species).

Species	Catch Weight Quartile Code Counts ^a				Catch Value Quartile Code Counts ^b				Vessel Length Class Total Quartile Code Counts ^c					Total Counts ^d
	1	2	3	4	1	2	3	4	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	
Northern Shrimp	227	470	644	661	332	461	585	624	0	21	803	156	1,022	2,002
Snow Crab	220	245	108	18	177	235	155	24	90	76	413	12	0	591
Greenland Halibut	58	108	92	19	38	102	102	35	0	43	103	28	103	277
Striped Shrimp	10	24	48	70	9	23	47	73	0	0	0	0	152	152
Redfish sp.	6	18	32	13	2	10	34	23	0	5	16	0	48	69
Roughhead Grenadier	6	7	17	10	3	6	15	16	0	0	0	0	40	40
Witch Flounder	2	5	16	9	1	3	16	12	0	4	1	0	27	32
American Plaice	2	5	10	8	1	3	10	11	0	0	0	0	25	25
Atlantic Halibut	0	2	1	0	0	1	2	0	0	0	3	0	0	3
Mackerel	0	1	0	0	1	0	0	0	0	0	1	0	0	1
Total	531	885	968	808	564	844	966	818	90	149	1,340	196	1,417	3,192

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

Note:

^a Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2012 quartile ranges: 1 = 0 – 2,618 kg, 2 = 2,619 – 12,233 kg, 3 = 12,234 – 47,739 kg, 4 = ≥ 47,740 kg.

^b Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2012 quartile ranges: 1 = \$0 – \$8,240, 2 = \$8,241 – \$35,022, 3 = \$35,023 – \$130,732, 4 = ≥ \$130,733.

^c Includes the total quartile code count for ranges 1–4, combined; total counts for catch weight and catch value are equal.

^d Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.6 Commercial Catch Weights and Values in the Study Area, May–November 2013 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] or vessel length classes attributed to each species).

Species	Catch Weight Quartile Code Counts ^a				Catch Value Quartile Code Counts ^b				Vessel Length Class Total Quartile Code Counts ^c					Total Counts ^d
	1	2	3	4	1	2	3	4	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	
Northern Shrimp	190	378	542	643	296	370	485	602	0	2	566	209	976	1,753
Snow Crab	104	137	88	23	81	136	87	48	56	40	233	23	0	352
Greenland Halibut	35	124	69	6	46	108	65	15	0	55	147	17	15	234
Striped Shrimp	12	28	39	38	11	24	38	44	0	0	0	0	117	117
Redfish sp.	1	4	6	4	1	2	5	7	0	6	0	0	9	15
Witch Flounder	0	4	4	6	0	0	4	10	0	0	0	0	14	14
American Plaice	0	3	5	6	0	0	3	11	0	0	0	0	14	14
Atlantic Halibut	0	2	3	5	0	0	2	8	0	0	0	0	10	10
Roughhead Grenadier	0	3	4	0	0	0	4	3	0	0	1	0	6	7
Atlantic Cod	1	0	0	0	1	0	0	0	0	1	0	0	0	1
Mackerel	0	0	1	0	0	1	0	0	0	1	0	0	0	1
Total	343	683	761	731	436	641	693	748	56	105	947	249	1,161	2,518

Source: DFO commercial landings database, All Atlantic Regions (2013).

Note:

^a Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2013 quartile ranges: 1 = 0 – 2,565 kg, 2 = 2,566 – 11,872 kg, 3 = 11,873 – 48,585 kg, 4 = ≥ 48,586 kg.

^b Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2013 quartile ranges: 1 = \$0 – \$8,934, 2 = \$8,395 – \$35,699, 3 = \$35,700 – \$125,728, 4 = ≥ \$125,729.

^c Includes the total quartile code count for ranges 1–4, combined; total counts for catch weight and catch value are equal.

^d Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.7 Commercial Catch Weights and Values in the Study Area, May–November 2014 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] or vessel length classes attributed to each species).

Species	Catch Weight Quartile Code Counts ^a				Catch Value Quartile Code Counts ^b				Vessel Length Class Total Quartile Code Counts ^c					Total Counts ^d
	1	2	3	4	1	2	3	4	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	
Northern Shrimp	120	228	300	468	163	210	289	454	0	19	319	148	630	1,116
Snow Crab	81	130	89	21	58	118	112	33	36	40	212	33	0	321
Greenland Halibut	12	102	76	17	19	105	61	22	0	49	120	20	18	207
Striped Shrimp	7	20	42	60	10	19	35	65	0	0	0	0	129	129
Witch Flounder	0	3	5	8	0	0	6	10	0	0	0	0	16	16
American Plaice	0	1	2	4	0	0	2	5	0	0	0	0	7	7
Redfish sp.	0	0	0	2	0	0	0	2	0	0	0	0	2	2
Roughhead Grenadier	0	0	1	1	0	0	1	1	0	0	0	0	2	2
Total	220	484	515	581	250	452	506	592	36	108	651	201	804	1,800

Source: DFO commercial landings database, All Atlantic Regions (2014).

Note:

^a Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2014 quartile ranges: 1 = 0 – 2,421 kg, 2 = 2,422 – 10,786 kg, 3 = 10,787 – 42,872 kg, 4 = ≥ 42,873 kg.

^b Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2014 quartile ranges: 1 = \$0 – \$8,851, 2 = \$8,852 – \$38,076, 3 = \$38,077 – \$140,695, 4 = ≥ \$140,696.

^c Includes the total quartile code count for ranges 1–4, combined; total counts for catch weight and catch value are equal.

^d Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.

Table 4.8 Commercial Catch Weights and Values in the Study Area, May–November 2015 (values indicate the frequency of catch weight and value quartile codes [i.e., 1–4] or vessel length classes attributed to each species).

Species	Catch Weight Quartile Code Counts ^a				Catch Value Quartile Code Counts ^b				Vessel Length Class Total Quartile Code Counts ^c					Total Counts ^d
	1	2	3	4	1	2	3	4	1-34.9'	35-44.9'	45-64.9'	65-99.9'	100-124.9'	
Northern Shrimp	147	271	399	515	154	238	344	596	0	11	332	194	795	1,332
Snow Crab	63	133	121	35	50	123	113	66	50	54	206	42	0	352
Striped Shrimp	16	40	68	65	18	40	53	78	0	0	0	0	189	189
Greenland Halibut	7	98	55	4	8	82	66	8	4	42	91	23	4	164
Roughhead Grenadier	0	9	3	2	0	1	10	3	0	0	0	10	4	14
Redfish sp.	0	1	2	2	0	1	2	2	0	0	0	1	4	5
American Plaice	0	0	1	2	0	0	1	2	0	0	0	0	3	3
Porcupine Crab	0	1	0	0	0	0	1	0	0	0	0	1	0	1
Skate sp.	0	1	0	0	0	0	1	0	0	0	0	1	0	1
Total	233	554	649	625	230	485	591	755	54	107	629	272	999	2,061

Source: DFO commercial landings database, All Atlantic Regions (2015).

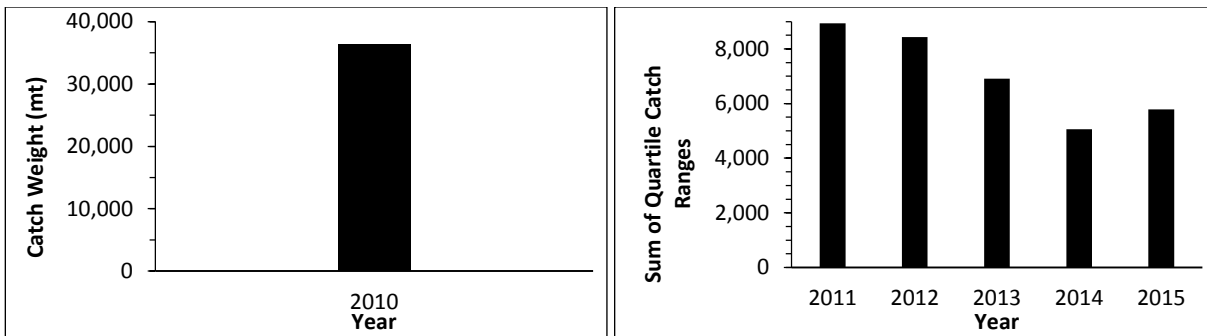
Note:

^a Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch weights in a given year, all species combined). 2015 quartile ranges: 1 = 0 – 2,253 kg, 2 = 2,254 – 9,535 kg, 3 = 9,536 – 40,703 kg, 4 = ≥ 40,704 kg.

^b Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2015 quartile ranges: 1 = \$0 – \$9,539, 2 = \$9,540 – \$37,526, 3 = \$37,527 – \$134,094, 4 = ≥ \$134,095.

^c Includes the total quartile code count for ranges 1–4, combined; total counts for catch weight and catch value are equal.

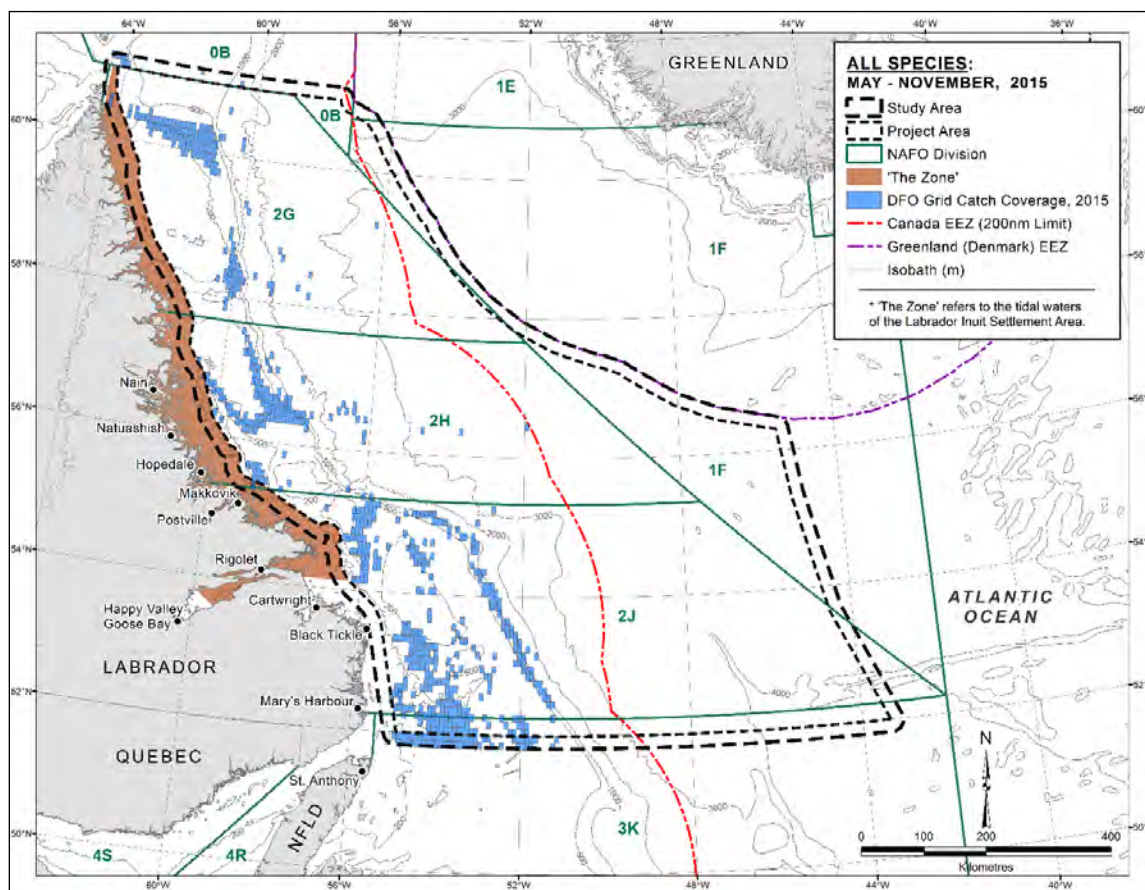
^d Total counts of the number of catch records per species; the total quartile range counts for catch weight and catch value are equal.



Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.3 Total Study Area Catch Weight, May–November 2010 (left), and Annual Total Catch Weight Quartile Codes, All Species, May–November 2011–2015 (right).



Source: DFO commercial landings database, 2015.

Figure 4.4 Distribution of Commercial Harvest Locations, All Species, May–November 2015.

Fishing Gear Used in the Study Area

A variety of fishing gear types were used in the Study Area during May–November 2010–2015. Northern shrimp were harvested using trawls. Snow crab were fished using pots, and Greenland halibut were caught incidentally in the pots (Tables 4.9 and 4.10). Longlines were used to harvest Atlantic halibut, with several additional species as incidental bycatch such as Greenland halibut and roughhead grenadier. Many of the fish species in Table 4.10 were caught using gillnets and trawls, either as targeted or incidental catch. Mackerel were caught using seine nets, and Atlantic cod were harvested using hand-lines (baited). Shrimp trawls (mobile gear) accounted for about 85% of the total catch weight of all species in the Study Area during 2010. Pots (fixed gear) accounted for ~7% of the total catch weight during this period. Overall, mobile and fixed gears accounted for ~90% and 10% of the total catch weight, respectively (Table 4.9).

Fishing gears and harvest locations by gear type typically used in the Study Area are provided in § 4.10.2.3 of the Labrador Shelf SEA (C-NLOPB 2008). As described in § 4.3.3.2 of LGL (2016), fixed gear has greater potential to interact with Project activities than the mobile gears.

Mobile and fixed gear harvest locations in Labrador waters during May–November 2005–2010 are shown in Figures 4.6–4.7 of LGL (2014). Fixed and mobile gear harvest locations in the Study Area during May–November 2013–2014 are shown in Figures 4.6–4.7 of LGL (2016). Figure 4.5 shows fixed and mobile gear catch locations in the Study Area during May–November 2015.

Harvest Timing in the Study Area

Total monthly catch weights of all species within the Study Area during May–November 2010 and total sum of monthly catch weight quartile codes for May–November 2011–2015 are indicated in Figure 4.6. Monthly catch weights were highest during the summer months and lowest during the late-fall. Note that the timing of harvesting can vary from year to year depending on resource availability, fisheries management plans and enterprise harvesting strategies.

Table 4.9 Total Study Area Catch Weight (mt) by Gear Type and Vessel Length Class, May–November 2010.

Species	Fixed Gear				Mobile Gear							
	mt		% of Total		mt				% of Total			
All Vessel Length Classes Combined												
Northern Shrimp	0		0		30,870				85			
Snow Crab	2,676		7		0				0			
Greenland Halibut	847		2		804				2			
Striped Shrimp	0		0		1,122				3			
Roughhead Grenadier	6		<0.1		0				0			
Redfish sp.	0.4		<0.1		4				<0.1			
Witch Flounder	0		0		1				<0.1			
Subtotal	3,528		10		32,801				90			
Grand Total	36,329											
Individual Vessel Length Classes												
Species	mt											
	1-34.9' ^a		35-44.9'			45-64.9'			65-99.9'			100-124.9' ^b
	Fixed Gear		Fixed Gear		Mobile Gear	Fixed Gear		Mobile Gear	Fixed Gear		Mobile Gear	Mobile Gear
	Gillnet	Pot	Gillnet	Pot	Trawl	Gillnet	Pot	Trawl	Gillnet	Pot	Trawl	Trawl
Northern Shrimp	0	0	0	0	13	0	0	8,976	0	0	895	20,986
Snow Crab	0	231	0	81	0	0	2,097	0	0	266	0	0
Greenland Halibut	3	0	233	0	0	549	0	51	61	0	0	754
Striped Shrimp	0	0	0	0	0	0	0	0	0	0	0	1,122
Roughhead Grenadier	0	0	0	0	0	4	0	0	2	0	0	0
Redfish sp.	0	0	0	0	0	0.4	0	3	0	0	0	0.5
Witch Flounder	0	0	0	0	0	0	0	0.1	0	0	0	1
Subtotal (Gear)	3	231	233	81	13	553	2,097	9,030	63	266	895	22,863
Subtotal (Gear Type)	234		314		13	2,650		9,030	330		895	22,863
Subtotal (Vessel Class)	234		327			11,680			1,224			22,863
Grand Total	36,329											

Source: DFO commercial landings database, 2010.

Note:

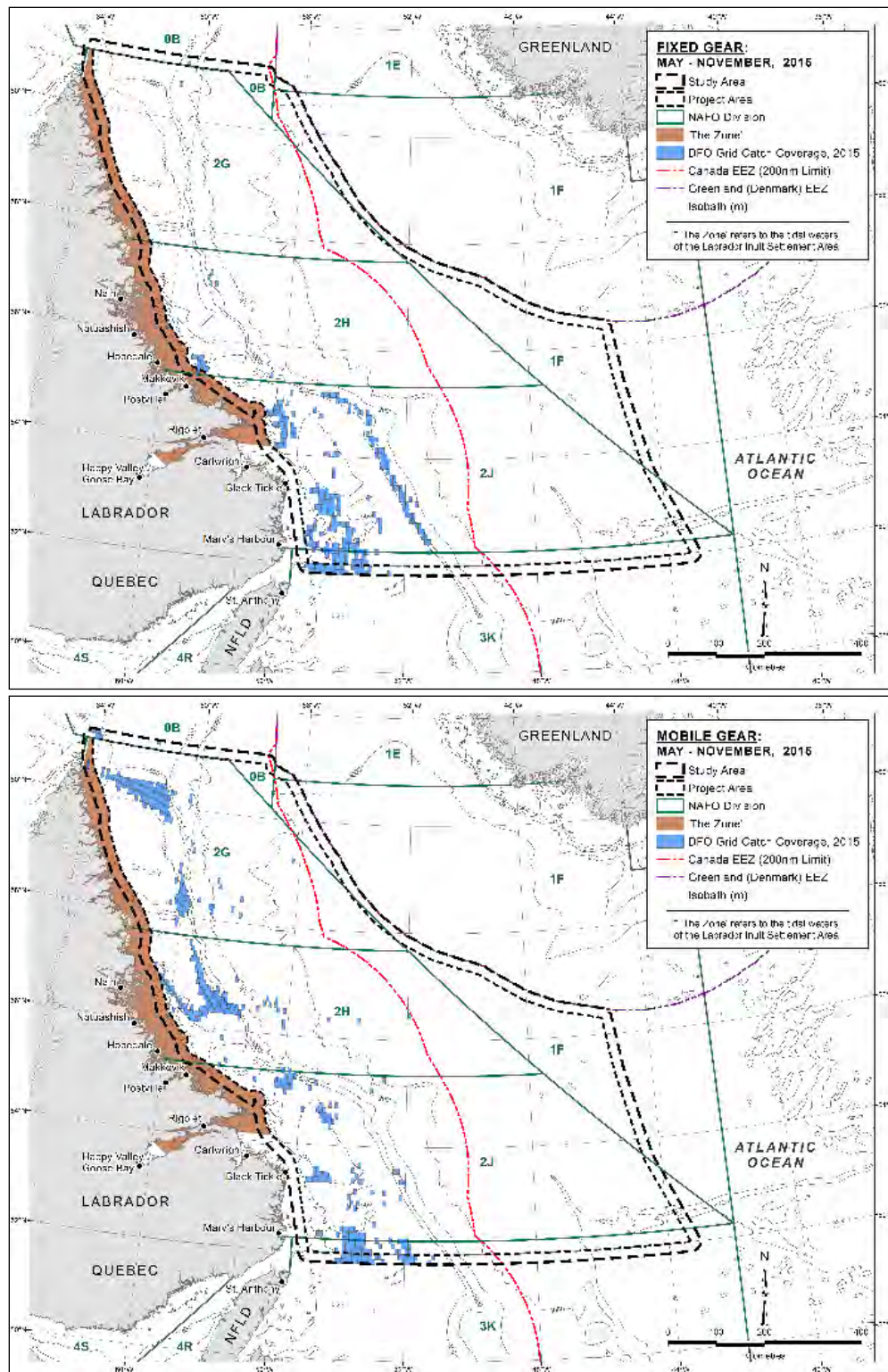
^a Denotes no mobile gear was utilized by vessel length class.

^b Denotes no fixed gear was utilized by vessel length class.

Table 4.10 Summary of Gear Type Used and Timing of the Commercial Fishery in the Study Area, May–November 2010–2015.

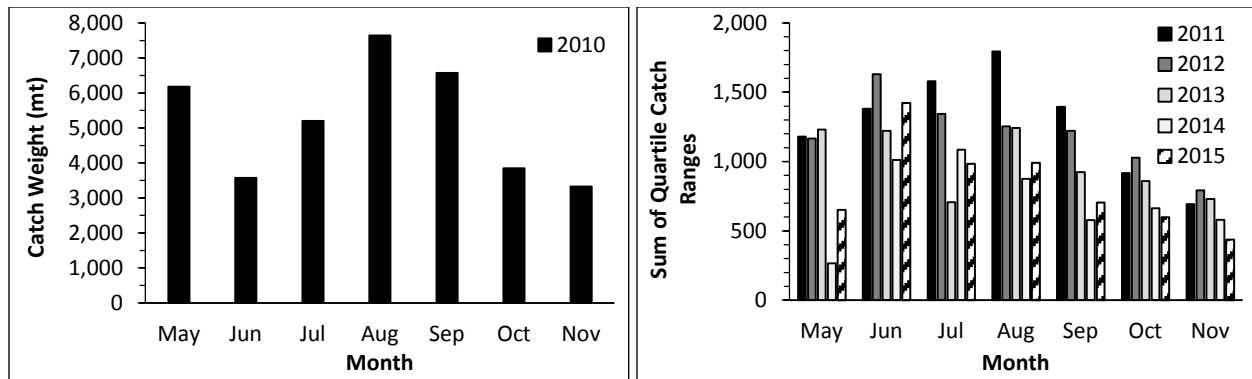
Species	Month Caught						Gear Type	
	2010	2011	2012	2013	2014	2015	Fixed	Mobile
Northern Shrimp	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	-	Trawl
Snow Crab	May–Sep	May–Aug	May–Jul	May–Jul	May–Aug	May–Aug	Pot	-
Greenland Halibut	May–Nov	Jun–Nov	May–Nov	May–Sep	May–Sep	Jun–Sep	Gillnet; Longline; Pot	Trawl
Striped Shrimp	May; Jul–Nov	Sep–Nov	May; Jul–Nov	May; Jul–Nov	May; Aug–Nov	May–Nov	-	Trawl
Roughhead Grenadier	Jun–Oct	Jun–Aug; Oct–Nov	May–Aug	May–Jun	May	Jun–Aug	Gillnet; Longline	Trawl
Redfish sp.	May–Oct	Jun–Aug	May–Aug	May–Jul	May–Jun	Jun–Jul	Gillnet	Trawl
Witch Flounder	May; Jul; Sep–Oct	-	May–Jun	May–Jun	May–Jun	-	Gillnet	Trawl
Atlantic Halibut	-	Jul–Aug	Jun	May–Jun	-	-	Gillnet; Longline	Trawl
American Plaice	-	-	May–Jun	May–Jun	Jun	Jun	-	Trawl
Mackerel	-	-	Sep	Oct	-	-	-	Seine
Atlantic Cod	-	-	-	Jul	-	-	-	Hand Line (Baited)
Porcupine Crab	-	-	-	-	-	Jul	Gillnet	-
Skate sp.	-	-	-	-	-	Jul	Gillnet	-

Source: DFO commercial landings database, 2010–2015.



Source: DFO commercial landings database, 2015.

Figure 4.5 Distribution of Fixed (top) and Mobile (bottom) Gear Commercial Harvest Locations, All Species, May–November 2015.



Source: DFO commercial landings database, 2010–2015.

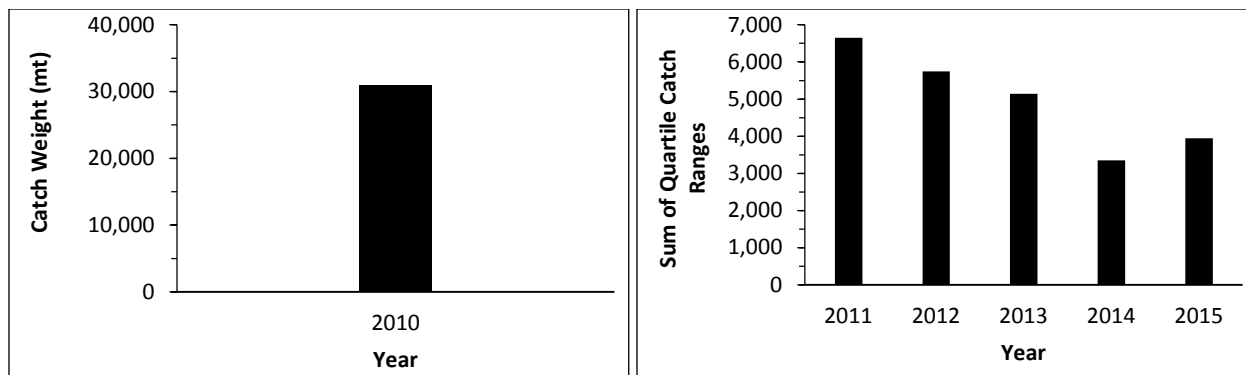
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.6 Total Monthly Catch Weight during May–November 2010 (left) and Total Monthly Sum of Catch Weight Quartile Codes, May–November 2011–2015 (right) (all species within the Study Area).

Principal Species in the Study Area

Northern Shrimp

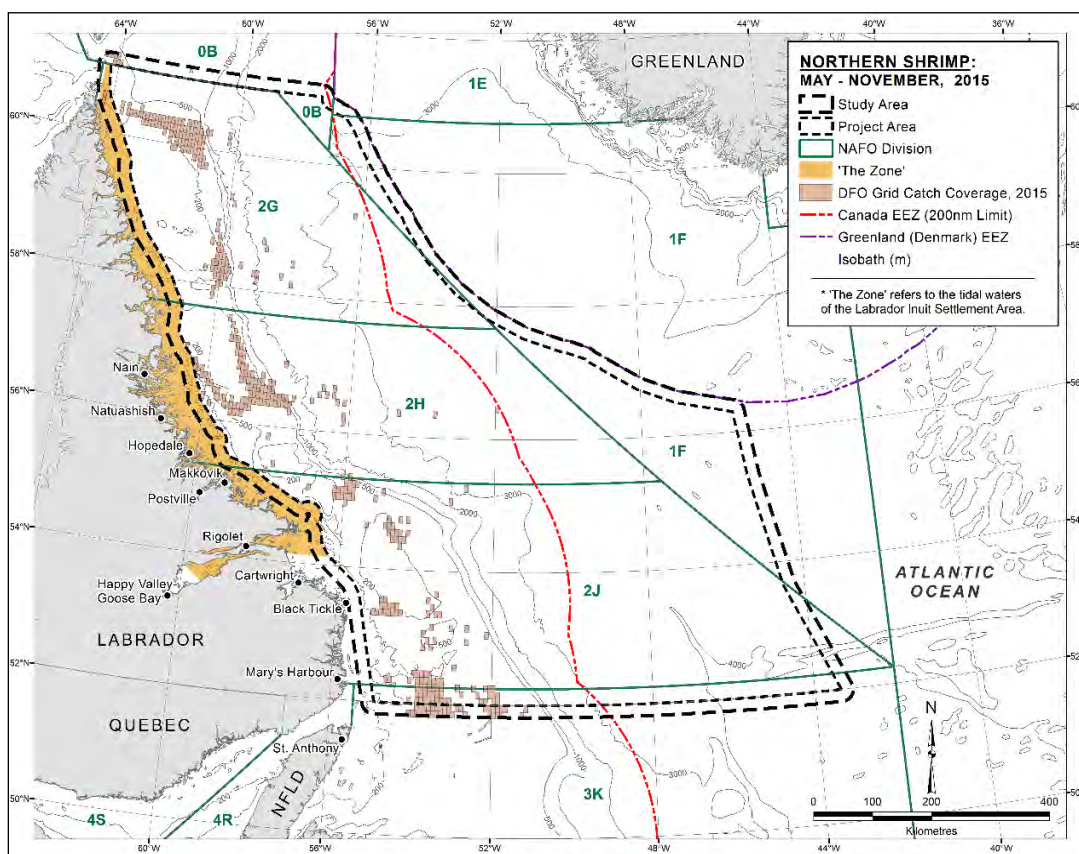
Based on both quantity and value, northern shrimp was the most important commercial species in the Study Area during May–November 2010–2015. The total annual catch weight (2010) and total annual catch weight quartile codes (2011–2015) for northern shrimp in the Study Area during May–November are shown in Figure 4.7. Shrimp harvest locations in the Study Area during May–November 2005–2012 and 2013–2014 are provided in Figures 4.11–4.13 of LGL (2014) and Figure 4.10 of LGL (2016), respectively. Harvest locations during May–November 2015 are shown in Figure 4.8. The majority of northern shrimp were harvested in the western portion of the Study and Project Areas, between the 200 and 500-m isobaths. An indication of total monthly northern shrimp harvests in the Study Area during the May–November 2010–2015 period is shown in Figure 4.9. Most of the northern shrimp was harvested during the summer.



Source: DFO commercial landings database, 2010–2015.

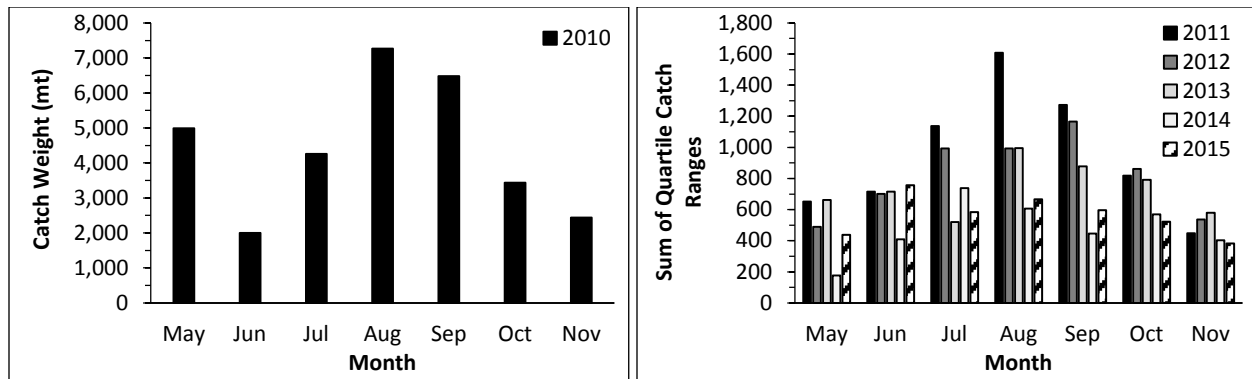
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.7 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Northern Shrimp in the Study Area.



Source: DFO commercial landings database, 2015.

Figure 4.8 Distribution of Commercial Harvest Locations for Northern Shrimp, May–November 2015.



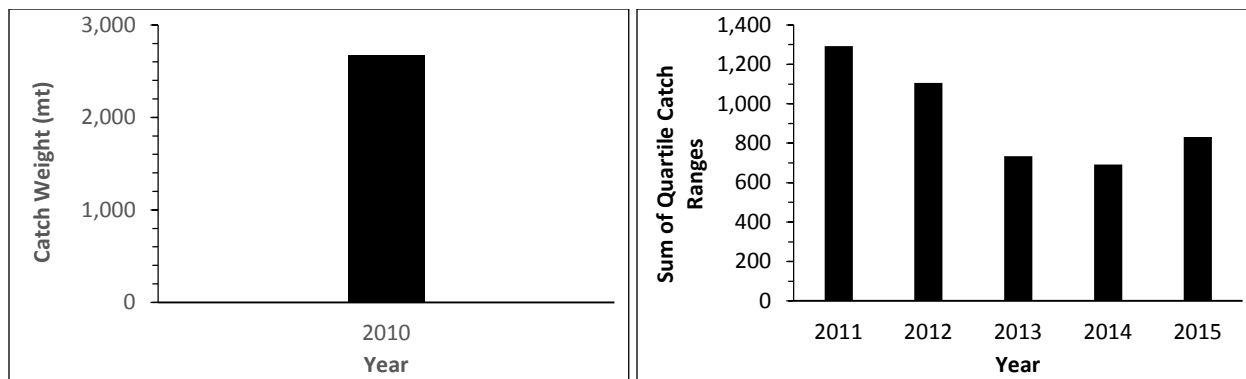
Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.9 Total Monthly Catch Weights, May–November 2010 (left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 (right) for Northern Shrimp in the Study Area.

Snow Crab

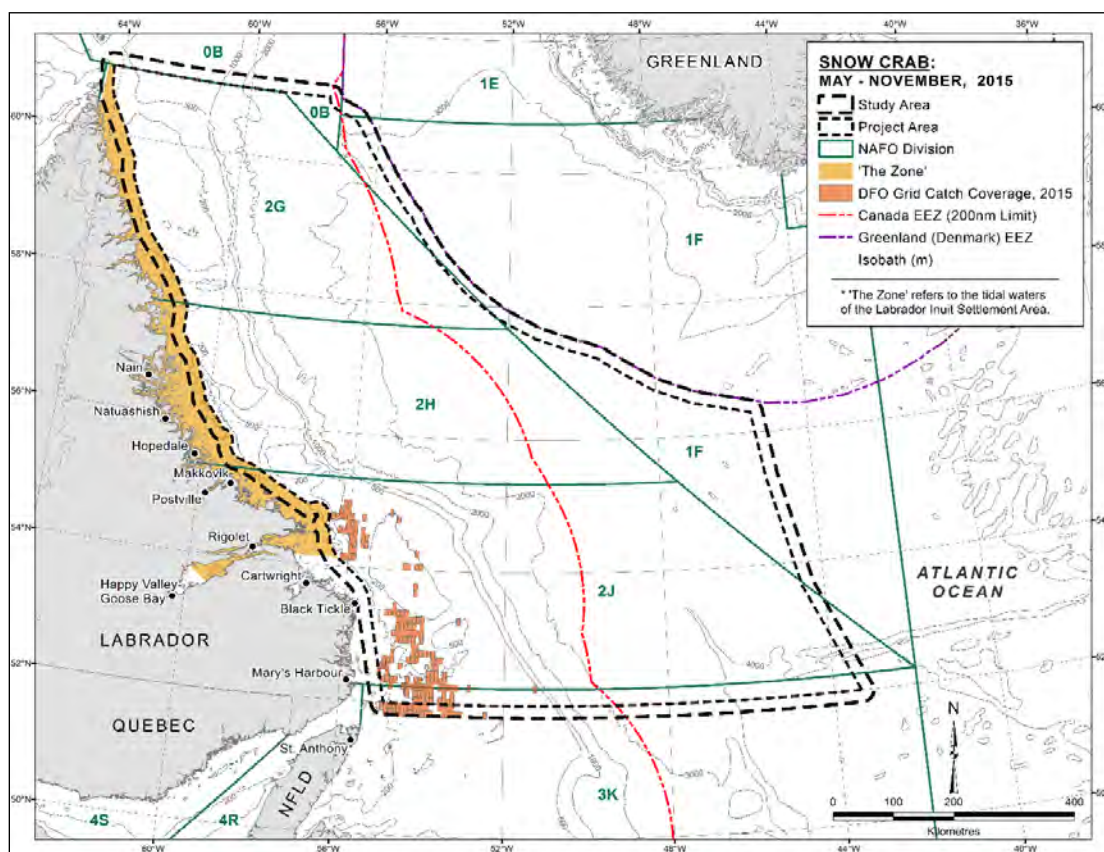
In terms of catch weight, snow crab was the second most important commercial species in the Study Area during May–November 2010–2015. Total annual catch weight (2010) and the total sum of catch weight quartile codes (2011–2015) for snow crab in the Study Area between May and November are indicated in Figure 4.10. Snow crab harvest locations in the Study Area during May–November 2005–2012 and 2013–2014 are provided in Figures 4.16–4.18 of LGL (2014) and Figure 4.13 of LGL (2016), respectively. Figure 4.11 indicates snow crab harvesting locations in the Study Area during May–November 2015. The majority of snow crab were caught in the southwestern portion of the Study and Project areas, in water depths <200 m. The total monthly snow crab harvests in the Study Area during May–November 2010–2015 are shown in Figure 4.12. Snow crab were captured between May and August in the Study Area, with the majority of catch taken during May–July.



Source: DFO commercial landings database, 2010–2015.

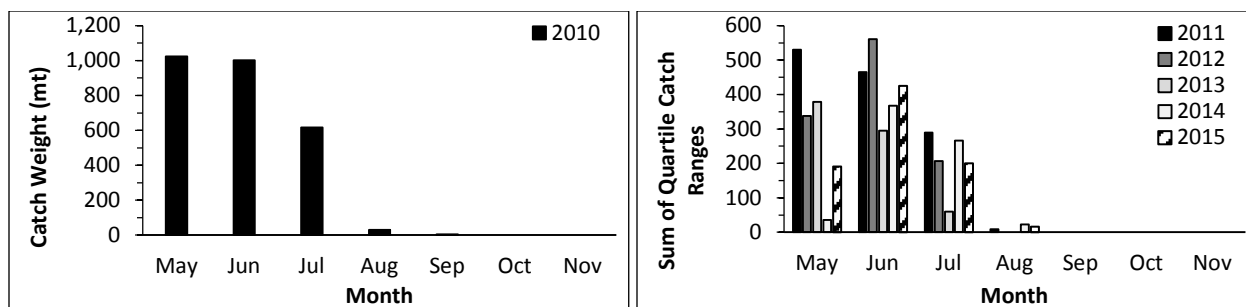
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.10 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Snow Crab in the Study Area.



Source: DFO commercial landings database, 2015.

Figure 4.11 Distribution of Commercial Harvest Locations for Snow Crab, May–November 2015.



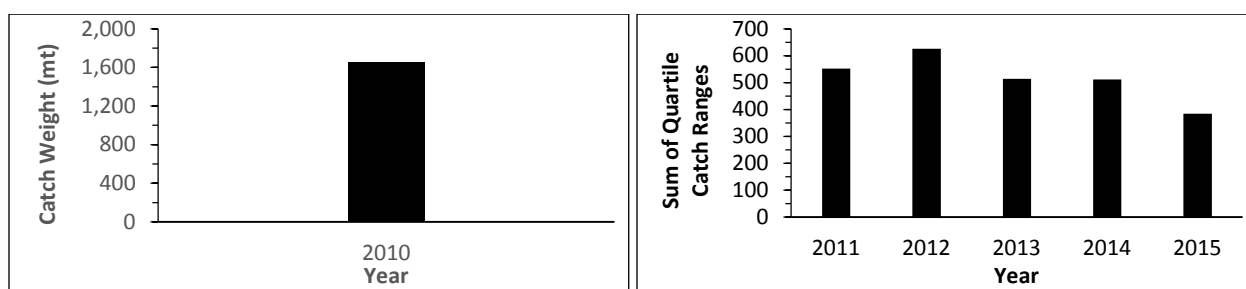
Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.12 Total Monthly Catch Weights, May–November 2010 (left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 (right) for Snow Crab in the Study Area.

Greenland Halibut

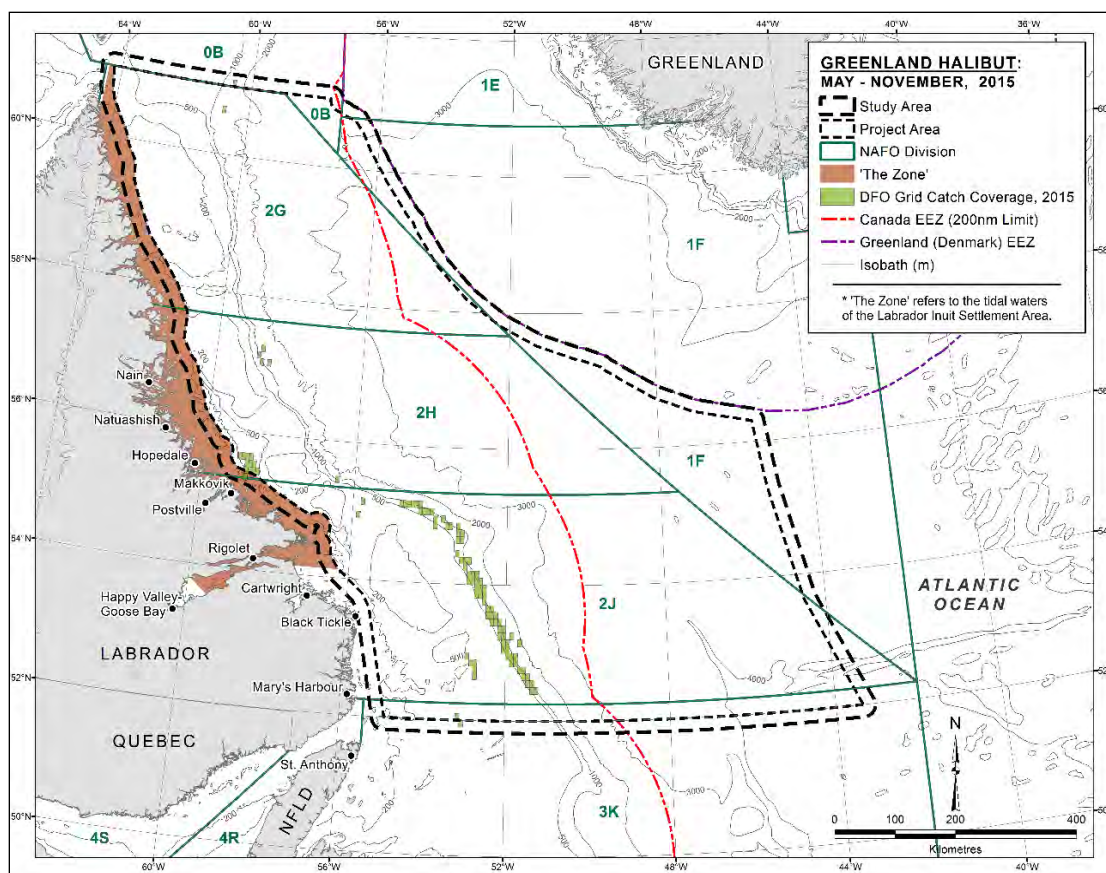
Greenland halibut comprised the largest portion of groundfish catches and was the third most important commercial species in the Study Area during May–November 2010–2014 in terms of catch weight and value (fourth most important during 2015). Total catch weight (2010) and the total sum of catch weight quartile codes (2011–2015) for Greenland halibut in the Study Area during May–November are shown in Figure 4.13. Greenland halibut harvest locations in the Study Area during May–November 2005–2012 are provided Figures 4.21–4.23 of LGL (2014) and during May–November 2013–2014 in Figure 4.13 of LGL (2016). Figure 4.14 shows Greenland halibut catch locations in the Study Area during May–November 2015. Greenland halibut were predominantly captured in the southwestern portion of the Study and Project Areas, almost exclusively between the 500 and 1,000-m isobaths. The total monthly Greenland halibut harvests in the Study Area during May–November 2010–2015 are indicated in Figure 4.15. This species was primarily taken during the June–August period in the Study Area.



Source: DFO commercial landings database, 2010–2015.

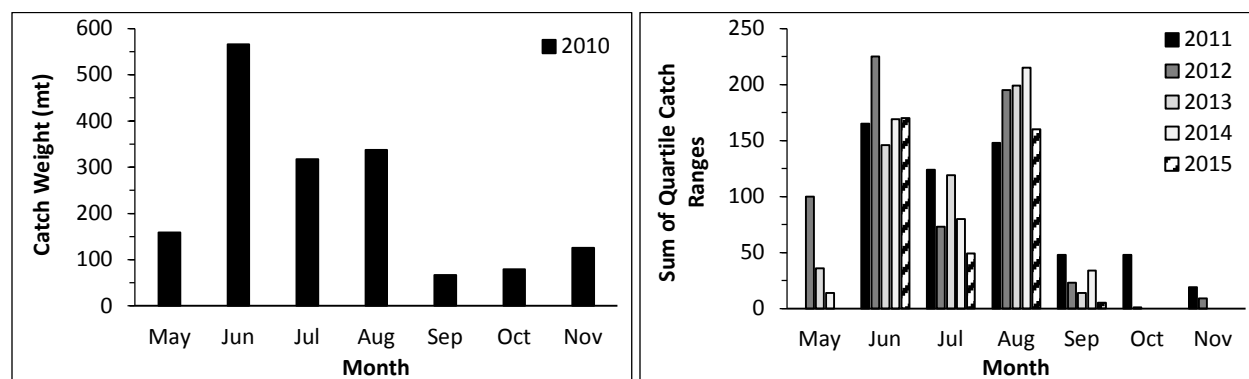
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.13 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Greenland Halibut in the Study Area.



Source: DFO commercial landings database, 2015.

Figure 4.14 Distribution of Commercial Harvest Locations for Greenland Halibut, May–November 2015.



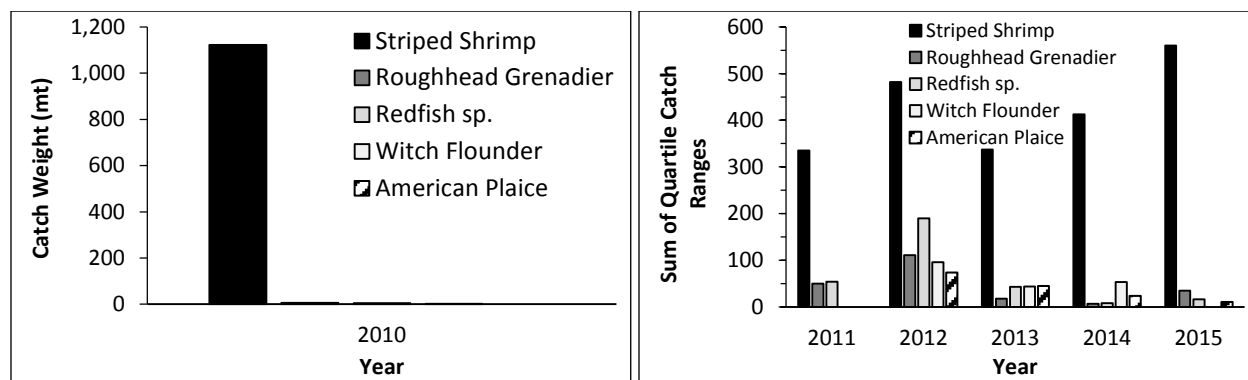
Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.15 Total Monthly Catch Weights, May–November 2010 (left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 (right) for Greenland Halibut in the Study Area.

Other Notable Species: Striped Shrimp, Roughhead Grenadier, Redfish, Witch Flounder and American Plaice

In addition to the three species already discussed, striped shrimp, roughhead grenadier, redfish, witch flounder and American plaice have also been identified as important commercial species in the Study Area (see § 4.3.3.2 and Tables 4.3–4.8). Total catch weight (2010) and the total sum of catch weight quartile codes (2011–2015) for these species between May and November are shown in Figure 4.16. Harvest locations for redfish and American plaice in the Study Area during May–November 2013 and 2014 are shown in Figures 4.20–4.21 of LGL (2016). Figures 4.17–4.21 indicate harvest locations in the Study Area for these five notable species during May–November 2010 and/or 2015. Most of these species were harvested offshore central or southern Labrador, in portions of the Study Area with water depths <1,000 m. The total monthly harvests for these species in the Study Area during the May–November 2010–2015 period are shown in Figure 4.22. Most harvesting of striped shrimp occurred during late-summer and fall. Roughhead grenadier and redfish were caught primarily during the summer, and witch flounder and American plaice were only caught during May and June.

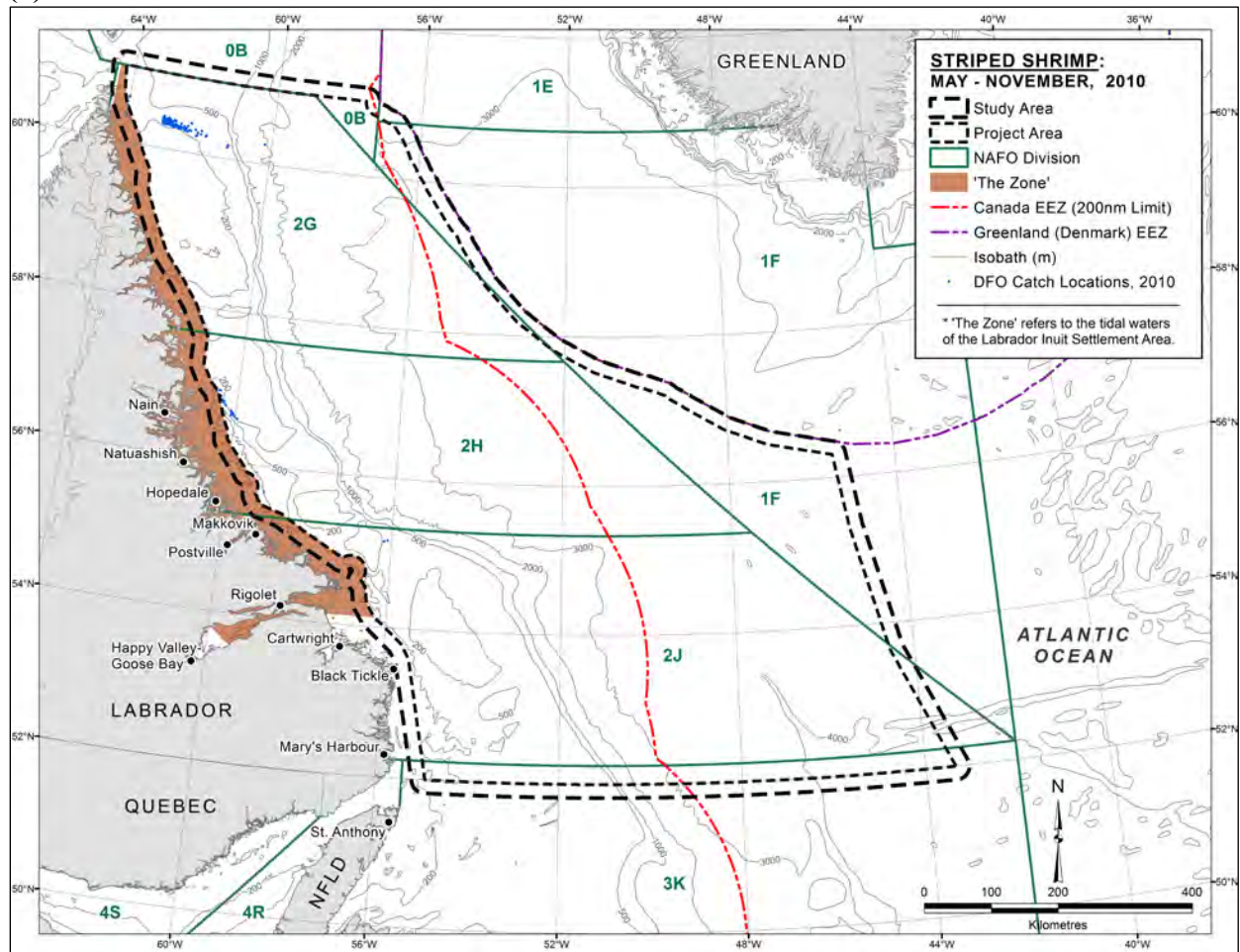


Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.16 Total Annual Catch Weight, May–November 2010 (left) and Total Annual Catch Weight Quartile Codes, May–November 2011–2015 (right) for Striped Shrimp, Roughhead Grenadier, Redfish, Witch Flounder and American Plaice in the Study Area.

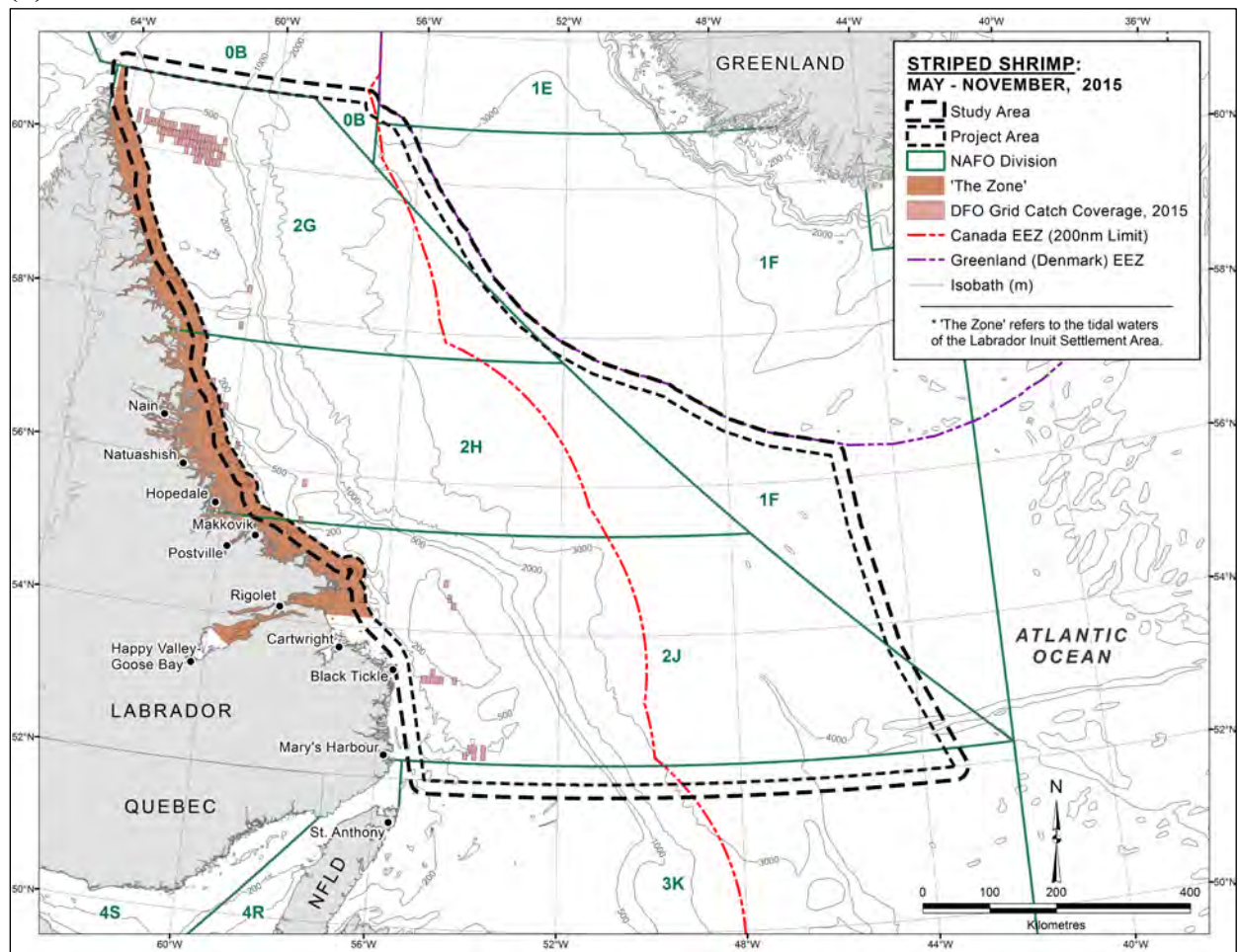
(a)



Source: DFO commercial landings database, 2015.

Figure 4.17 Distribution of Commercial Harvest Locations for Striped shrimp, May–November (a) 2010 and (b) 2015.

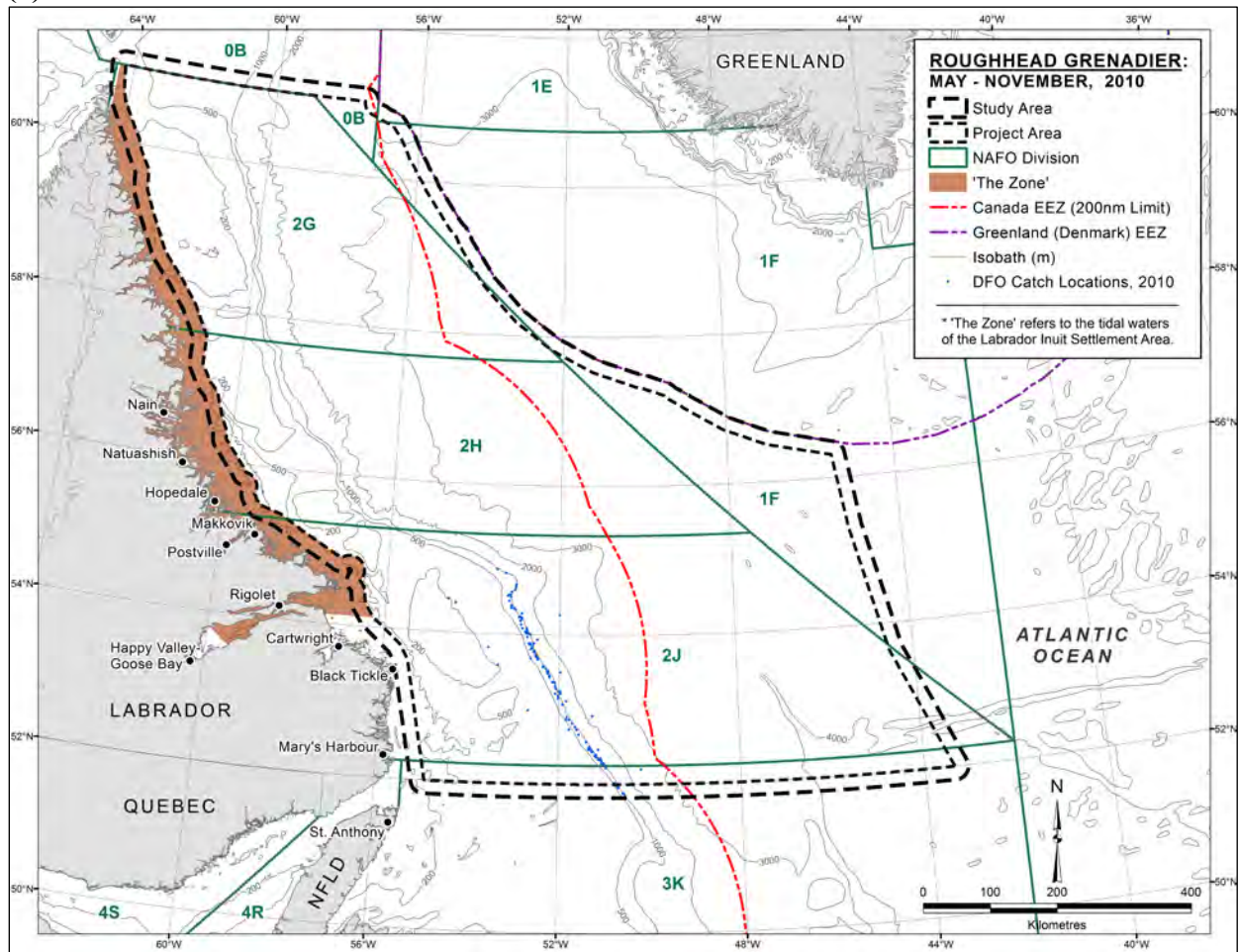
(b)



Source: DFO commercial landings database, 2015.

Figure 4.17 (cont'd) Distribution of Commercial Harvest Locations for Striped shrimp, May–November (a) 2010 and (b) 2015.

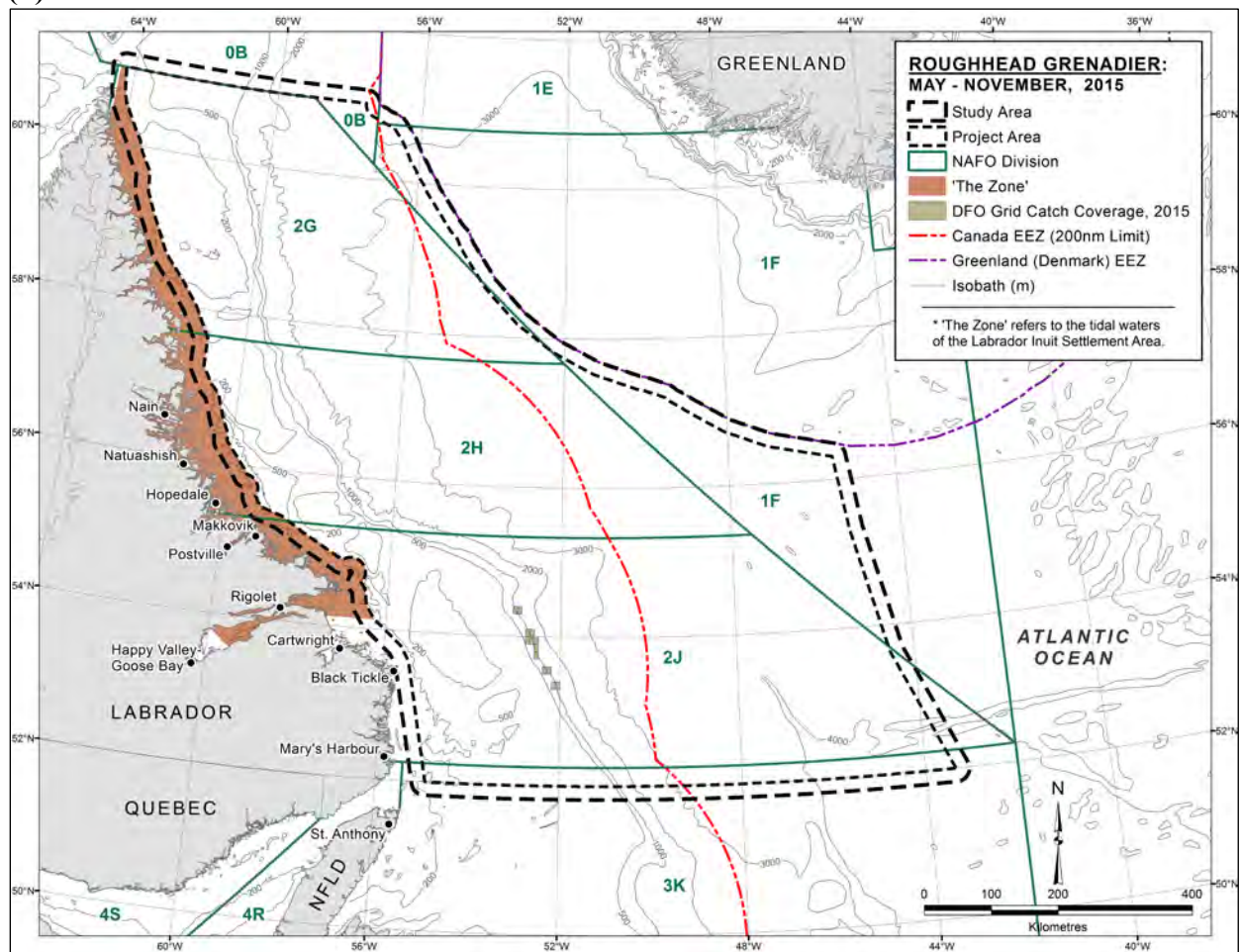
(a)



Source: DFO commercial landings database, 2015.

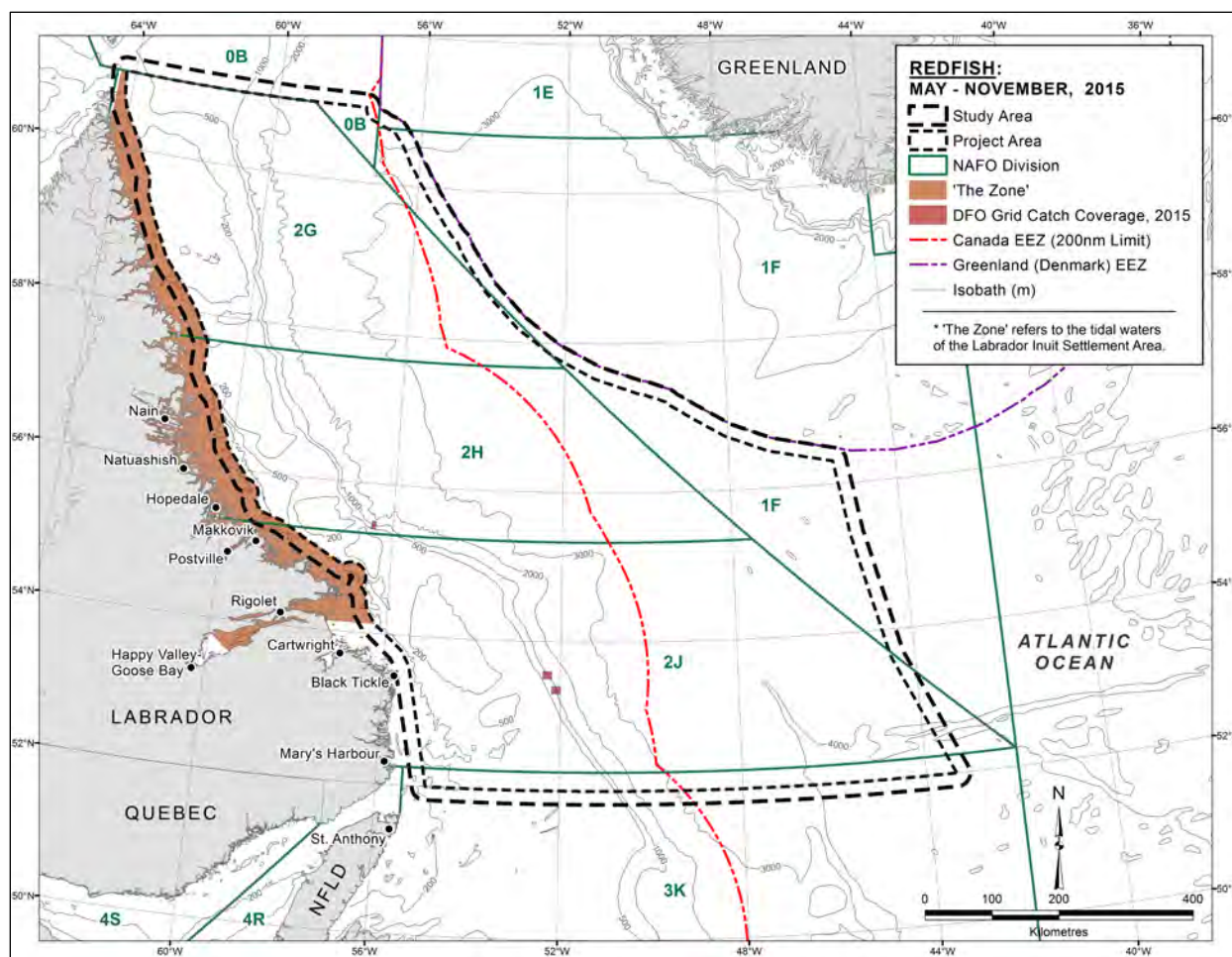
Figure 4.18 Distribution of Commercial Harvest Locations for Roughhead Grenadier, May–November (a) 2010 and (b) 2015.

(b)



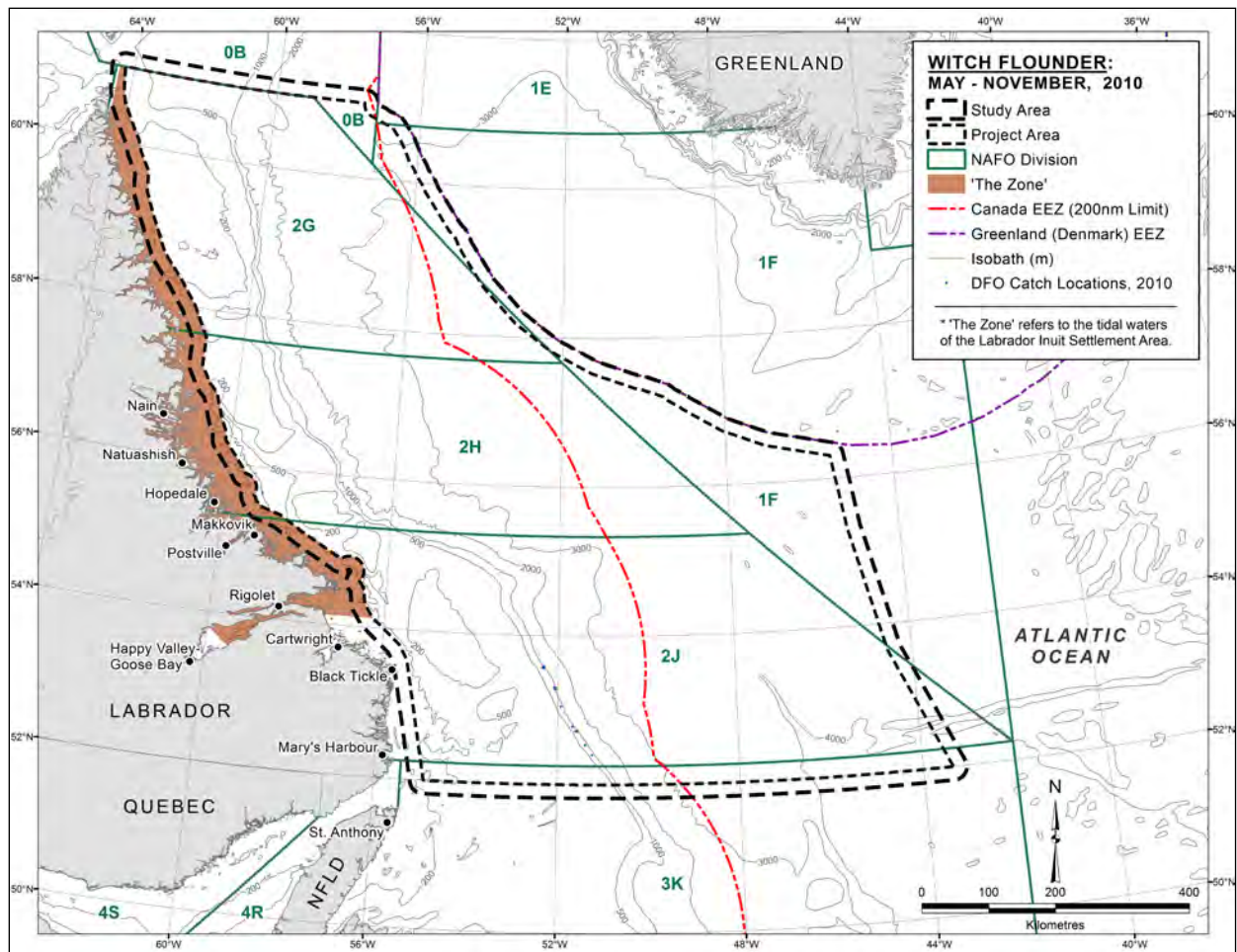
Source: DFO commercial landings database, 2015.

Figure 4.18 (cont'd) Distribution of Commercial Harvest Locations for Roughhead Grenadier, May–November (a) 2010 and (b) 2015.



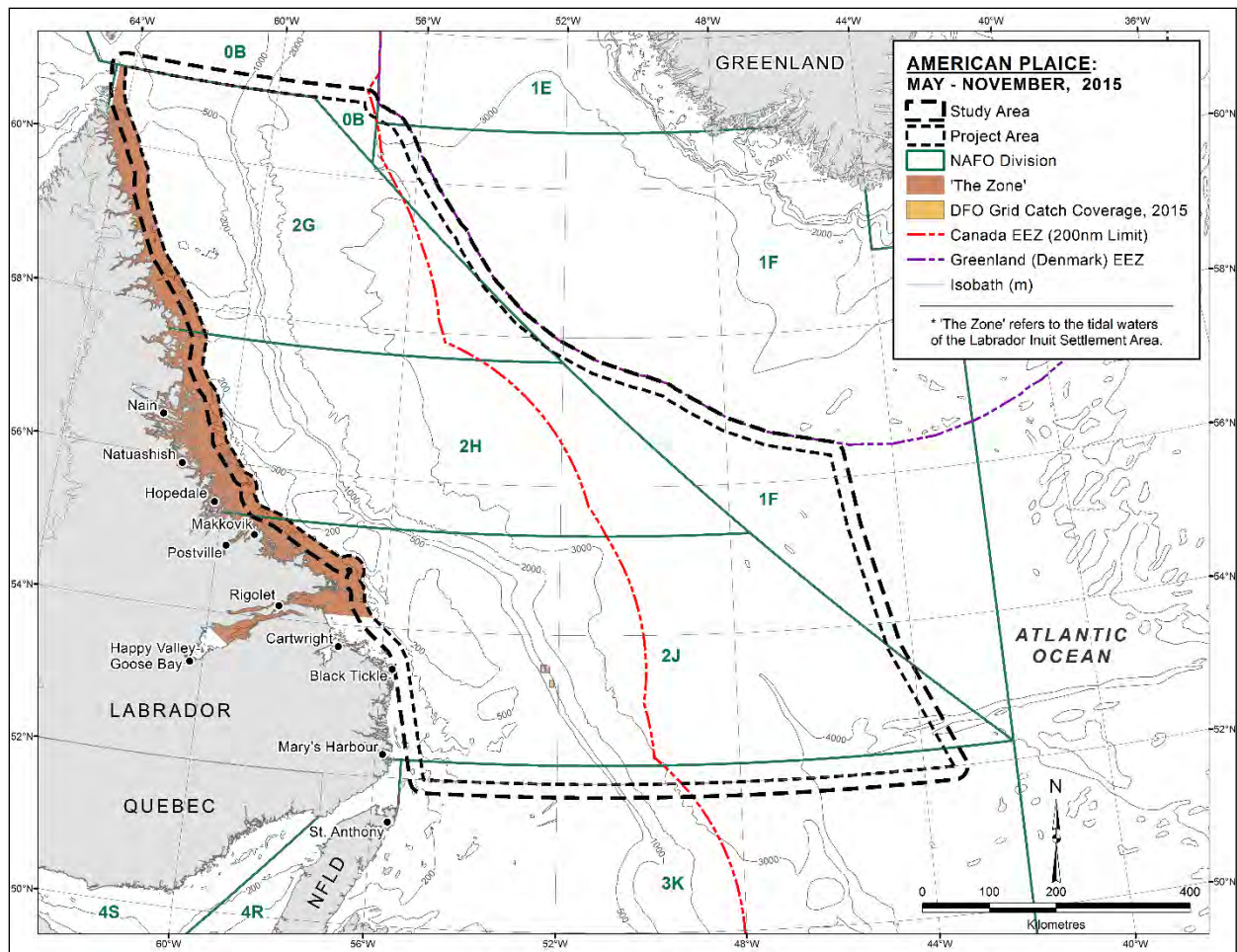
Source: DFO commercial landings database, 2015.

Figure 4.19 Distribution of Commercial Harvest Locations for Redfish, May–November 2015.



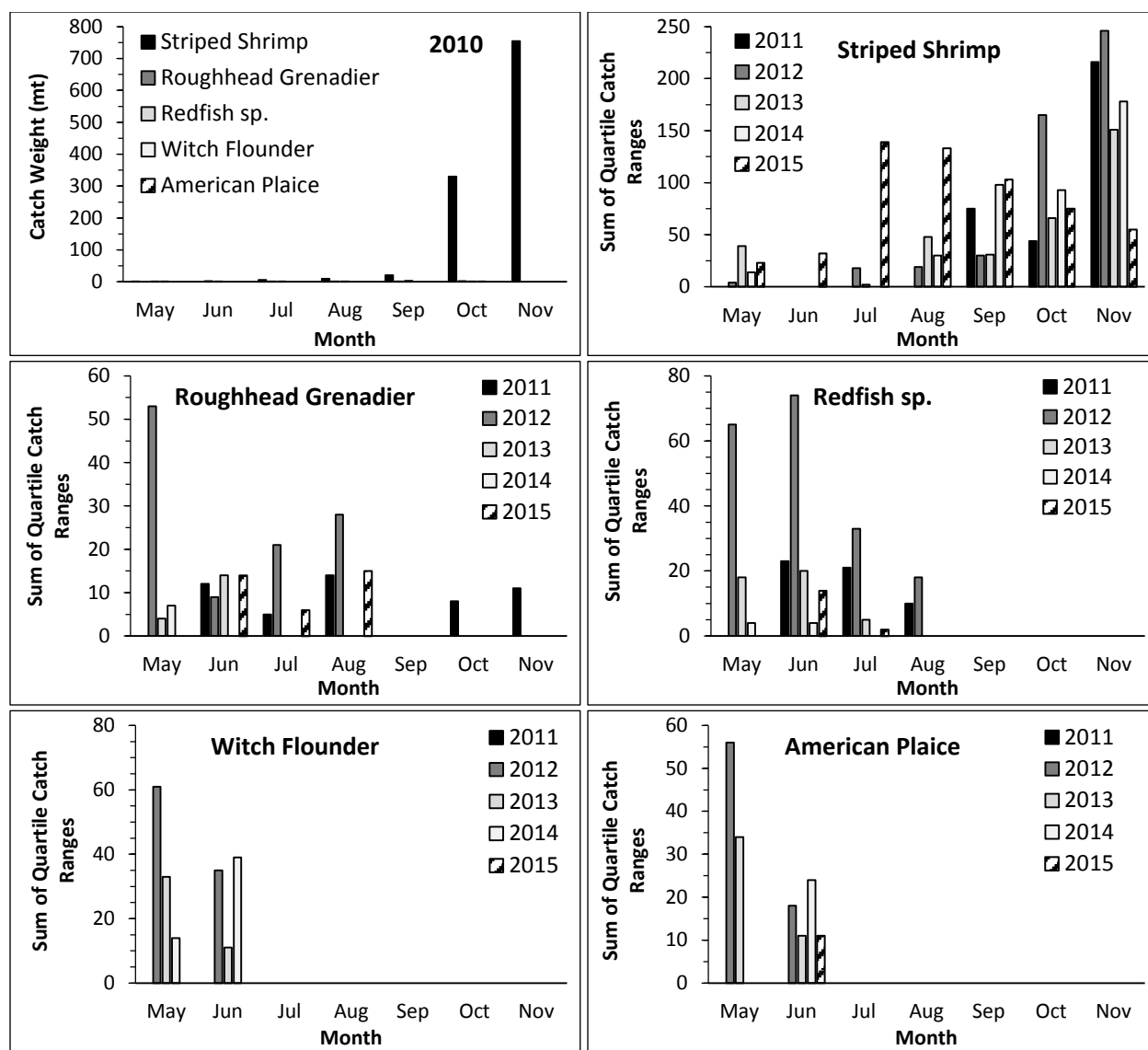
Source: DFO commercial landings database, 2015.

Figure 4.20 Distribution of Commercial Harvest Locations for Witch Flounder, May–November 2010.



Source: DFO commercial landings database, 2015.

Figure 4.21 Distribution of Commercial Harvest Locations for American Plaice, May–November 2015.



Source: DFO commercial landings database, 2010–2015.

Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.22 Total Monthly Catch Weights, May–November 2010 (top left) and Total Monthly Catch Weight Quartile Codes, May–November 2011–2015 for Striped Shrimp, Roughhead Grenadier, Redfish, Witch Flounder and American Plaice in the Study Area.

4.3.4 Traditional and Aboriginal Fisheries

Traditional and Aboriginal fisheries within the Study Area, including Communal Commercial Fisheries Licences (CCFL) and a communal fixed gear groundfish licence, are described in § 4.3.4 of LGL (2014, 2016) (Note: pers. comm.’s within the aforementioned section are attributed to D. Ball and D. Tobin of “DFO, Resource Management and Aboriginal Affairs”; this

should instead be listed as “DFO, Resource Management and Aboriginal Fisheries”). Traditional fishing activities are also reviewed in § 1.8, § 4.10.3 and § 5.8.3 of the Labrador Shelf SEA (C-NLOPB 2008).

During the 2018/2019 fishing season, the communal quotas for snow crab in Div. 2H (north of 56°N) and Div. 2J north (north of 54°40’N to 56°N) are 100 mt and 310 mt, respectively (DFO 2018a), unchanged since 2016 (with no changes for Div. 2J since at least 2014).

The TAC for the Innu Nation and Nunatsiavut Government for northern shrimp in SFA 4 during the 2018/2019 fishing season are 1,192 mt (8.5% of the total TAC) and 1,403 (10%), respectively (DFO 2018a), unchanged from 2017 but increased from 1,125 mt and 675 mt, respectively, during 2016 (DFO 2016e). In an effort to increase Indigenous access to the northern shrimp fishery in SFA 5, three Indigenous groups (Innu, the NunatuKavut Community Council and Nunatsiavut Government) received “increased stable and predictable shares” as of the 2016/2017 fishing season (DFO 2016e), accounting for ~21% of the TAC among all fleets/interests during the 2016/2017 season. For the 2018/2019 fishing season, the TAC levels are as follows (approximate percent share of total TAC provided in brackets): Northern Coalition (7,176 [38%]), Innu Nation (7,176 mt [28%]), Nunatsiavut Government (2,537 mt [10%]), Imakpick (710 mt [3%]), and NunatuKavut Community Council (1,594 mt [6%]), representing ~85% of the TAC among all fleets/interests during this season (DFO 2018a). The TAC for the Innu Nation in SFA 6 in 2018/2019 is 148 mt, approximately 2% of the total TAC (DFO 2018a), decreased from 177 mt (~2%) during 2017.

4.3.5 Recreational Fisheries

Recreational fisheries in Newfoundland are described in § 5.8.4 of the Labrador Shelf SEA (C-NLOPB 2008), and § 4.3.5 of LGL (2014, 2015). The recreational groundfish fishery occurs in all NAFO Divisions around the province, including 2GHJ, 3KLPsPn and 4R, with the exception of the Eastport and Gilbert Bay Marine Protected Areas (MPA) (DFO 2017b). Of these NAFO Div., 2GHJ and 3K overlap with the Study Area. It is possible that recreational fisheries will be conducted within the shallower portions of the Study Area.

The 2017 Newfoundland and Labrador recreational groundfish fishery was open for a total of 46 days, an increase of 14 days from previous years (prior to 2016), beginning with the first weekend in July and ending in the beginning of October (DFO 2017b). This extension was considered a transitional measure that was implemented ahead of the upcoming licence and tag regime for all recreational fishery participants, which was anticipated prior to the 2017 season (DFO 2016e); however, as of the 2018 season, there is still no requirement for licences or tags (DFO 2017b, 2018a). The 2018 season will be shortened to 39 days, beginning the last weekend of June until the end of September (DFO 2018a).

As during the 2017 recreational fishery seasons, during 2018 fishers are limited to five groundfish per day, including cod, and no fish were permitted to be wasted (DFO 2017b, 2018a).

4.3.6 Aquaculture

Aquaculture operations (or the absence thereof) in Labrador are described in § 4.10.4 of the Labrador Shelf SEA (C-NLOPB 2008). Currently, all aquaculture sites in Newfoundland and Labrador are located in coastal waters of the island portion of the province. There are no approved aquaculture sites within the Study Area (FLR 2018).

4.3.7 Macroinvertebrates and Fishes Collected during DFO Research Vessel (RV) Surveys

DFO RV survey data collected during annual multi-species trawl surveys provide additional distributional information for some of the commercial species described in § 4.3.3, as well as for species not discussed in that subsection.

The total catch weight during the 2009–2014 spring (July–August) and fall (October–November) DFO RV surveys in the Study Area was 219 mt. Data collected during these surveys were analyzed, and catch weights, catch numbers and mean catch depths of species/groups contributing $\geq 0.1\%$ of the total catch weight as well as species at risk (§ 4.6) are presented in Table 4.11.

Table 4.11 Catch Weights and Numbers and Mean Catch Depths of Macroinvertebrates and Fishes Collected during DFO RV Surveys within the Study Area, May–November 2009–2014.^a

Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Northern Shrimp	54	12,282,378	361	291
Deepwater Redfish	53	331,727	389	382
Greenland Halibut	32	127,631	328	431
Sponges	17	81 ^b	283	482
Shrimp (Natantia)	12	0 ^b	167	457
Atlantic Cod	7	11,537	237	274
Striped Shrimp	5	1,255,280	310	215
Jellyfishes (Scyphozoa)	3	21	392	609
American Plaice	3	20,418	255	297
Capelin	3	162,608	157	231
Roughhead Grenadier	3	8,653	421	628
Northern Wolffish	3	510	315	465
Arctic Cod	2	91,101	229	228
Thorny Skate	2	6,606	372	326
Blue Hake	1	10,262	467	923
Roundnose Grenadier	1	10,356	565	923
Spotted Wolffish	1	574	320	279

Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Atlantic (striped) Wolffish	1	5,105	229	268
Sea Anemone (Actinaria)	1	22,456	447	449
Basket Star (<i>Gorgonocephalus arcticus</i>)	1	265	289	277
Snow Crab	1	11,552	-	281
Arctic Argid Shrimp (<i>Argis dentata</i>)	1	166,923	317	173
Basket Star (Gorgonocephalidae)	1	201	165	271
Lanternfish sp.	1	65,820	423	646
Longnose Eel (<i>Synaphobranchus kaupii</i>)	1	7,110	489	824
Invertebrate sp.	0.5	7	331	278
Black Herring	0.5	182	-	1,278
Spinytail Skate	0.4	74	297	770
Green Sea Urchin (<i>Strongylocentrotus droebachiensis</i>)	0.4	36,725	-	221
Witch Flounder	0.4	970	549	456
Golden Redfish	0.3	415	358	393
Black Dogfish	0.3	265	581	865
Shanny (<i>Lumpenus maculatus</i>)	0.3	55,846	231	219
Mud Star (<i>Ctenodiscus crispatus</i>)	0.3	78,805	-	411
Common Lumpfish	0.3	142	-	248
Rigid Cushion Star (<i>Hippasteria phrygiana</i>)	0.3	1,296	-	457
Eelpout sp. (<i>Lycodes</i> sp.)	0.3	8,886	-	306
Corals	0.3 ^b	2,606 ^b	315	589
Greenland Shrimp (<i>Eualus macilentus</i>)	0.3	295,387	190	206
Sea Urchin (<i>Strongylocentrotus</i> sp.)	0.3	25,056	160	210
Sevenline Shrimp (<i>Sabinea septemcarinata</i>)	0.2	76,370	192	213
Sea Urchin sp.	0.2	21,492	174	407
Deepsea Cat Shark (<i>Apristurus profundorum</i>)	0.2	114	-	1,261
Marlin Spike	0.2	1,631	501	667
Moustache Sculpin	0.1	12,139	-	241
Octopus (<i>Octopoda octopoda</i>)	0.1	649	422	716
Jensen's Skate	0.1	30	-	1,120
Spiny Lebbeid Shrimp (<i>Lebbeus groenlandicus</i>)	0.1	26,115	167	174
Shrimp (<i>Eualus gaimardii belcheri</i>)	0.1	48,839	240	171
Eelpout sp.	0.1	3,344	311	202
Spiny Brown Crab (<i>Lithodes maja</i>)	0.1	241	387	712
Smooth Skate	<0.1	1,395	-	453
Cusk	<0.1	8	-	464
Spiny Dogfish	<0.1	11	-	577
White Hake	<0.1	3	-	310
Winter Skate	<0.1	3	-	426
Total	216	15,298,221	303	402

Source: DFO RV Survey Data, 2009–2014.

Note:

^a There were no RV tows conducted north of the northern shelf of the Nain Bank (57.7°N) between 2013–2013.

^b Denotes data incomplete.

Northern shrimp accounted for 25% of the total May–November 2009–2014 catch weight, followed by deepwater redfish (24%), Greenland halibut (14%), sponges (8%), shrimp (Natantia; 5%), Atlantic cod (3%), striped shrimp and jellyfishes (Scyphozoa) (2% each). All other species/groups accounted for ≤1% of the total May–November 2009–2014 catch weight in the

Study Area. Principal species captured during the May–November 2009–2014 DFO RV surveys were generally representative of predominant species targeted using similar mobile gear (bottom trawls) in the commercial fishery in recent years (§ 4.3.3).

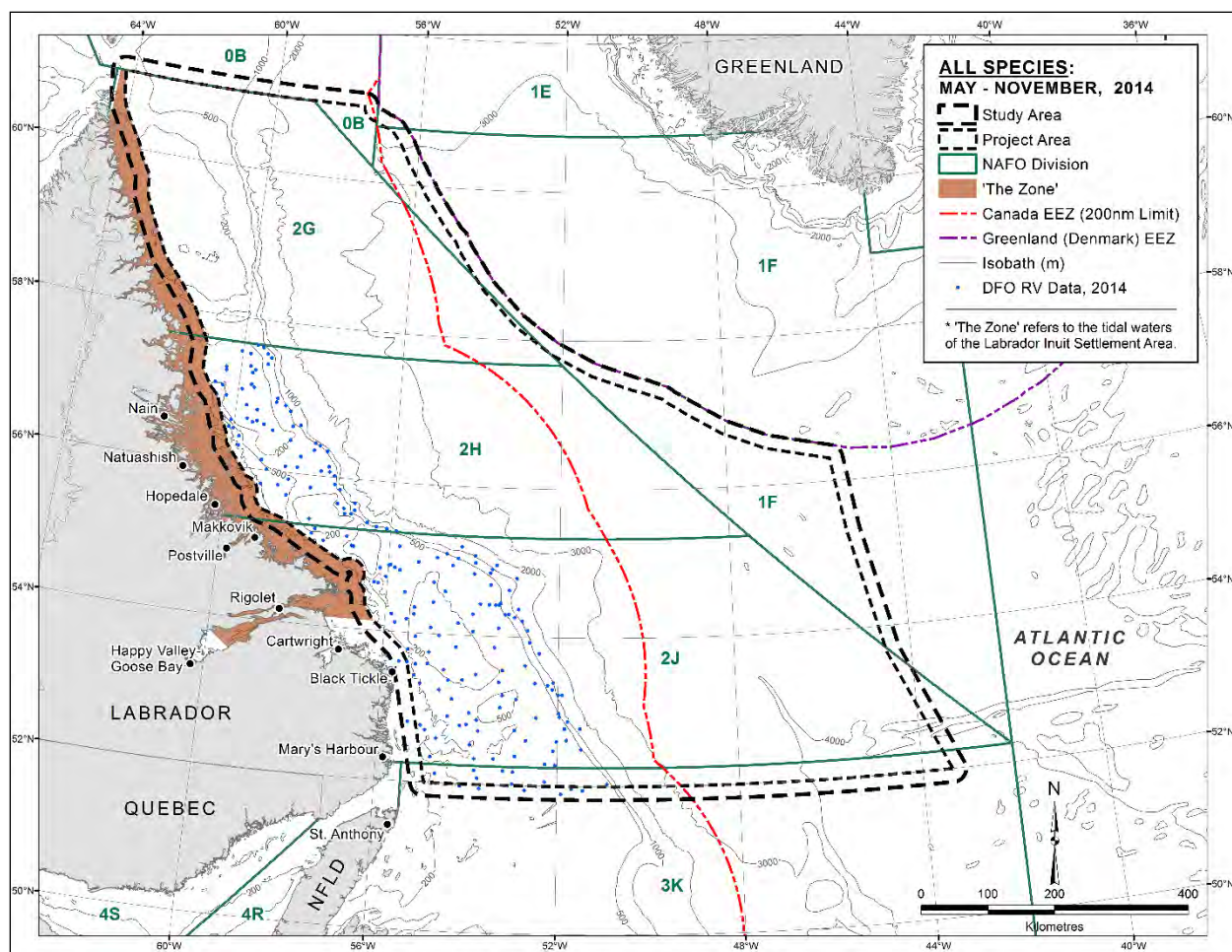
DFO RV survey catch locations for all species in the Study Area during May–November 2007–2011 and 2013 are shown in Figure 4.30 of LGL (2014) and Figure 4.23 of LGL (2016), respectively. The distribution of georeferenced catch locations reported during the May–November 2014 DFO RV surveys within the Study Area is shown in Figure 4.23 below. Species were captured in the western portions of the Study Area during the May–November 2009–2014 DFO RV surveys, in water depths <2,000 m (predominantly <1,000 m). Across all species caught during the May–November 2009–2014 DFO RV surveys in the Study Area, total catch weight ranged from 31–40 mt per year.

Spring and fall surveys accounted for 9% and 91% of the total catch weight, respectively. The average mean depths of catch during spring and fall surveys during 2009–2014 were 303 m (min: 80 m; max: 657 m) and 402 m (min: 110 m; max 1,526 m), respectively.

In descending order, the top five species/groups in terms of catch weight during the 2009–2014 spring surveys were northern shrimp, deepwater redfish, sponges, striped shrimp and Arctic cod; and during the fall surveys were deepwater redfish, northern shrimp, Greenland halibut, sponges and shrimp (Natantia). Species/groups captured predominantly during the spring surveys included unidentified invertebrates, eelpout sp. and shrimp (*Eualus gaimardii belcheri*); all other species were predominantly caught during the fall. The survey depth differences between spring and fall surveys likely account for some of the seasonal differences observed.

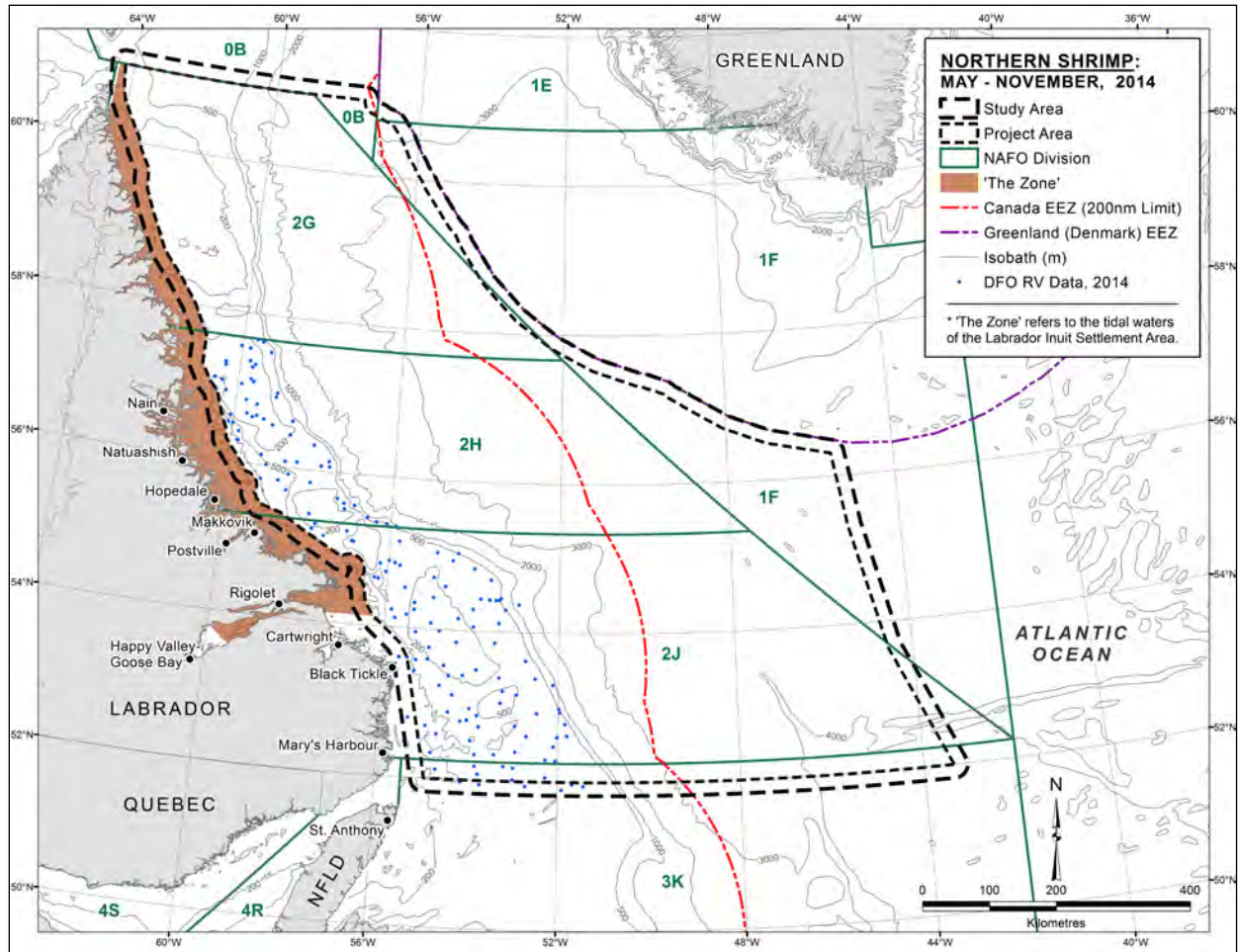
Figures 4.31–4.37 of LGL (2014) indicate 2007–2011 DFO RV survey catch locations for offshore Labrador for northern shrimp, deepwater redfish, shrimp (Natantia), Greenland halibut, sponges, corals, and wolffishes. Figures 4.24–4.26 of LGL (2016) indicate May–November 2013 DFO RV survey catch locations within the Study Area for deepwater redfish, yellowtail flounder, American plaice, Atlantic cod, thorny skate, northern shrimp, Greenland halibut, sponges, wolffishes and corals. Figures 4.24–4.31 below show catch locations during 2014 DFO RV surveys for northern shrimp, deepwater redfish, Greenland halibut, sponges, Atlantic cod, striped shrimp, wolffishes and corals, in order of descending total catch weight (see Table 4.11). There were no catches of shrimp (Natantia) during May–November 2014 RV surveys.

Catches at various mean depth ranges are also examined in this subsection. Table 4.12 presents total catch weights and predominant species/groups caught within each mean depth range in the Study Area during the May–November 2009–2014 period. Northern shrimp and Greenland halibut (predominant commercial species; mainly targeted using mobile gear) were caught primarily at depths ranging from 200–300 m and 400–500 m, respectively.



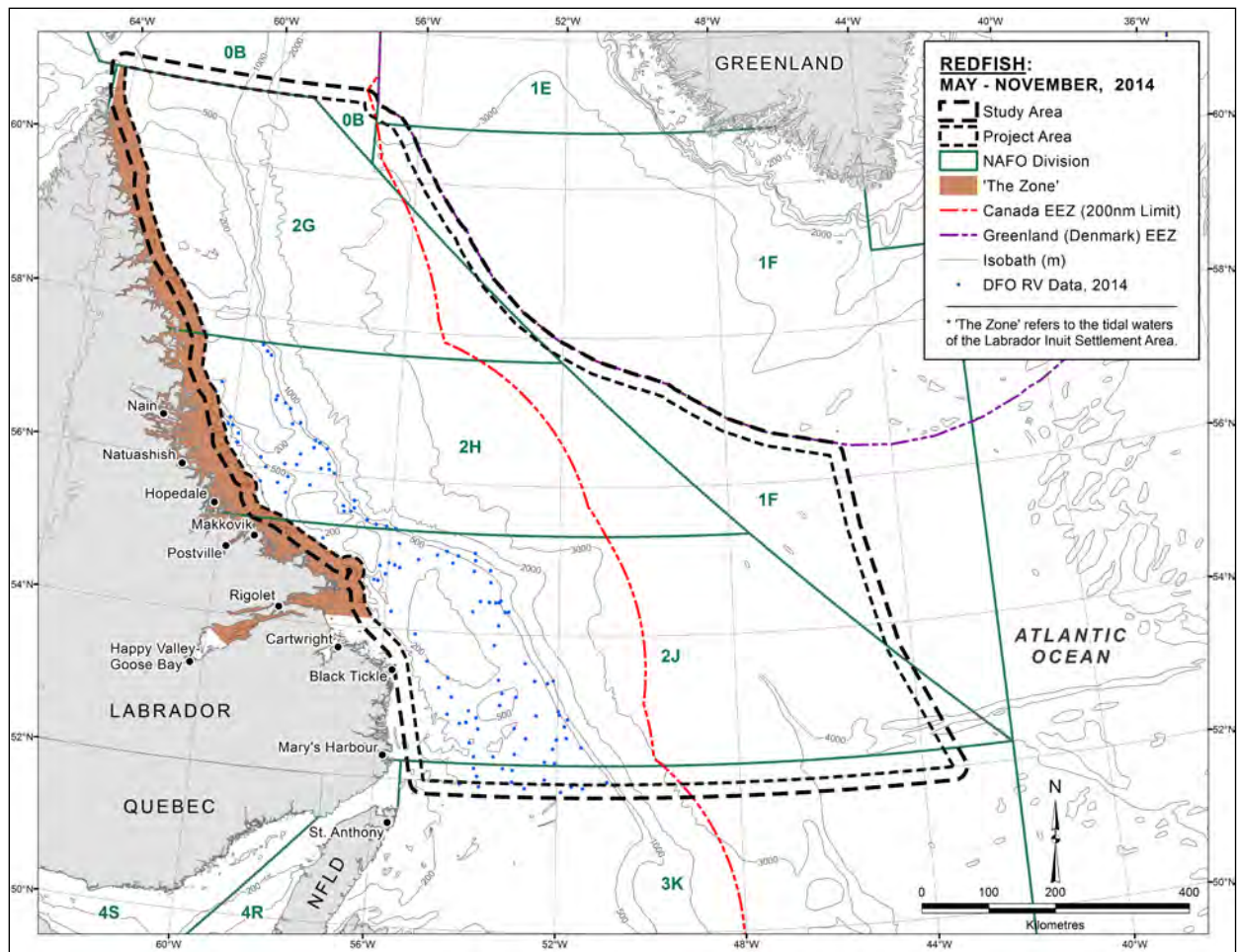
Source: DFO RV Survey database, 2014.

Figure 4.23 Distribution of DFO RV Survey Catch Locations in the Study Area, All Species, May–November 2014.



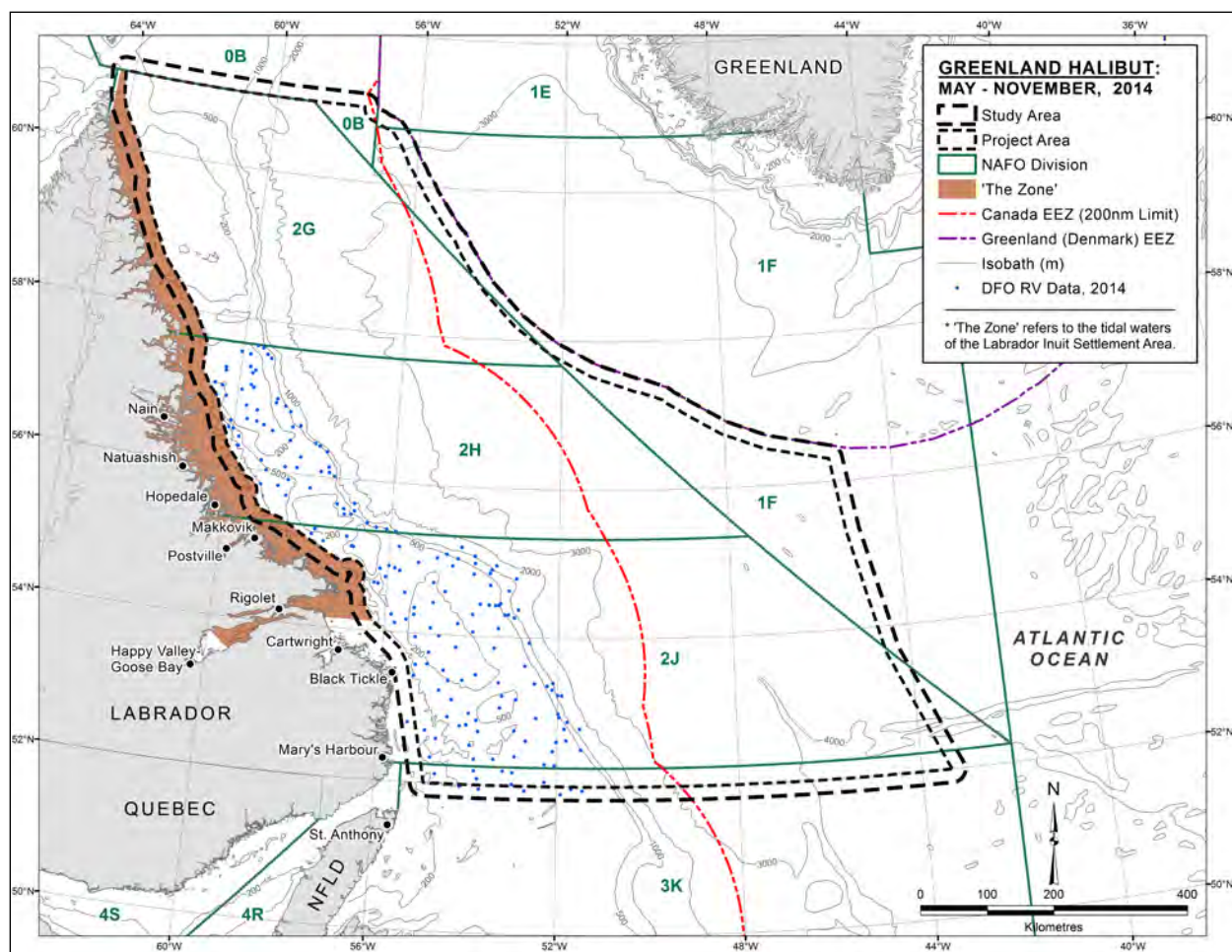
Source: DFO RV Survey database, 2014.

Figure 4.24 Distribution of DFO RV Survey Catch Locations of Northern Shrimp in the Study Area, May–November 2014.



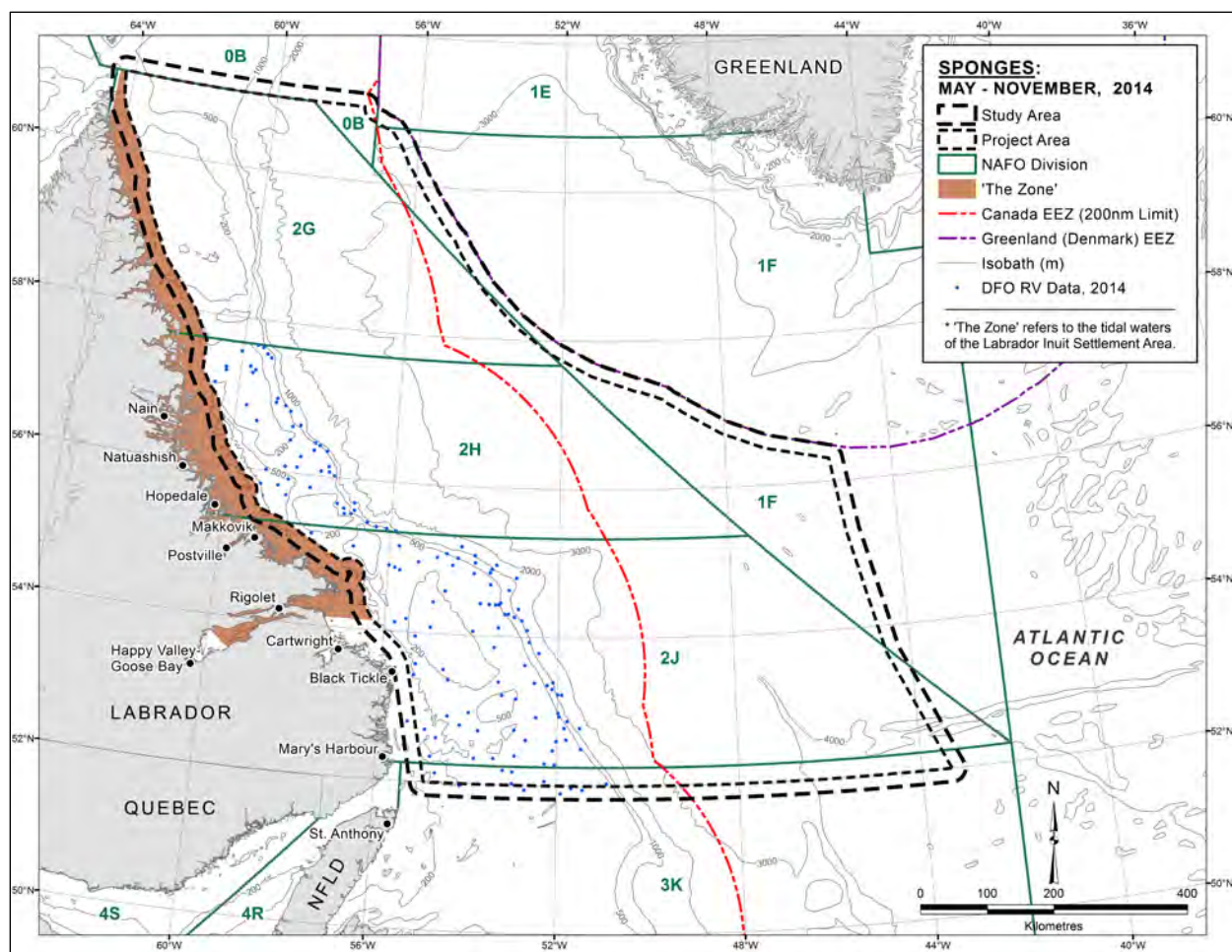
Source: DFO RV Survey database, 2014.

Figure 4.25 Distribution of DFO RV Survey Catch Locations of Deepwater Redfish in the Study Area, May–November 2014.



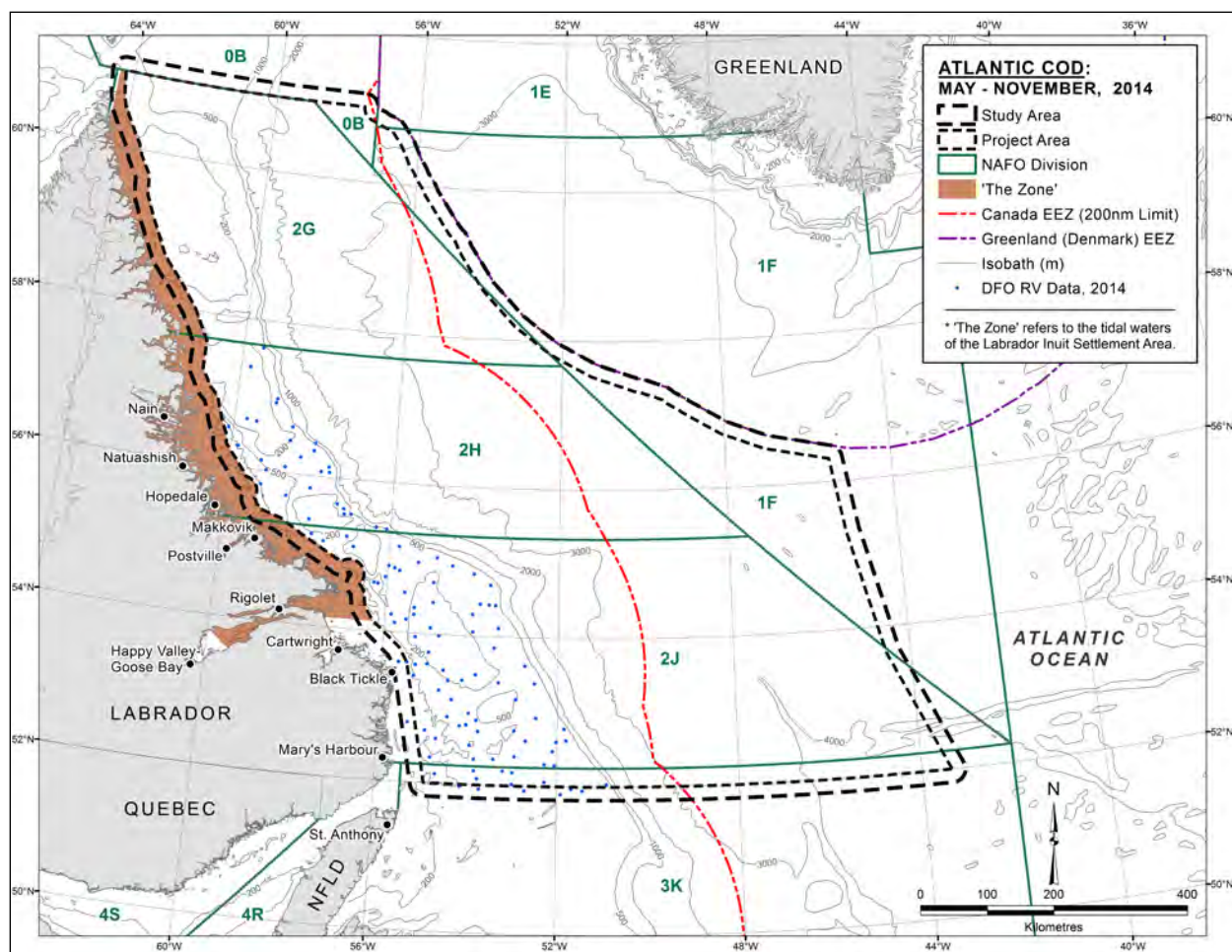
Source: DFO RV Survey database, 2014.

Figure 4.26 Distribution of DFO RV Survey Catch Locations of Greenland Halibut in the Study Area, May–November 2014.



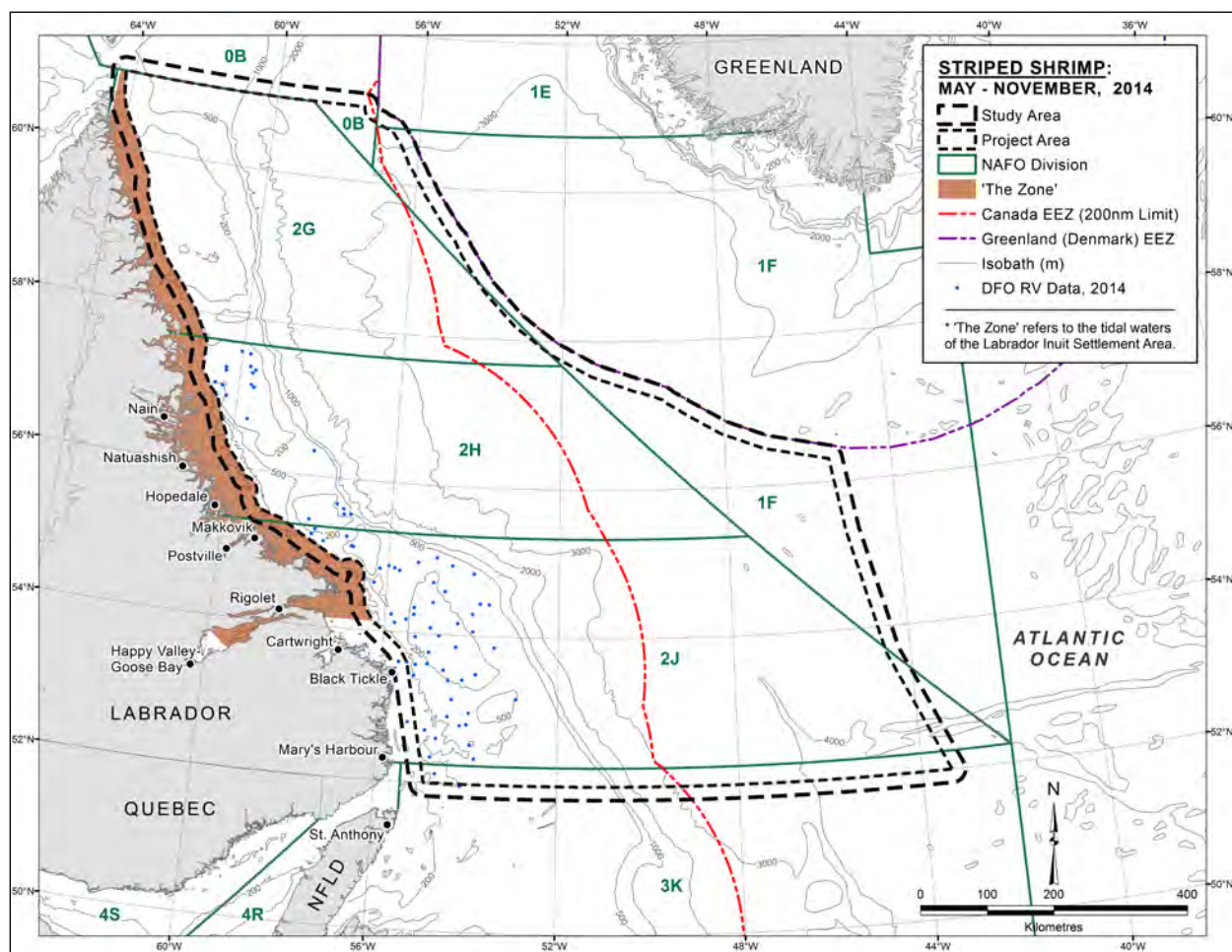
Source: DFO RV Survey database, 2014.

Figure 4.27 Distribution of DFO RV Survey Catch Locations of Sponges in the Study Area, May–November 2014.



Source: DFO RV Survey database, 2014.

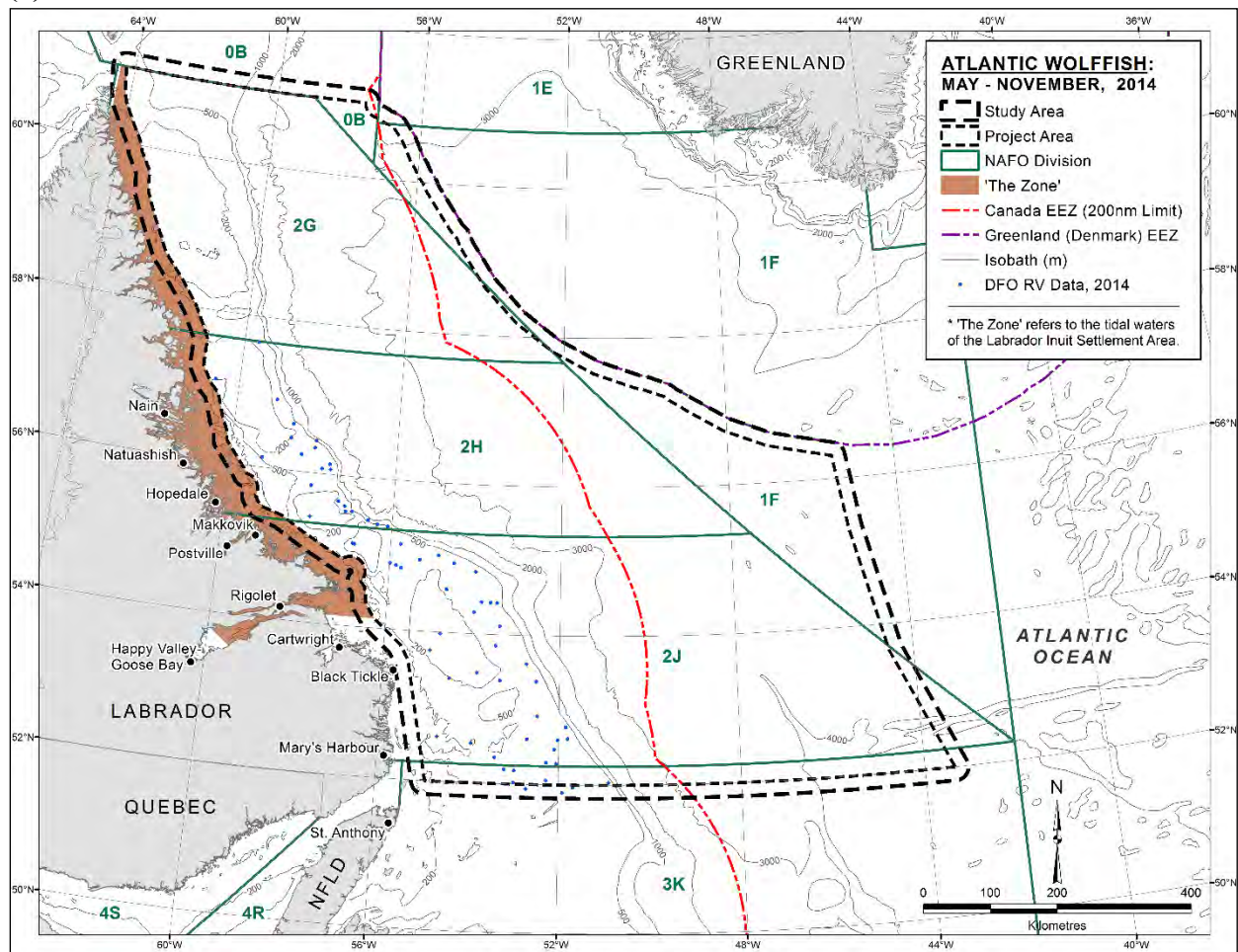
Figure 4.28 Distribution of DFO RV Survey Catch Locations of Atlantic Cod in the Study Area, May–November 2014.



Source: DFO RV Survey database, 2014.

Figure 4.29 Distribution of DFO RV Survey Catch Locations of Striped Shrimp in the Study Area, May–November 2014.

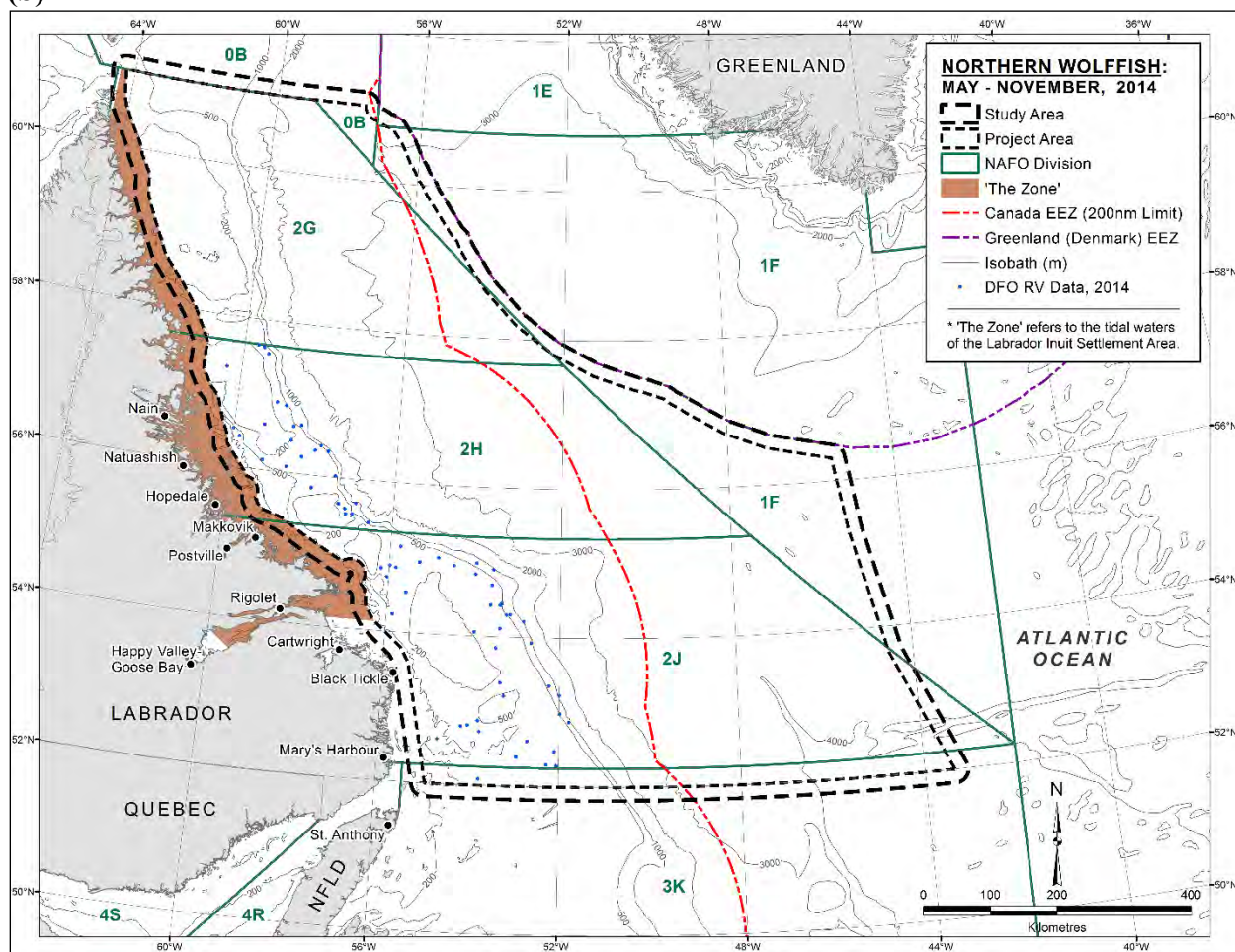
(a)



Source: DFO RV Survey database, 2014.

Figure 4.30 Distribution of DFO RV Survey Catch Locations of (a) Atlantic (striped), (b) Northern and (c) Spotted Wolffish in the Study Area, May–November 2014.

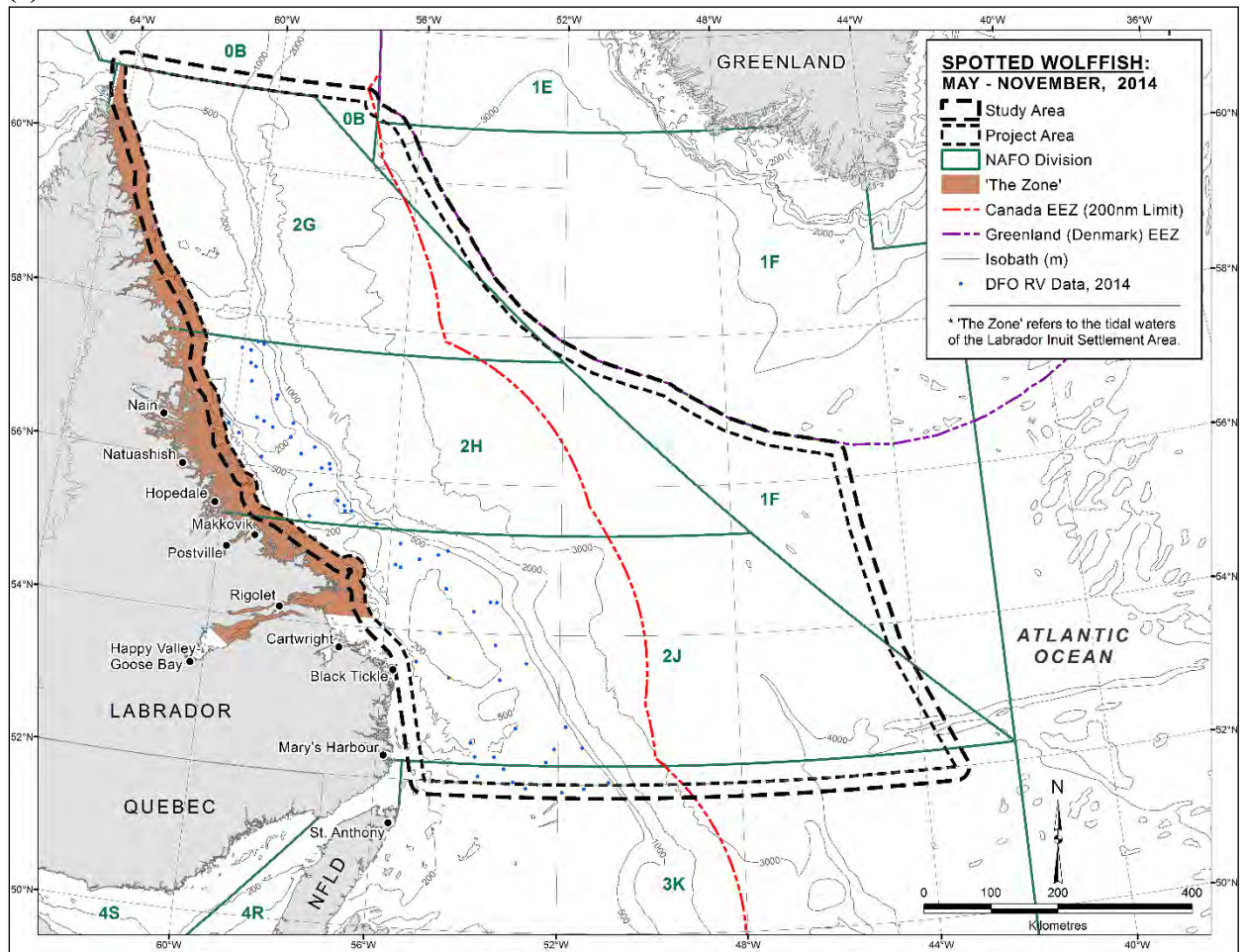
(b)



Source: DFO RV Survey database, 2014.

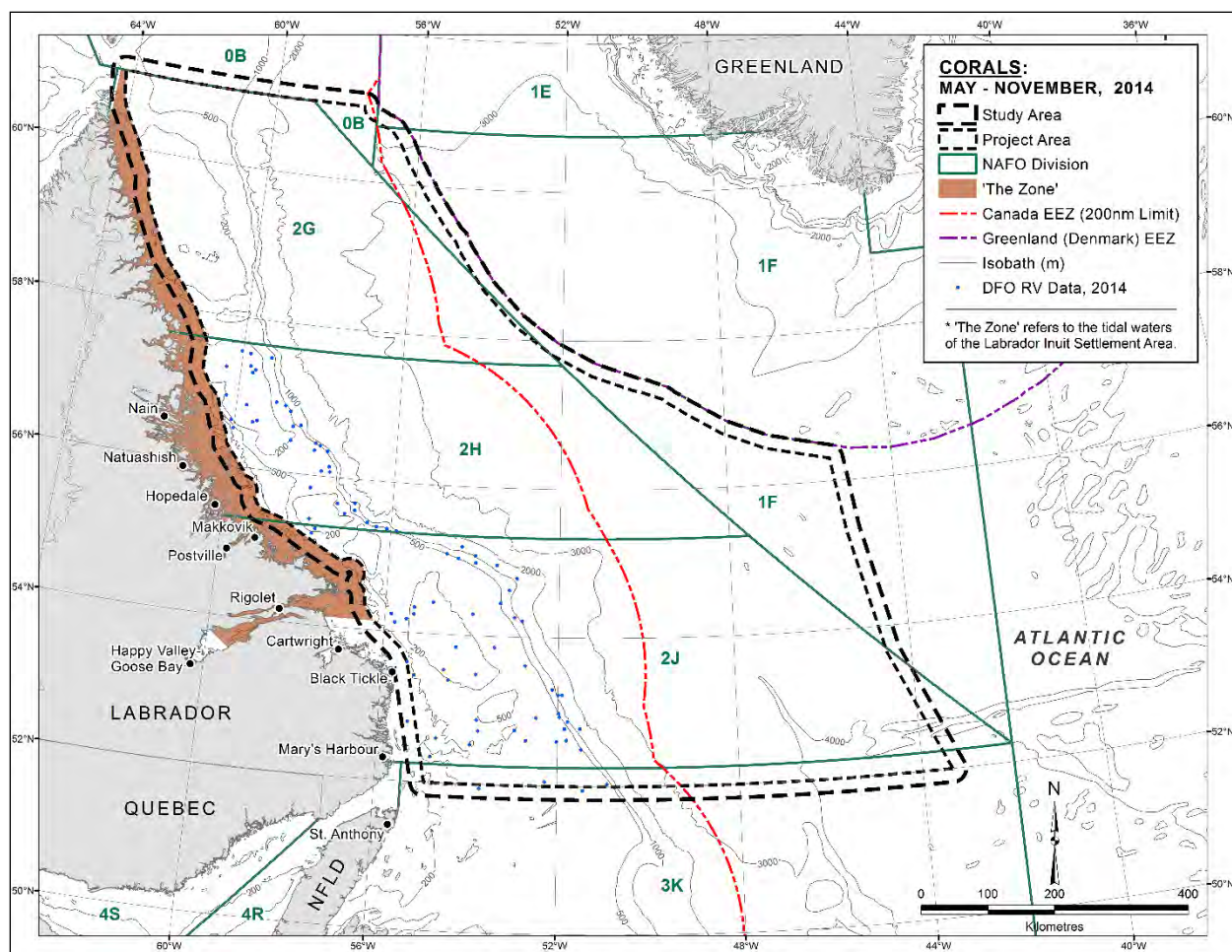
Figure 4.30 (cont'd) Distribution of DFO RV Survey Catch Locations of (a) Atlantic (striped), (b) Northern and (c) Spotted Wolffish in the Study Area, May–November 2014.

(c)



Source: DFO RV Survey database, 2014.

Figure 4.30 (cont'd) Distribution of DFO RV Survey Catch Locations of (a) Atlantic (striped), (b) Northern and (c) Spotted Wolffish in the Study Area, May–November 2014.



Source: DFO RV Survey database, 2014.

Figure 4.31 Distribution of DFO RV Survey Catch Locations of Corals in the Study Area, May–November 2014.

Table 4.12 Total Catch Weights and Predominant Species Caught at Various Mean Catch Depth Ranges, DFO RV Surveys, May–November 2009–2014.

Mean Catch Depth Range (m)	Total Catch Weight (mt)	Predominant Species (% of Total Catch Weight)
<100	0	-
≥100 – <200	1	Arctic Argid Shrimp (<i>Argis dentata</i> ; 65%) Spiny Lebbeid Shrimp (<i>Lebbeus groenlandicus</i> ; 9%) Shrimp (<i>Eualus gaimardii belcheri</i> ; 9%)
≥200 – <300	82	Northern Shrimp (65%) Atlantic Cod (8%) Striped Shrimp (6%)
≥300 – <400	56	Deepwater Redfish (95%) Thorny Skate (3%)
≥400 – <500	66	Greenland Halibut (48%) Sponges (26%) Shrimp (Natantia; 18%)
≥500 – <600	0.4	Corals (67%) Arctic Squid (<i>Gonadus fabricii</i> ; 5%) Heart Urchin (<i>Brisaster fragilis</i> ; 5%)
≥600 – <700	7	Jellyfishes (Scyphozoa; 45%) Roughhead Grenadier (40%)
≥700 – <800	1	Spinytail Skate (57%) Shrimp (<i>Pasiphaea</i> sp.; 11%) Shrimp (<i>Pasiphaea tarda</i> ; 6%)
≥800 – <900	2	Blue Hake (62%) Longnose Eel (23%) Black Dogfish (14%)
≥900 – <1,000	2	Roundnose Grenadier (82%)
≥1,000	1	Black Herring (37%) Deepsea Cat Shark (15%) Jensen's Skate (10%)

Source: DFO Research Vessel Survey Database, 2009–2014.

4.3.8 Industry and DFO Science Surveys

Fisheries research surveys conducted by DFO and the fishing industry are important to the commercial fisheries in determining stock status. In a given year, there will be spatial overlap between the Study Area and research surveys in NAFO Divisions 2HJ and 3K.

The tentative schedule of DFO RV surveys in the Study Area in 2018 is indicated in Table 4.13. Fall surveys within the Study Area are scheduled to commence 7 November and continue until 19 December.

Table 4.13 Tentative 2018 Schedule of DFO RV Surveys in and near the Study Area.

NAFO Division	Start Date	End Date	Vessel
3K + 3L	7 November	20 November	<i>Needler</i>
2H	5 October	24 October	<i>Teleost</i>
2H + 2J	24 October	6 November	<i>Teleost</i>
2J	7 November	20 November	<i>Teleost</i>
3K	20 November	4 December	<i>Teleost</i>
3K	5 December	19 December	<i>Teleost</i>

Note:

Start/end dates subject to change as trip plans are finalized (D. Power, DFO, NAFO Senior Science Advisor/Coordinator, Science Branch, pers. comm., 31 January 2018).

Members of the FFAW have been involved in a DFO-industry collaborative post-season snow crab trap survey annually since 2003. This survey is intended to “allow the fishing industry to more accurately assess and ultimately better manage the valuable snow crab resource” (FFAW|Unifor 2017). Data from these surveys are incorporated into the scientific assessment of snow crab and as a result, harvesters and managers have improved partnership and higher confidence in the accuracy of recent stock status assessments (FFAW|Unifor 2017).

The post-season snow crab survey typically occurs between early-September and November. The annual snow crab TAC for this survey was 350 mt during the 2015 and 2016 seasons (DFO 2016e) and 470 mt during 2017 (DFO 2017b) and is 460 mt during 2018 (DFO 2018a). The station locations remained consistent from year to year up to and including the 2016 survey year. The total number of stations increased to 1,316 in 2017, occurring in NAFO Divisions 2J3KLOPs. Of these, 87 stations occur in the Project Area and within 30 km of the Project Area (i.e., spatial buffer for the stations) (80 in Project Area; 7 within 30 km of Project Area). The survey station locations in relation to the Study and Project Areas are shown in Figure 4.32. All of the stations will not necessarily be sampled during a given year; rather, the new plan by DFO is to randomize the survey locations within each NAFO Division (N. Paddy, PGS, pers. comm., 11 February 2017).

4.3.9 Data Gaps associated with the Fisheries VEC

The following data gaps associated with the Fisheries VEC were identified in the Labrador Shelf SEA (§ 4.10.7 of C-NLOPB 2008).

- Inconsistent multispecies surveys off Labrador since 1995 has resulted in major sources of uncertainty; and
- The effects of climate change on the fisheries are unknown.

In addition to the data gaps identified in the SEA, as of 2011, DFO commercial fishery landings data are no longer provided as empirical data, but rather as quartile ranges of landed catch weight and value for 6' x 6' grid cells. There is also uncertainty regarding the spatial and/or temporal extent of potential reduction in catch rates of shrimp and groundfish species associated with nearby seismic activity, a concern reported by stakeholders during consultations for the original EA (e.g., see questions from Mary's Harbour, Appendix A in LGL 2017a).

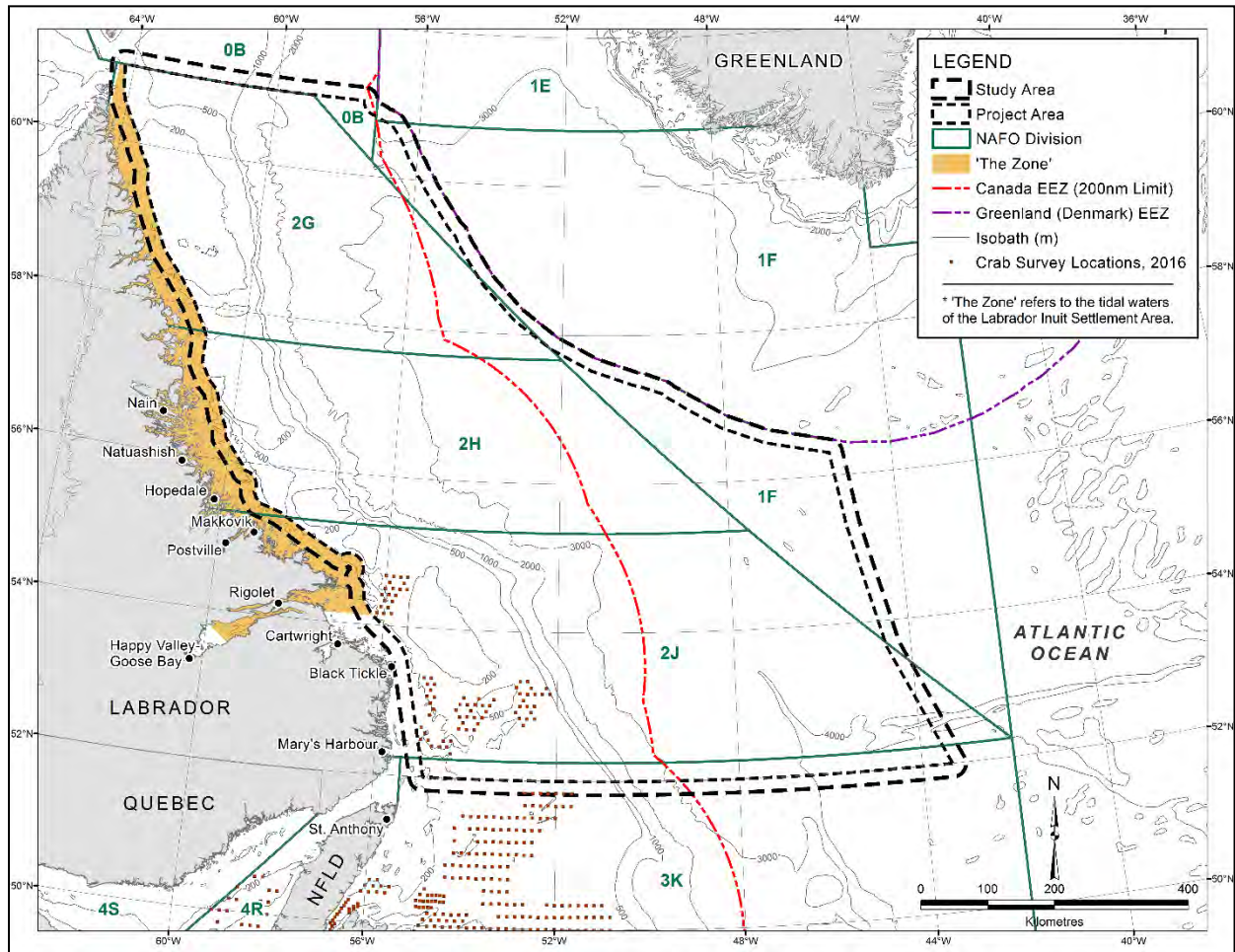


Figure 4.32 Locations of DFO-Industry Collaborative Post-Season Snow Crab Trap Survey Stations in relation to the Study Area and Project Area.

All of the above data gaps still exist, although efforts are being put forth for upcoming seasons to improve the gathering of data regarding recreational fisheries in Newfoundland and Labrador by implementing a licence and tag regime for all recreational fishery participants (see § 4.3.5), and post-season snow crab survey data have been altered through randomization of survey stations to be sampled as of 2017 (see § 4.3.8).

Although filling these data gaps could result in changes to the data presented in § 4.3, it is unlikely that increased data accuracy would alter the overall results, such as predominant species caught within the Study Area. As such, these data gaps are unlikely to limit the assessment of potential interactions between the Project and the Fisheries VEC. MKI will revise the Fisheries VEC and associated assessments as needed as new fisheries data become available and will reflect these changes in future EA Updates.

4.4 Marine-associated Bird VEC

The Marine-associated Bird VEC of the Study Area has been described in the Labrador Shelf SEA (§ 4.9.8 to 4.9.13 of C-NLOPB 2008) and two project-specific EAs (§ 4.4 of LGL 2014, 2016). An overview of the marine-associated birds of the Study Area, based on the aforementioned documents, is provided below. Newly available information since publication of the SEA and EAs is also summarized. Data gaps regarding marine-associated birds identified in the SEA are reviewed in terms of current status.

Pelagic seabird abundance data in the shelf areas off Newfoundland and Labrador are available from the Canadian Wildlife Service (CWS) programme intégré de recherches sur les oiseaux pélagiques (PIROP) shipboard surveys conducted during 1967–1994 (Lock et al. 1994), the more recent (2006–2009) CWS Eastern Canadian Seabirds at Sea (ECSAS) survey program (Fifield et al. 2009), and the most recent (2006–2016) on-line ECSAS atlas (Bolduc et al. 2018). The most current census data related to important seabird nesting colonies in Newfoundland and Labrador have been acquired from the CWS and are incorporated into this EA.

The Study Area encompasses a wide range of marine habitats extending from the Labrador Sea to 52°N. Seabirds tend to concentrate over oceanographic features such as continental shelf edges and convergences of warm and cold currents, both of which occur in the Study Area. The Labrador Current running southward along the edge of continental shelf edge creates areas of upwelling and water mixing that brings mineral nutrients to the surface, thereby resulting in high phytoplankton productivity which forms the basis for increased productivity at higher trophic levels (e.g., seabirds). A summary of the marine bird life in the Study Area can be found in § 4.4 of LGL (2016).

Offshore Labrador is a known wintering area for the Ivory Gull (*Pagophila eburnea*), a species with *endangered* status under Schedule 1 of SARA, COSEWIC, and the Newfoundland and Labrador *Endangered Species Act*. Ivory Gull occurs in the Study Area mainly outside the time frame of the proposed seismic survey period (i.e., May–November) (Spencer et al. 2016). This species is typically associated with pack ice, which will be avoided during seismic exploration. Offshore Labrador also serves as a wintering area for small numbers of Ross's Gulls (*Rhodostethia rosea*) nesting in the Canadian Arctic (Maftei et al. 2015). This species is designated *threatened* by COSEWIC and is listed on Schedule 1 of SARA as *threatened*. Harlequin Duck (*Histrionicus histrionicus*) and Barrow's Goldeneye (*Bucephala islandica*)

moult and stage at some sites along the Labrador coast and around islands off the Labrador coast. Both species have *special concern* status under Schedule 1 of SARA and COSEWIC. Typically, they would occur outside the Study Area close to shorelines of the coast or coastal islands but may also occur incidentally in the Study Area during migration. Other species of conservation concern that may occur incidentally in the Study Area during migration to and from the Arctic are the Buff-breasted Sandpiper (*Tryngites subruficollis*) and Red Knot *rufa* subspecies (*Calidris canutus rufa*). The Red Knot is designated as *endangered* under Schedule 1 of SARA and COSEWIC, and the Buff-breasted Sandpiper is designated as *special concern* under Schedule 1 of SARA and COSEWIC. Additional species of conservation interest that may rarely occur in nearshore regions of the Study Area include the Piping Plover *melodus* subspecies (*Charadrius melodus melodus*), Common Nighthawk (*Chordeiles minor*), Olive-sided Flycatcher (*Contopus cooperi*), and Red Crossbill *percna* subspecies (*Loxia curvirostra percna*). Details on Barrow's Goldeneye and Harlequin Duck are in § 4.4.2.1 of LGL (2016) while Ivory Gull is discussed in § 4.6 of LGL (2016). Shorebirds and other species found on the coast but not in the Study Area are not discussed in detail in this EA. Details on coastal species can be found in the Labrador Shelf SEA (§ 4.9.10 and § 4.9.11 of C-NLOPB 2008).

4.4.1 Seasonal Occurrence and Abundance

The global range, seasonal occurrence and seasonal abundance of seabirds occurring regularly in the Study Area are described below. Table 4.14 summarizes the predicted monthly abundance status for each species in the Study Area. The following four categories that qualitatively define the relative abundance of seabirds are used.

- 1) Common: likely present daily in moderate to high numbers;
- 2) Uncommon: likely present daily in small numbers;
- 3) Scarce: likely present regularly in very small numbers; and
- 4) Rare: usually absent, individuals occasionally present.

Seasonal occurrence and abundance information was derived from Brown (1986), Lock et al. (1994), Fifield et al. (2009), and Bolduc et al. (2018).

There are over 30 species of marine-associated birds occurring regularly in the Labrador Sea (Table 4.14). Large numbers of seabirds occur in parts of the Study Area at all times of the year.

4.4.2 Breeding Seabirds in Newfoundland and Labrador

There are seabird breeding colonies of worldwide significance in southeast Labrador (Table 4.15). The Gannet Islands, off southern Labrador, host North American's largest Razorbill colony, large numbers of nesting Common Murre and Atlantic Puffin, and smaller numbers of Northern Fulmar, Leach's Storm-Petrel, three gull species, Thick-billed Murre and Black Guillemot. These birds use the Study Area during their breeding season. After the nesting

season, seabirds disperse widely over the Newfoundland and Labrador offshore area, including most of the Study Area. Large numbers of seabirds that do not nest in Newfoundland and Labrador also spend part of their non-breeding season within the Study Area. Several million Great and Sooty Shearwaters migrate from breeding islands in the South Atlantic and occur in waters offshore Newfoundland and Labrador in summer. Many of the 3.8 million Thick-billed Murres breeding in the eastern Canadian Arctic as well as up to 10 million Dovekies from Greenland either winter in the Labrador Sea and Grand Banks or migrate through these areas on the way to the continental shelf waters of Nova Scotia and areas farther south. 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.

Table 4.14 Monthly Occurrences and Abundances of Pelagic Seabirds in Offshore Labrador (52°N to 62°N).

Species	Scientific Name	J	F	M	A	M	J	J	A	S	O	N	D
Northern Fulmar*	<i>Fulmarus glacialis</i>	C ¹	C	C	C	C	C	C	C	C	C	C	C
Great Shearwater	<i>Ardenna gravis</i>					R	U	U	U	U	U	R	
Sooty Shearwater	<i>Ardenna grisea</i>					R	U	U	U	U	R		
Manx Shearwater*	<i>Puffinus puffinus</i>						R	R	R	R			
Wilson's Storm-Petrel	<i>Oceanites oceanicus</i>						R	R	R	R			
Leach's Storm-Petrel*	<i>Oceanodroma leucorhoa</i>					U	U	U	U	U	U		
Northern Gannet*	<i>Morus bassanus</i>					R	R	R	R	R	R		
Red-necked Phalarope*	<i>Phalaropus lobatus</i>					U	U	U	U	U	S		
Red Phalarope	<i>Phalaropus fulicarius</i>					S	S	U	U	U	S		
Great Skua	<i>Stercorarius skua</i>								R	R	R	R	
South Polar Skua	<i>Stercorarius maccormicki</i>							R	S	S	S	S	
Pomarine Jaeger	<i>Stercorarius pomarinus</i>					U	U	U	U	U	U		
Parasitic Jaeger	<i>Stercorarius parasiticus</i>					U	U	U	U	U	U		
Long-tailed Jaeger	<i>Stercorarius longicaudus</i>					U	U	U	U	U			
Dovekie	<i>Alle alle</i>	C	C	C	C	C	U	S	S	U	C	C	C
Common Murre*	<i>Uria aalge</i>	R	R	R	R	C	C	C	C	C	C	U	S
Thick-billed Murre*	<i>Uria lomvia</i>	S			C	C	C	U	U	U	C	S	S
Razorbill*	<i>Alca torda</i>				R	C	C	C	C	C	C	U	R
Black Guillemot*	<i>Cephus grylle</i>	U	U	U	C	C	C	C	C	C	C	C	C
Atlantic Puffin*	<i>Fratercula arctica</i>				U	U	U	U	U	U	U	U	
Black-legged Kittiwake*	<i>Rissa tridactyla</i>	C	C	C	C	C	C	C	C	C	C	C	C
Ivory Gull	<i>Pagophila eburnea</i>	U	U	U	U	U						S	U
Ross's Gull	<i>Rhodostethia rosea</i>	R	R	R	R	R					R	R	R
Herring Gull*	<i>Larus argentatus</i>				C	C	C	C	C	C	C	U	U
Iceland Gull	<i>Larus glaucoides</i>	C	C	C	C	C	U	S	S	S	C	C	C
Lesser Black-backed Gull	<i>Larus fuscus</i>				S	S	S	S	S	S			
Glaucous Gull*	<i>Larus hyperboreus</i>	C	C	C	C	C	C	C	C	C	C	C	C
Great Black-backed Gull*	<i>Larus marinus</i>	S	S	S	U	U	U	U	U	U	U	U	U
Common Tern*	<i>Sterna hirundo</i>					U	U	U	U	S			
Arctic Tern*	<i>Sterna paradisaea</i>					C	C	C	C	U			

Note:

* Breeds in Newfoundland and Labrador.

¹ Abundance definitions valid for at least part of Study Area but not necessarily the whole Study Area. C = Common, likely present daily in moderate to high numbers; U = Uncommon, likely present daily in small numbers; S = Scarce, likely present regularly in very small numbers; R = Rare, usually absent, individuals occasionally present. Blank spaces indicate not expected to occur in that month. Predicted monthly occurrences derived from extrapolation of marine bird distribution at sea in eastern Canada in Brown (1986), Lock et al. (1994), Fifield et al. (2009), and Bolduc et al. (2018).

Table 4.15 Number of Pairs of Seabirds Nesting at Colonies in Labrador (62°N to 52°N).

Species	Southeast of Nain	Quaker Hat	Northeast Groswater Bay	Gannet Islands	Bird Island
Northern Fulmar	-	-	-	24 ^d	-
Leach's Storm-Petrel	-	-	10 ^a	20 ^a	present
Herring Gull	30 ^a	-	220 ^a	-	-
Glaucous Gull	385 ^a	-	-	-	-
Great Black-backed Gull	90 ^a	-	125 ^a	30 ^d	20
Black-legged Kittiwake	-	4 ^a	-	72 ^a	-
Common Murre	87 ^a	648 ^a	2,360 ^{a,c}	31,170 ^a	3,100
Thick-billed Murre	5,200 ^a	126 ^a	365 ^a	1,846 ^a	present
Razorbill	815	450 ^a	1,520 ^{a,c}	14,801 ^a	1,530
Black Guillemot	1,850 ^a	-	present	110 ^a	-
Atlantic Puffin	2,470 ^{a,c}	2,100 ^a	18,210 ^{a,c}	38,666 ^d	8,070
Total	10,927	3,328	22,810	86,739	12,720

Source: ^a ECCC-CWS unpublished data, ^b Cairns et al. 1989, ^c Robertson et al. 2002, ^d Robertson and Elliot 2002.

Important Bird Areas (IBAs) form a network 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 14 IBAs along coastal Labrador. Figure 4.96 in C-NLOPB (2008) shows the IBA locations in and proximate to the Study Area.

The following subsections address the distribution and abundance of the various regularly occurring species of marine-associated birds in the Study Area.

4.4.2.1 Anatidae (Ducks and Geese)

Large numbers of Common Eider nest on the Labrador coast and occur during migration and winter in open water from Labrador to Newfoundland. Moulting aggregations of Surf, Black and White-winged Scoters occur on the Labrador coast by mid-summer. Barrow's Goldeneye and Harlequin Duck (eastern populations) both have *special concern* status under Schedule 1 of SARA. Detailed profiles of Barrow's Goldeneye and Harlequin Duck are provided in § 4.6.1.11 and § 4.6.1.10, respectively, of the MKI Labrador Sea EA (LGL 2014). Subsection 4.4.2.1 of LGL (2016) provides more information on waterfowl occurrence and abundance in the Study Area.

4.4.2.2 Procellariidae (Fulmarine Petrels and Shearwaters)

Five species of this family occur regularly in the Study Area: (1) Northern Fulmar, (2) Great Shearwater, (3) Sooty Shearwater, (4) Manx Shearwater, and (5) Leach's Storm-Petrel.

Northern Fulmar

Northern Fulmar is expected to be common throughout the Study Area year-round (see Table 4.14). The number of breeding pairs and their breeding locations are indicated in Table 4.15. Subsection 4.4.2.2 of LGL (2014) provides more information on Northern Fulmar occurrence and abundance in the Study Area.

Great Shearwater

Great Shearwater is expected to be uncommon throughout the Study Area during June–October but either scarce or rare during May and November (see Table 4.14). Subsection 4.4.2.2 of LGL (2014) provides more information on Great Shearwater occurrence and abundance in the Study Area.

Other Shearwaters

Sooty Shearwater is expected to be uncommon in the Study Area during June–September and rare during May and October (see Table 4.14). Manx Shearwater is expected to be rare in the Study Area during June–September (see Table 4.14). Manx Shearwater nests in Europe and at a colony at Middle Lawn Island off of Newfoundland's south coast. Subsection 4.4.2.2 of LGL (2014) provides more information on occurrences and abundances of Sooty Shearwater and Manx Shearwater in the Study Area.

4.4.2.3 Hydrobatidae (Storm-Petrels)

Leach's Storm-Petrel

Leach's Storm-Petrel is expected to be uncommon in the Study Area during May–October (see Table 4.14). Number of breeding pairs and their breeding locations in the Study Area are indicated in Table 4.15.

More than two million pairs of Leach's Storm-Petrel nest on the Avalon Peninsula of Newfoundland. Accumulating evidence suggests the population of Newfoundland Leach's Storm-Petrels is experiencing a substantial decline. Preliminary results from a 2013 survey of nesting Leach's Storm-Petrel on Baccalieu Island, the largest breeding colony of Leach's Storm-Petrels in the world, give an estimate of just over 2 million pairs, a decline of 40% from the previous survey in 1984 (ECCC-CWS unpublished data). The results of surveys of nesting

Leach's Storm-Petrels on Gull Island in the Witless Bay Ecological Reserve indicated a decline from 352,000 breeding pairs in 2001 to 180,000 pairs in 2012, a drop of 51% (ECCC-CWS unpublished data). A 2015 population estimate update for Green Island, Fortune Bay (next to St. Pierre et Miquelon) was 48,000 pairs (ECCC-CWS unpublished data), down from a previous estimate of 103,833 pairs (Russell 2008). The cause of the Leach's Storm-Petrel population decline has not yet been determined.

Recent studies using geolocators attached to the birds examined the movements of Leach's Storm-Petrel. A bird outfitted with a geocator in the Gull Island, Newfoundland, colony migrated to Cape Verde Islands off the west coast of Africa in early December, averaging 420 km/day over 12 days of migration. It remained in this area for at least five weeks at which time the transmitter stopped working. A Nova Scotia bird followed a similar track southward but departed in mid-October. It staged for several weeks near the Cape Verde Islands before continuing to the eastern tip of Brazil where it spent the rest of the winter. It migrated north in early-April (Pollet et al. 2014a).

Leach's Storm-Petrels with geolocators travel up to $1,015 \pm 238$ km during foraging trips from nesting colonies in Nova Scotia to the deep waters off the continental shelf (Pollet et al. 2014b). Newfoundland and Labrador breeders can be expected to travel a similar distance from the breeding colonies, if required, putting most of the Study Area within reach of these birds. Subsection 4.4.2.3 of LGL (2014) provides more information on Leach's Storm-Petrel occurrence and abundance in the Study Area.

Wilson's Storm-Petrel

Wilson's Storm-Petrel is expected to be rare in the Study Area during June–September (see Table 4.14). Subsection 4.4.4.2 of LGL (2015) provides more information on Wilson's Storm-Petrel occurrence and abundance off Newfoundland and Labrador.

4.4.2.4 Sulidae (Gannets)

Northern Gannet

Northern Gannet is expected to be rare in the Study Area during June–September (see Table 4.14). The closest nesting colony to the Study Area is on Funk Island, about 250 km south of the Study Area. Subsection 4.4.2.4 of LGL (2014) provide more information on Northern Gannet occurrence and abundance in the Study Area.

4.4.2.5 Tringinae (Phalaropes)

Red and Red-necked Phalaropes

Red Phalarope is expected to be scarce in the Study Area during May, June, and October, and uncommon during July–September (see Table 4.14). Red-necked Phalarope is expected to be uncommon in the Study Area during May–September and scarce in October (see Table 4.14). Subsection 4.4.2.5 of LGL (2014) provides more information on Red and Red-necked Phalarope occurrences and abundances in the Study Area.

4.4.2.6 Laridae (Gulls and Terns)

Great Black-backed, Herring, Iceland, Glaucous and Lesser Black-backed Gulls

Great Black-backed Gull, Herring Gull, and Glaucous Gull are expected to be uncommon to common in the Study Area during May–November (see Table 4.14). Iceland Gull is expected to be either uncommon or scarce in the Study Area during June–September and common in May, October and November (see Table 4.13). Lesser Black-backed Gull is expected to be scarce in the Study Area during April–September (see Table 4.14). The numbers of breeding pairs of Herring, Glaucous and Great Black-backed Gulls and their breeding locations are indicated in Table 4.15. Subsection 4.4.2.6 of LGL (2014) provides more information on the occurrences and abundances of these gull species in the Study Area.

Black-legged Kittiwake

Black-legged Kittiwake is expected to be common year-round during May–November in the Study Area (see Table 4.14). The number of breeding pairs of Black-legged Kittiwake and their breeding locations are indicated in Table 4.15. Subsection 4.4.2.6 of LGL (2014) provides more information on the occurrence and abundance of Black-legged Kittiwake in the Study Area.

Ivory and Ross’s Gulls

Ivory Gull likely occurs in small numbers in the Study Area where sea ice is present in late-winter and early-spring. As indicated in Table 4.14, Ivory Gull is expected to be either uncommon or scarce during May and November in the Study Area. Ivory Gull has *endangered* status under Schedule 1 of SARA, COSEWIC (SARA website 2018), and the provincial *Endangered Species Act*. More information on Ivory Gull is presented in § 4.6 of LGL (2016). Ross’s Gull is expected to be rare in the Study Area from October–May. Ross’s Gull is designated *threatened* under both Schedule 1 of SARA and COSEWIC.

Arctic and Common Terns

Arctic Tern and Common Tern are expected to be common and uncommon, respectively, in the Study Area during May–August, and either uncommon or scarce in September (see Table 4.14). Common Tern is less likely to occur in the offshore areas than Arctic Tern. Arctic Tern and Common Tern breed in small colonies along the Labrador coast. Subsection 4.4.2.6 of LGL (2014) provides more information on tern occurrence and abundance in the Study Area.

4.4.2.7 Stercorariidae (Skuas and Jaegers)

Great and South Polar Skuas

South Polar Skua is expected to be rare in the Study Area in May and June and scarce during July–October (see Table 4.14). Great Skua is expected to be rare during June–September in the Study Area (see Table 4.14). Subsection 4.4.2.7 of LGL (2014) provides more information on skua occurrence and abundance in the Study Area.

Pomarine, Parasitic and Long-tailed Jaeger

All three jaeger species are expected to be uncommon in the Study Area during May–October (see Table 4.14). Subsection 4.4.2.7 of LGL (2014) provide more information on jaeger occurrence and abundance in the Study Area.

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

There are six species of alcids that breed in the North Atlantic. All of these, except for Dovekie, nest in Labrador (see Tables 4.14 and 4.15). Dovekie nests primarily in Greenland. Dovekie, Common Murre, Thick-billed Murre and Atlantic Puffin occur in the Study Area during a large portion of the year. Black Guillemot and Razorbills are more coastal and are expected to be scarce or uncommon within most of the Study Area.

Dovekie

Dovekie is expected to be common in the Study Area from October–May uncommon in June and September, and scarce in July and August (see Table 4.14). Subsection 4.4.2.8 of LGL (2014) provides more information on Dovekie occurrence and abundance in the Study Area.

Murres

Since Common Murre and Thick-billed Murre are often difficult to differentiate with certainty at sea, they are often pooled as “murres” during offshore seabird surveys and in summaries of those data. Common Murre is expected to be common in the Study Area during May–October,

uncommon in November, and scarce to rare from December–April (see Table 4.14). Thick-billed Murre is expected to be common in the Study Area during April–June, October and November, uncommon during July–September, and scarce from November–January (see Table 4.14).

Studies using geolocators attached to 19 Thick-billed Murres and 20 Common Murres from five nesting colonies in the NW Atlantic revealed that murres exhibit a combination of site fidelity and flexibility during both migration and the winter (McFarlane Tranquilla et al. 2014). During the non-breeding season, Thick-billed Murres occurred in the offshore from Davis Strait south to the Flemish Cap and Southeast Grand Banks. Common Murres occurred off eastern Newfoundland to Flemish Cap and the Southeast Grand Banks during migration and winter (McFarlane Tranquilla et al. 2014). The numbers of breeding pairs for each species and their breeding locations are indicated in Table 4.15. Subsection 4.4.2.8 of LGL (2014) provides more information on murre occurrence and abundance in the Study Area.

Atlantic Puffin

Atlantic Puffin is expected to be uncommon in the Study Area during May–November (see Table 4.14). The number of breeding pairs and their breeding locations are indicated in Table 4.15. Subsection 4.4.2.8 of LGL (2014) provides more information on Atlantic Puffin occurrence and abundance in the Study Area.

Razorbill and Black Guillemot

Razorbill and Black Guillemot are expected to be common in the Study Area during May–October (see Table 4.14). Black Guillemot is expected to be common in nearshore areas off Labrador. 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. The number of breeding pairs for each species and their breeding locations are indicated in Table 4.15. Subsection 4.4.2.8 of LGL (2014) provides more information on Razorbill and Black Guillemot occurrences and abundances in the Study Area.

4.4.3 Prey and Foraging Habits

Seabirds in the Study Area employ a variety of foraging strategies and feed on a variety of prey species. The estimated submergence time (i.e., time with head underwater) and diving depth of various seabirds are provided in Table 4.16 in § 4.4.3 of LGL (2016).

More details regarding prey and foraging habits of seabirds likely to occur in the Study Area are provided in § 4.4.3 of LGL (2014).

4.4.4 Marine-associated Bird Data Gaps Identified in Relevant SEAs

The following data gap associated with the Marine-associated Bird VEC was identified in the Labrador Shelf SEA (§ 4.9.12 of C-NLOPB 2008).

- Many of the data related to marine-associated birds in Labrador are either dated or deficient.

The data gap indicated above has been partially addressed for continental shelf and slope waters. ECCC-CWS has published an on-line atlas of abundance and distribution in Atlantic Canada based on data collected from 2006–2016 (Bolduc et al. 2018), and this EA has been updated to reflect those data. Because few surveys have been conducted in the deep, basin waters, the certainty of impact predictions made in § 5.7.6 for that area is therefore limited. Opportunistic efforts are being made during geophysical surveys to collect more distribution and abundance data for seabirds.

4.5 Marine Mammals and Sea Turtles VEC

The Marine Mammal and Sea Turtle VEC of the Study Area has been described in the Labrador Shelf SEA (§ 4.9.1 to 4.9.7 of C-NLOPB 2008) and two project-specific EAs (§ 4.5 of LGL 2014, 2016). An overview of marine mammals and sea turtles that occur in the Study Area, based primarily on the aforementioned documents, is provided below. New information not included in the SEA and EAs is also summarized. DFO research and scientific documents and COSEWIC species assessment and status reports also served as primary sources of information on the occurrence, distribution, and abundance of marine mammals and sea turtles in the Study Area. Historical and more recent sightings of cetaceans and sea turtles within Newfoundland and Labrador waters have been compiled and made available by DFO in St. John's (§ 4.5.1.1). Marine mammal and sea turtle data gaps identified in the SEA are also discussed in terms of current status.

4.5.1 Marine Mammals

Twenty-five marine mammal species are known to occur near or within the Study Area, including 17 species of cetaceans (whales, dolphins, and porpoises), six species of phocids (true seals), the walrus, and the polar bear (Table 4.16). Most marine mammals use the area seasonally. The region likely represents important foraging habitat for many marine mammals.

Table 4.16 Marine Mammals with Reasonable Likelihood of Occurrence in the Study Area.

Species	Study Area		Habitat	SARA Status ^a	COSEWIC Status ^b
	Occurrence	Season			
<i>Baleen Whales (Mysticetes)</i>					
Bowhead Whale (<i>Balaena mysticetus</i>) Eastern Canada-West Greenland population	Rare ^c	Fall–spring	Ice- associated; coastal & shelf	NS	SC
Humpback Whale (<i>Megaptera novaeangliae</i>) Western North Atlantic population	Common	Year-round; mostly spring–fall	Coastal & banks	Schedule 3: Special Concern	NAR
Common Minke Whale (<i>Balaenoptera acutorostrata acutorostrata</i>) North Atlantic subspecies	Common	Year-round; mostly spring–fall	Coastal, shelf & banks	NS	NAR
Sei Whale (<i>Balaenoptera borealis</i>) Atlantic population	Uncommon	Summer–fall	Pelagic	NS	DD
Fin Whale (<i>Balaenoptera physalus</i>) Atlantic population	Common	Year-round; mostly spring–fall	Shelf breaks, banks & pelagic	Schedule 1: Special Concern	SC
Blue Whale (<i>Balaenoptera musculus</i>) Atlantic population	Rare	Year-round; mostly summer	Coastal & pelagic	Schedule 1: Endangered	E
<i>Toothed Whales (Odontocetes)</i>					
Sperm Whale (<i>Physeter macrocephalus</i>)	Common	Year-round; mostly spring–fall	Slope, canyons & pelagic	NS	NAR; MPC
Northern Bottlenose Whale (<i>Hyperoodon ampullatus</i>) Davis Strait-Baffin Bay- Labrador Sea population	Uncommon	Year-round?	Slope, canyons & pelagic	NS	SC
Beluga Whale (<i>Delphinapterus leucas</i>) St. Lawrence Estuary, Cumberland Sound, Eastern Hudson Bay, Western Hudson Bay, Eastern High Arctic-Baffin Bay, and Ungava Bay populations	Rare	Winter or Summer	Coastal & ice edge	Schedule 1: Endangered (SLE); Threatened (CS); NS ^c	E (SLE, EHB, UB); T (CS); SC (BB, WHB) _d
Sowerby’s Beaked Whale (<i>Mesoplodon bidens</i>)	Rare	Year-round?	Slope, canyons & pelagic	Schedule 1: Special Concern	SC
Short-beaked Common Dolphin (<i>Delphinus delphis</i>)	Uncommon	Summer–Fall	Shelf & pelagic	NS	NAR
White-beaked Dolphin (<i>Lagenorhynchus albirostris</i>)	Common	Year-round; mostly summer–fall	Shelf & pelagic	NS	NAR
Atlantic White-sided Dolphin (<i>Lagenorhynchus acutus</i>)	Common	Year-round; mostly summer–fall	Coastal & shelf	NS	NAR
Risso’s Dolphin (<i>Grampus griseus</i>)	Rare	Year-round?	Continental slope	NS	NAR

Species	Study Area		Habitat	SARA Status ^a	COSEWIC Status ^b
	Occurrence	Season			
Killer Whale (<i>Orcinus orca</i>) Northwest Atlantic/Eastern Arctic population	Uncommon	Year-round; mostly summer–fall	Coastal & pelagic	NS	SC
Long-finned Pilot Whale (<i>Globicephala melas</i>)	Common	Spring–fall	Shelf break, pelagic & slope	NS	NAR
Harbour Porpoise (<i>Phocoena phocoena phocoena</i>) Northwest Atlantic population	Uncommon	Year-round; mostly summer–fall	Coastal, shelf & pelagic	Schedule 2: Threatened	SC
Pinnipeds					
Harp Seal (<i>Pagophilus groenlandicus</i>)	Common	Year-round; mostly winter–spring	Pack ice & pelagic	NS	NC; LPC
Hooded Seal (<i>Cystophora cristata</i>)	Common	Year-round; mostly winter–spring	Pack ice & pelagic	NS	NAR; MPC
Grey Seal (<i>Halichoerus grypus</i>)	Rare	Summer?	Coastal & shelf	NS	NAR
Harbour Seal (<i>Phoca vitulina concolor</i>) Atlantic and Eastern Arctic subspecies	Uncommon	Year-round	Coastal	NS	NAR
Ringed Seal (<i>Phoca hispida</i>)	Common	Year-round; mostly winter–spring	Landfast ice with snow cover	NS	NAR
Bearded Seal (<i>Erignathus barbatus</i>)	Uncommon	Year-round	Coastal, shallow & ice edge	NS	DD;MPC
Atlantic Walrus (<i>Odobenus rosmarus rosmarus</i>) Central/Low Arctic population	Rare	Year-round?	Coastal, & shelf	NS	SC
Ursids					
Polar Bear (<i>Ursus maritimus</i>)	Uncommon	Winter–summer	Coastal & pack ice	Schedule 1: Special Concern	SC

Note:

^a Species designation under the *Species at Risk Act* (SARA website 2018); NS = No Status.

^b Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC website 2017); E = Endangered, SC = Special Concern, DD = Data Deficient, NAR = Not at Risk, NC = Not Considered, LPC = Low-priority Candidate, MPC = Mid-priority Candidate.

^c The St. Lawrence Estuary (SLE) population is listed as endangered under Schedule 1 of SARA, and the Cumberland Sound (CS) population is listed as threatened under Schedule 1 of SARA; the other populations have no status.

^d The St. Lawrence Estuary (SLE), Eastern Hudson Bay (EHB), and Ungava Bay populations (UB) are considered endangered by COSEWIC. The Cumberland Sound (CS) population is considered threatened. The Western Hudson Bay (WHB) and Eastern High Arctic-Baffin Bay (BB) populations are considered special concern.

^e Considered rare except during migration in and out of Hudson Strait.

Information on the occurrence, habitat, and conservation status for each of the marine mammal species that could occur near or within the Study Area is presented in Table 4.16. Six cetacean species that have been reported within or near the Study Area in the past (North Atlantic right whale, *Eubalaena glacialis*, pygmy sperm whale *Kogia breviceps*, false killer whale *Pseudorca crassidens*, Cuvier's beaked whale *Ziphius cavirostris*, common bottlenose dolphin *Tursiops*

truncatus, striped dolphin *Stenella coeruleoalba*) are considered unlikely to occur in the Study Area during the seismic program and are not discussed further.

4.5.1.1 DFO Sightings Database

A large database of cetacean and sea turtle sightings in Newfoundland and Labrador waters has been compiled from various sources by DFO in St. John's (J. Lawson, DFO Research Scientist, pers. comm., January 2017), and has been made available for the purposes of describing species sightings within the Study Area. These data have been opportunistically gathered and have no corresponding survey effort. Therefore, while these data can be used to indicate what species may occur in the Study Area, they cannot be used to reliably predict species abundance, distribution, or fine-scale habitat use in the area.

The caveats that should be considered when using data from the DFO sightings database were described in § 4.5.1.1 of LGL (2014).

Cetacean sightings in the Study Area which occurred within the temporal boundary of the Project (May–November) and which were compiled from the DFO sightings database (1947–2015) are summarized in Table 4.17. Sightings include baleen whales, large toothed whales, dolphins and porpoises.

Table 4.17 Cetacean Sightings in the Study Area during the Temporal Boundary of the Project (compiled from the DFO sightings database, 1947–2015).

Species	Number of Sightings	Number of Individuals	Months Sighted
<i>Mysticetes</i>			
Humpback Whale	622	4,773	May–Nov
Minke Whale	165	358	May–Nov
Sei Whale	105	206	Jul–Nov
Fin Whale	636	1,003	May–Nov
Sei/Fin Whale	6	18	Jul–Oct
Blue Whale	6	7	Jul–Sep
Unidentified Baleen Whale	33	51	Jul–Oct
<i>Odontocetes</i>			
Sperm Whale	186	601	May–Nov
Northern Bottlenose Whale	116	596	May–Nov
Sowerby's Beaked Whale	1	7	Nov
Beluga	4	34	Jul
White-beaked Dolphin	136	789	Jul, Aug, Oct, Nov
Atlantic White-sided Dolphin	45	291	Jul–Nov
Bottlenose Dolphin	1	1	Oct
Risso's Dolphin	20	36	Aug, Oct, Nov
Common Dolphin	25	133	Jul–Sep, Nov

Species	Number of Sightings	Number of Individuals	Months Sighted
Killer Whale	48	289	May–Nov
Long-finned Pilot Whale	220	4,678	May–Nov
Harbour Porpoise	40	93	Jul–Nov
Unidentified Dolphin	126	844	Jun–Nov
Unidentified Beaked Whale	1	2	Aug
Unidentified Small Whale	14	33	May, Aug, Oct, Nov
Other			
Unidentified Cetacean	15	43	Jul–Oct
Unidentified Large Whale	86	236	May–Nov

Note:

See § 4.3.1.1 for description of DFO sightings database and caveats associated with these data.

4.5.1.2 Baleen Whales (Mysticetes)

Six species of baleen whales are known to occur in the Study Area, three of which occur commonly (see Table 4.16). Given that the Atlantic population of blue whale has *endangered* status under Schedule 1 of SARA, it is described in § 4.6, Species at Risk. Although some individual baleen whales may be present in offshore waters of Newfoundland and Labrador year-round, most baleen whale species presumably migrate to lower latitudes during the winter months (C-NLOPB 2014).

Bowhead Whale (Eastern Canada-West Greenland Population)

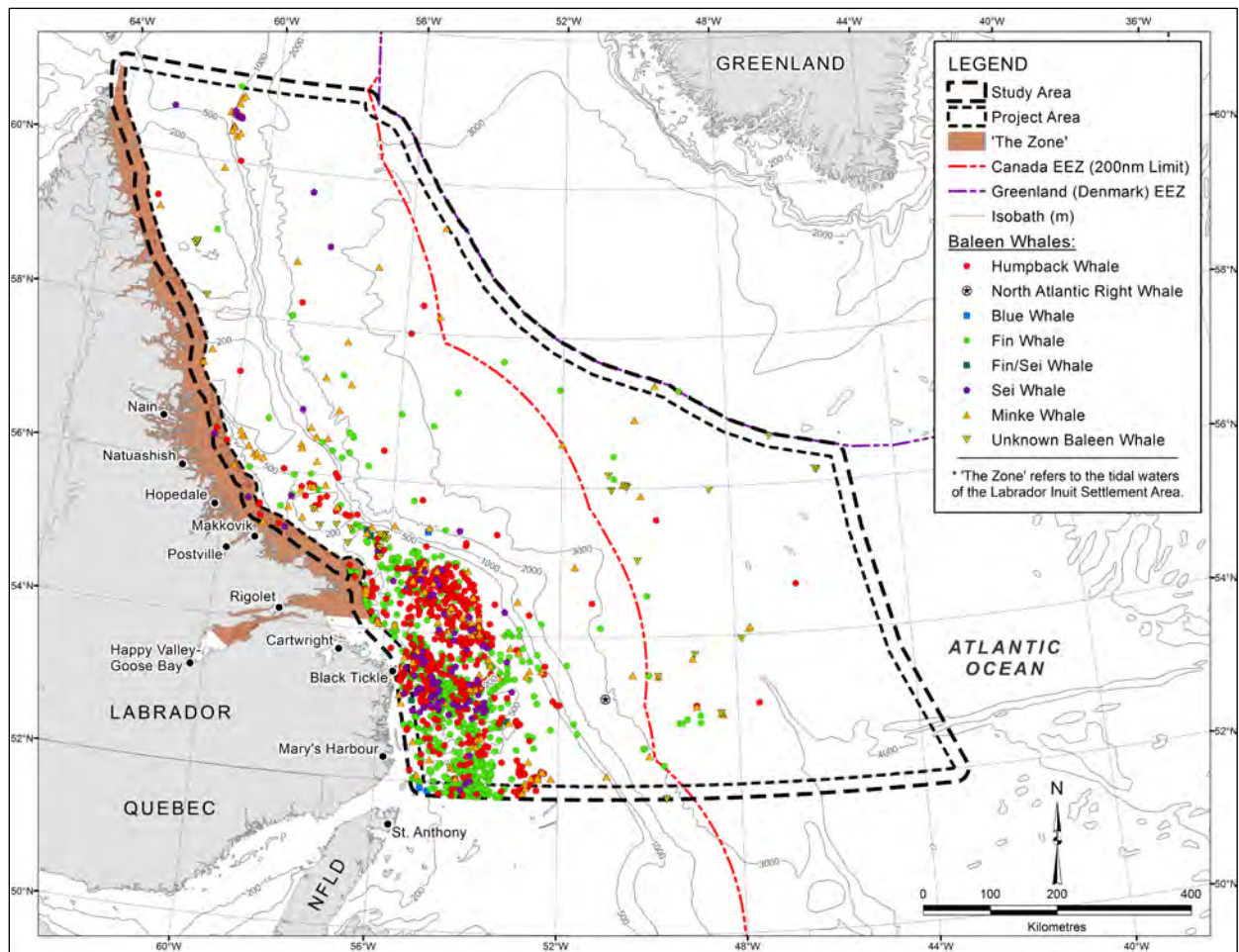
The Eastern Canada-West Greenland population of bowhead whale currently has *special concern* status under COSEWIC (COSEWIC 2009) but has no status under SARA. Bowhead whales from this population summer in the Canadian High Arctic and surrounding waters and winter in areas with unconsolidated pack ice including northern Hudson Bay, Hudson Strait, Davis Strait, and southern Baffin Bay (COSEWIC 2009). 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 2009). There are no records for the Study Area in the DFO sightings database; however, bowheads do occur in and near the northern portion of the Study Area, particularly when they migrate in and out of Hudson Strait.

Humpback Whale (Western North Atlantic Population)

The western North Atlantic population of the humpback whale currently has a *special concern* status under Schedule 3 of SARA (SARA website 2018). Humpbacks are one of the most commonly recorded mysticetes in the Study Area in the DFO sightings database (622 sightings; 4,773 individuals). While humpback sightings occur year-round, they are predominantly reported during August–November (see Table 4.17; Figure 4.33). Modeling by

Mannocci et al. (2017) for the summer months in the Study Area showed higher densities farther offshore than nearshore. Humpback whales are expected to be common in the Study Area.

The North Atlantic subspecies of the common minke whale is the third most commonly recorded mysticete in the Study Area in the DFO sightings database (165 sightings; 358 individuals), with most sightings recorded during July–October (see Table 4.17; Figure 4.33). One sighting was made near the southeastern-most edge of the Study Area in July 2012 (Ryan et al. 2013). Modeling by Mannocci et al. (2017) showed the highest year-round densities in the southern portion of the Study Area. Minke whales are considered common within the Study Area.



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

Figure 4.33 Baleen Whale Sightings in the Study Area during May–November (compiled from the DFO sightings database, 1947–2015).

Sei Whale (Atlantic Population)

Based on the DFO sightings database, there have been at least 105 sightings (206 individuals) of sei whales in the Study Area; sightings occurred mainly during September and October (see Table 4.17; Figure 4.33). Habitat-density modeling for the summer by Mannocci et al. (2017) showed that sei whales are likely to occur at similar densities throughout the Study Area. A 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, 2014). Sei whales are considered uncommon in the Study Area.

Fin Whale (Atlantic Population)

The Atlantic population of fin whale currently has a *special concern* status under Schedule 1 of SARA (SARA website 2018) and COSEWIC (COSEWIC 2005), and a management plan was released in 2017 (DFO 2017c). Delarue et al. (2014) suggested that there are four distinct stocks in the NW Atlantic based on geographic differences in fin whale calls.

Fin whales are one of the most commonly recorded mysticetes in the Study Area in the DFO sightings database (636 sightings; 1,003 individuals), with most sightings reported during July–November (see Table 4.17; Figure 4.33). According to Edwards et al. (2015), highest densities of fin whales occur in offshore waters off Newfoundland during June–August. Modeling by Mannocci et al. (2017) showed the highest year-round densities in the southern portion of the Study Area. Fin whales are expected to be common throughout the Study Area during late-spring to fall.

4.5.1.3 Toothed Whales (Odontocetes)

Eleven species of toothed whales are likely to occur in the Study Area (see Table 4.16), ranging from the largest, the sperm whale, to one of the smallest, the harbour porpoise. Several of these species only occur in the Study Area seasonally, but in general, there is little information about the distribution and abundance of these species.

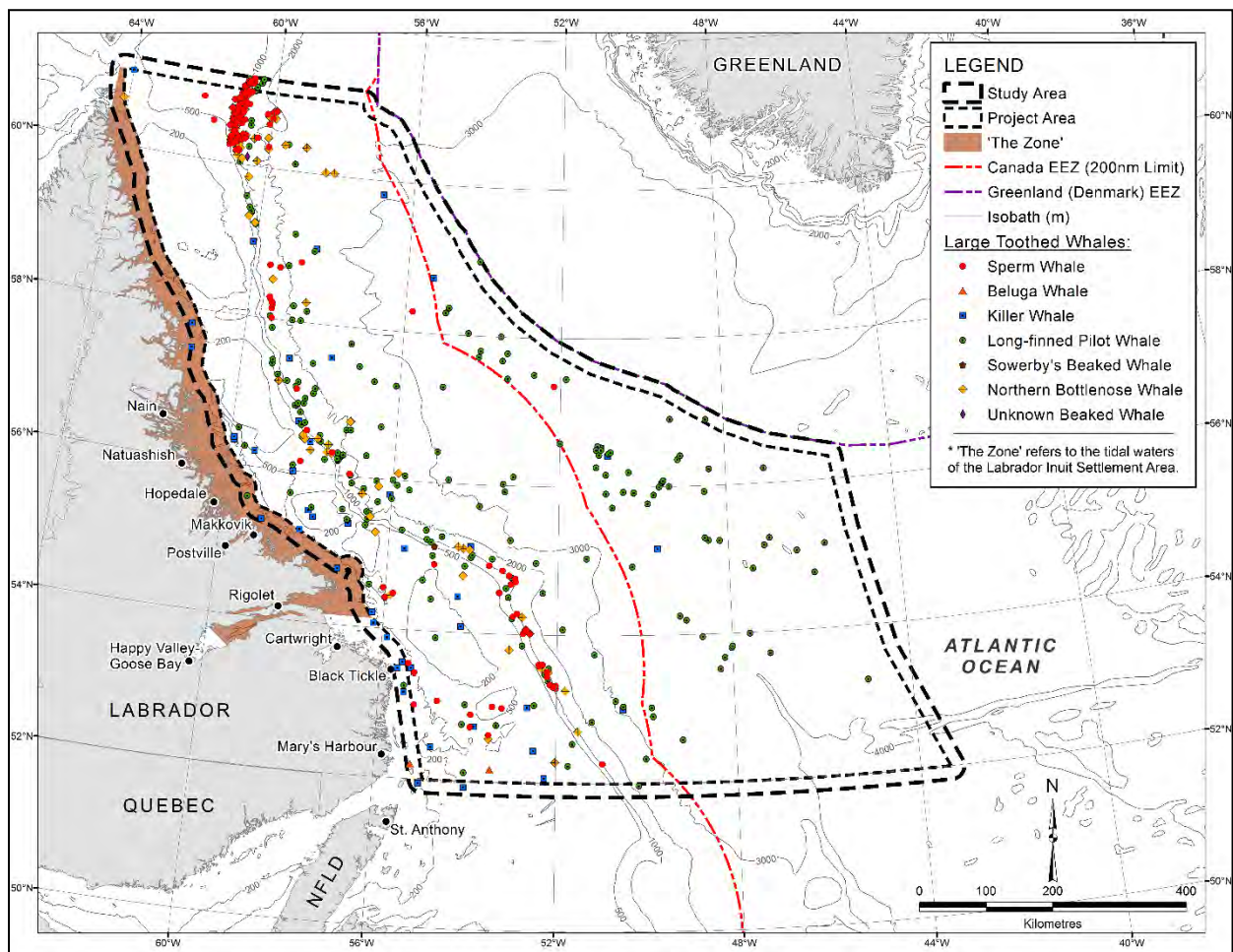
Two genetically distinct populations of northern bottlenose whales have been identified in Canada (Dalebout et al. 2006). Only the Davis Strait-Baffin Bay-Labrador Sea population of northern bottlenose whales is likely to occur in the Study Area; it has no status under SARA. The Scotian Shelf population of northern bottlenose whale has *endangered* status under Schedule 1 of SARA, but it is not expected to occur in the Study Area.

Based on distinct summer distributions and genetic isolation, seven populations of beluga are recognized in Canadian waters. The St. Lawrence Estuary population has *endangered* status

under Schedule 1 of SARA, and the Cumberland Sound population has *threatened* status under Schedule 1 of SARA; these populations are described in § 4.6, Species at Risk.

Sperm Whale

There are 186 sightings (601 individuals) of sperm whales in the Study Area in the DFO sightings database, with most records for June–October; however, sightings occur year-round (see Table 4.17; Figure 4.34). Mannocci et al. (2017) presented modeled year-round densities of sperm whales, with higher densities occurring in deep, offshore waters of the Study Area. Sperm whales are expected to be common in deep waters of the Study Area.



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

Figure 4.34 Toothed Whale Sightings in the Study Area during May–November (compiled from the DFO sightings database, 1947–2015).

Northern Bottlenose Whale (Davis Strait-Baffin Bay-Labrador Sea Population)

The Davis Strait-Baffin Bay-Labrador Sea population of northern bottlenose whale has no status under *SARA* (*SARA* website 2018) and *special concern* status under COSEWIC (COSEWIC 2011); there is no reliable population estimate. Northern bottlenose whales are expected to be uncommon in the Study Area (see Table 4.16 in § 4.5). There are 116 sightings (596 individuals) of northern bottlenose whales in the Study Area in the DFO sightings database. These sightings occurred primarily in the deeper waters and near the shelf break during June–August (see Table 4.17 and Figure 4.34).

Preliminary photo-ID work has found that at least 78 different animals occurred in the Grand Banks, Flemish Pass, and Flemish Cap area during 2016–2017 (L.J. Feyrer, Ph.D. Candidate, Dalhousie University, pers. comm., 5 February 2018). Although genetic and other tissue analyses are underway at Dalhousie University based on samples collected from some of those individuals, results are not yet available to elucidate whether animals in that area were from the Scotian Shelf or Davis Strait-Baffin Bay-Labrador Sea population (L.J. Feyrer, Ph.D. Candidate, Dalhousie University, pers. comm., 5 February 2018).

Beluga Whale (Populations without *SARA* status)

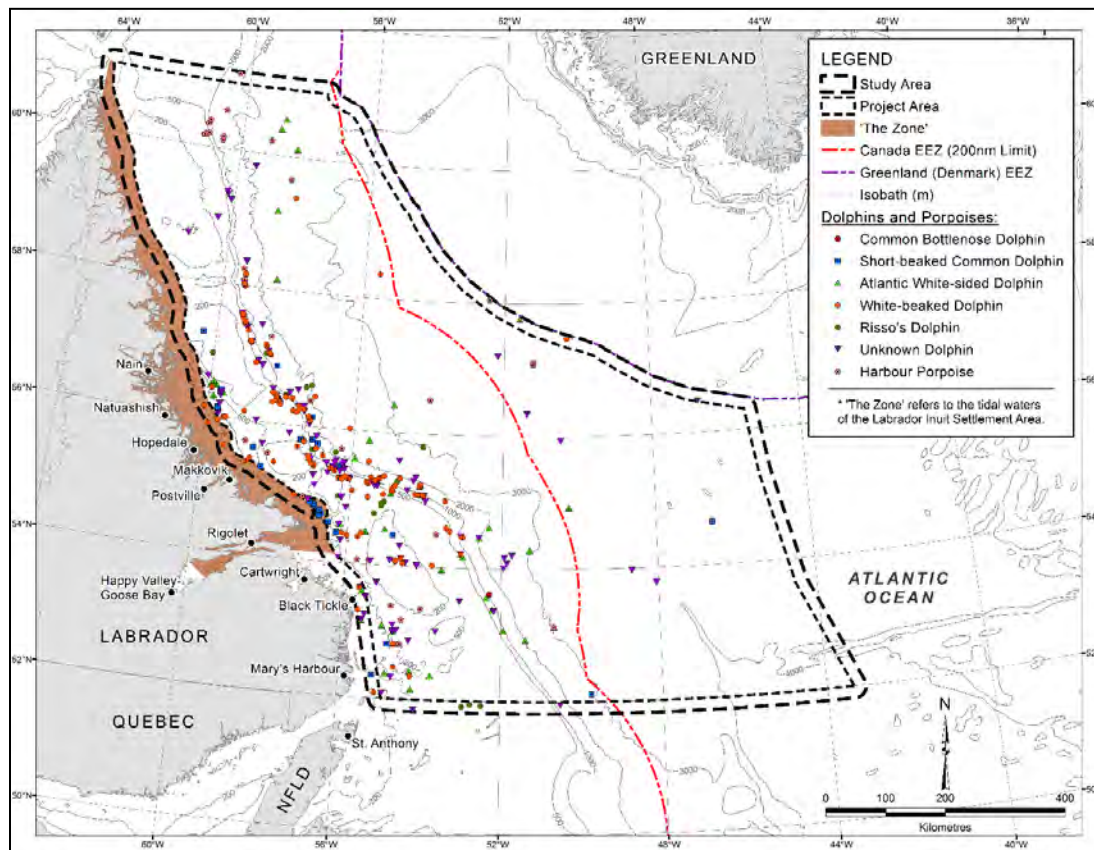
The Ungava Bay and Eastern Hudson Bay populations of beluga have no status under *SARA* (*SARA* website 2018) but have *endangered* status under COSEWIC (2004). The Western Hudson Bay and Eastern High Arctic-Baffin Bay populations also have no status under *SARA* (*SARA* website 2018) but are considered *special concern* under COSEWIC (2004). Beluga whales are considered rare in the Study Area. Beluga whales occurring offshore of Labrador likely represent either the Ungava Bay or the eastern Hudson Bay populations, although individuals from other populations, such as the St. Lawrence Estuary, might also occur there (COSEWIC 2004, 2014). Based on the DFO cetacean sightings database, there are four beluga sightings of 34 individuals during July in the Study Area (see Table 4.17; Figure 4.34).

Sowerby's Beaked Whale

Sowerby's beaked whale has a *special concern* status under Schedule 1 of *SARA* (*SARA* website 2018) and COSEWIC (COSEWIC 2006), and a management plan was released in 2017 (DFO 2017d). It is considered rare in the Study Area. There is one sighting of seven Sowerby's beaked whales in the Study Area in the DFO sightings database during November 2013 (see Table 4.17; Figure 4.34). There are also several stranding records for Newfoundland and Labrador (DFO 2017d).

Short-beaked Common Dolphin

Based on the DFO sightings database, there are 25 sightings (133 individuals) of short-beaked common dolphins in the Study Area, most occurred during July and August (see Table 4.17; Figure 4.35). Mannocci et al. (2017) presented modeled year-round densities of short-beaked common dolphins for Study Area, with higher densities in deep, offshore waters. The short-beaked common dolphin is expected to be uncommon in the Study Area.



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

Figure 4.35 Dolphin and Porpoise Sightings in the Study Area during May–November (compiled from the DFO sightings database, 1947–2015).

White-beaked Dolphin

Based on the DFO sightings database, there are 136 sightings (789 individuals) of white-beaked dolphins in the Study Area; most sightings occurred during August (see Table 4.17; Figure 4.35). The white-beaked dolphin is considered common in the Study Area. One sighting was made near the southeastern-most edge of the Study Area during July 2012 (Ryan et al. 2013). Two rare sightings in high latitudes of the Canadian Arctic off south-eastern Baffin Island, Nunavut, have also been reported (Reinhart et al. 2014).

Atlantic White-sided Dolphin

Based on the DFO sightings database, there are 45 sightings (291 individuals) of Atlantic white-sided dolphins in the Study Area. Sightings occurred primarily during August and September (see Table 4.17; Figure 4.35). Based on modeling by Mannocci et al. (2017), Atlantic white-sided dolphins are expected to occur throughout the Study Area. The Atlantic white-sided dolphin is considered common in the Study Area.

Risso's Dolphin

There are 20 sightings (36 individuals) of Risso's dolphins in the Study Area in the DFO sightings database; sightings occurred during August, October, and November (see Table 4.17; Figure 4.35). Jefferson et al. (2014) also reported on the occurrence of Risso's dolphins off Newfoundland and Labrador. Mannocci et al. (2017) predicted the highest densities in the Study Area along the shelf break. Risso's dolphins are considered rare in the Study Area.

Killer Whale (Northwest Atlantic/Eastern Arctic Population)

Based on the DFO sightings database, there are 48 sightings (289 individuals) of killer whales in the Study Area (see Table 4.17; Figure 4.34). Most sightings off Labrador occurred during July–October (see Table 4.17). The Labrador/Strait of Belle Isle appears to be a hotspot for killer whales in the Study Area (Lawson and Stevens 2013). High scarring rates on humpback whales indicate that killer whales may preferentially feed on marine mammals off Newfoundland (McCordic et al. 2014). Killer whales are considered uncommon in the Study Area.

Long-finned Pilot Whale

Long-finned pilot whales are the most commonly recorded odontocete (220 sightings; 4,678 individuals) in the Study Area in the DFO sightings database (see Table 4.17; Figure 4.34); sightings have been reported year-round but predominantly during July and August. Long-finned pilot whales are considered common in the Study Area. Mannocci et al. (2017) modeled year-round densities of pilot whales off Newfoundland and Labrador, showing the highest densities in deeper, offshore areas.

Harbour Porpoise (Northwest Atlantic Population)

Based on the DFO sightings database, there are 40 recorded sightings (93 individuals) of harbour porpoises in the Study Area. While sightings are reported year-round, the majority occurred during August (see Table 4.17; Figure 4.35). Harbour porpoises are generally considered uncommon in the offshore regions, although Mannocci et al. (2017) reported relatively high densities in offshore and nearshore waters of the Study Area. In addition, harbour porpoises

were detected acoustically near the southeastern-most edge of the Study Area during July 2012 (Ryan et al. 2013).

4.5.1.4 Pinnipeds

Seven pinniped species could occur in the Study Area, including the Atlantic walrus and six phocids (see Table 4.16).

Atlantic Walrus (Central/Low Arctic Population)

The Nova Scotia-Newfoundland-Gulf of St. Lawrence population of Atlantic walrus is considered extinct (COSEWIC 2017). The High Arctic and Central/Low Arctic populations are designated as *special concern* under COSEWIC, but only the Central/Low Arctic population could occur within the nearshore waters of the northern-most region of the Study Area (COSEWIC 2017). Atlantic walrus are considered rare south of Hebron-Okak Bay on the Labrador coast (COSEWIC 2017).

True Seals (Phocids)

Hooded seals are likely to be most common in the Study Area during spring and fall. During spring and late-fall/winter, hooded seals outfitted with satellite relay data loggers showed movements throughout the Study Area during 2004–2008 (Andersen et al. 2012, 2013, 2014). Andersen et al. (2012) suggested that hooded seals prefer areas with topographic and oceanographic conditions off the coast of Newfoundland and Labrador that produce good feeding conditions. During autumn/winter, males showed greater search effort in areas with complex seabed relief, including near the Flemish Cap; whereas females spent more effort along the Labrador Shelf.

Harp seals are common during spring off northeast Newfoundland and southern Labrador where they congregate to breed and pup on the pack ice. Harp seals migrate to Arctic and Greenland waters during summer, but some harp seals remain in southern waters (DFO 2012a). The NW Atlantic harp seal population which occurs off Labrador appears to have leveled off since 2008 at ~7.4 million (Hammill et al. 2015). Declines in sea ice associated with climate change may cause harp seals to use whelping areas farther to the north (Stenson and Hammill 2014). Ringed seals are also likely to be common within the Study Area.

Given their preference for nearshore areas, the grey seal and the Atlantic and Eastern Arctic subspecies of the harbour seal are likely to be rare and uncommon in the Study Area, respectively. The 2014 grey seal population was estimated at 505,000 individuals (Hammill et al. 2014). The 2012 estimate for harbour seals in New England was 75,834 individuals (Waring et al. 2015). Bearded seals are likely to be uncommon within the Study Area.

4.5.1.5 Polar Bear

Polar bears have *special concern* status under Schedule 1 of SARA (SARA website 2018) and COSEWIC (COSEWIC 2008). However, a management plan for this species will not be available until sometime in 2018 (DFO 2016f; ECCC 2018). The size of the Davis Strait population of polar bears was estimated at 2,158 for 2007 (Peacock et al. 2013). Polar bears have been reported along the northeastern tip of Labrador between 2000 and 2010 (Rode et al. 2012). Peacock et al. (2013) also reported polar bear records for Labrador, including the Study Area.

4.5.2 Sea Turtles

Sea turtles are uncommon in the Labrador Sea, but two species could occur in the Study Area. Information on the occurrence, habitat, and conservation status for the leatherback and loggerhead sea turtles in the Study Area is presented in Table 4.18. The leatherback and loggerhead sea turtles have an *endangered* status under Schedule 1 of SARA and are included in § 4.6, Species at Risk. Based on the DFO sightings database, there have been no records of sea turtle sightings in the Study Area.

Table 4.18 Sea Turtles with Reasonable Likelihood of Occurrence in the Study Area.

Species	Study Area		Habitat	SARA Status ^a	COSEWIC Status ^b
	Occurrence	Season			
Leatherback Sea Turtle (<i>Dermochelys coriacea</i>) Atlantic population	Rare	April–December	Shelf & pelagic	Schedule 1: Endangered	E
Loggerhead Sea Turtle (<i>Caretta caretta</i>)	Rare	Summer and fall	Pelagic	Schedule 1: Endangered	E

Note:

^a Species designation under the *Species at Risk Act* (SARA website 2018); NS = No Status.

^b Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC website 2017); E = Endangered.

4.5.3 Marine Mammal and Sea Turtle Data Gaps Identified in Relevant SEAs

The following data gap associated with the Marine Mammal and Sea Turtle VEC was identified in the Labrador Shelf SEA (§ 4.9.6 of C-NLOPB 2008).

- Distribution and abundance of marine mammals and sea turtles that occur in Labrador waters.

The data gap indicated above still exists and thus limits the certainty of impact predictions made in § 5.7.7. However, opportunistic efforts are being made during seismic surveys to collect more distribution and abundance data for marine mammals and sea turtles. More specifically, during periods of daylight, MMOs are required to be on watch during the 30-minute pre-ramp up watch

and during all periods while airguns are active. During seismic monitoring programs, MMOs will also conduct systematic watches during periods when the airguns are inactive. All marine mammal and sea turtle data are summarized in a data report and included in an Excel spreadsheet; this information is then submitted to the C-NLOPB. It is the proponent's understanding that the C-NLOPB then forwards the data and report to DFO each year.

4.6 Species at Risk VEC

The Species at Risk VEC has been described in the Labrador Shelf SEA (§ 4.2 and 4.3 C-NLOPB 2008) and two project-specific EA (§ 4.6 of LGL 2014, 2016). An overview of the species at risk of the Study Area, based on information from the aforementioned SEA and EAs, along with new information, is provided below. Relevant data gaps identified in the SEA are also discussed in terms of current status.

4.6.1 Species at Risk within the Study Area

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/populations by COSEWIC) and June 2004 (e.g., prohibitions against harming or harassing species/populations with either endangered and threatened status or damaging or destroying their critical habitat). Species/populations are listed under SARA on Schedules 1 to 3, with only those with either an *endangered* or *threatened* status under Schedule 1 having immediate legal implications. Schedule 1 is the official list of wildlife species/populations at risk in Canada. Once a species/population is designated, the measures to protect and recover that species/population are implemented. Two fish species/populations, three marine-associated bird species/subspecies, three cetacean species/populations, and two sea turtle species that have potential to occur in the Study Area are legally protected under SARA (Table 4.19). In addition, one fish species, three bird species/populations, and three marine mammal species/populations have a *special concern* status under Schedule 1 of SARA (Table 4.19). Schedules 2 and 3 of SARA identify species that have “at risk” status under COSEWIC prior to October 1999 and must be reassessed using revised criteria before they can be considered for addition to Schedule 1 of SARA. Species/populations that potentially occur in the Study Area and are considered at risk but have not received specific legal protection (i.e., prescribed penalties and legal requirement for recovery strategies and plans) under SARA are also listed in Table 4.19, as are species/populations with *endangered*, *threatened* or *special concern* status under COSEWIC.

Under SARA, a ‘recovery strategy’ and corresponding ‘action plan’ must be prepared for *endangered*, *threatened* and *extirpated* species/populations. A ‘management plan’ must be prepared for species/populations with *special concern* status. Final recovery strategies have been prepared for seven species/populations currently with *endangered* or *threatened* status under Schedule 1 and the potential to occur in the Study Area: (1) the northern wolffish (Kulka et al. 2007); (2) the spotted wolffish (Kulka et al. 2007); (3) the Ivory Gull (ECCC 2014);

(4) the Red Knot (ECCC 2017a); (5) the blue whale (Beauchamp et al. 2009); (6) the St. Lawrence Estuary population of beluga (DFO 2012b); and (7) the leatherback sea turtle (ALTRT 2006). A management plan has been prepared for the Atlantic wolffish (Kulka et al. 2007), Red Knot (ECCC 2017a), fin whale (DFO 2017c), and Sowerby's beaked whale (DFO 2017d). A proposed management plan for the polar bear is expected to be available in 2018 (DFO 2016f; ECCC 2018).

During 2016–2017, DFO planned to develop and post action plans for blue whale (Atlantic population), leatherback sea turtle (Atlantic population), and northern and spotted wolffish (DFO 2016f). However, these are not yet available.

MKI will monitor SARA issues through the Canadian Association of Petroleum Producers (CAPP), the law gazettes, the Internet and communication with DFO and ECCC, and will adaptively manage any issues that may arise in the future. MKI will comply with relevant regulations pertaining to SARA Recovery Strategies and Action Plans.

MKI acknowledges the possibility of other marine species/populations receiving *endangered* or *threatened* status under Schedule 1 of SARA during the course of the Project.

4.6.2 Profiles of Marine Species/Populations with *Endangered* or *Threatened* Status under Schedule 1 of SARA

The status of all species/populations profiled below are current as of May 2018.

4.6.2.1 Fishes

Two fish species/populations have an *endangered* or *threatened* status under Schedule 1 of the SARA: (1) northern wolffish; and (2) spotted wolffish. These three species are profiled in this section. Some of the other fish species/populations that are included in Table 4.19 below (e.g., Atlantic wolffish, Atlantic cod) are profiled in § 4.2 of this EA.

Northern and Spotted Wolffishes

Northern and spotted wolffishes currently have a *threatened* status under both Schedule 1 of SARA and COSEWIC. Profiles of these species are provided in § 4.6.1 of LGL (2014).

During DFO RV surveys conducted in the Study Area during May–November 2014, northern wolffish and spotted wolffish were caught primarily offshore central and southern Labrador, within water depths <1,000 m (see Figure 4.30 in § 4.3.7).

Table 4.19 SARA- and COSEWIC-listed Marine Species with Reasonable Likelihood of Occurrence in the Study Area.

SPECIES		SARA ^a			COSEWIC ^b		
Common Name	Scientific Name	Endangered	Threatened	Special Concern	Endangered	Threatened	Special Concern
Marine Fish							
Northern Wolffish	<i>Anarhichas denticulatus</i>		Schedule 1			X	
Spotted Wolffish	<i>Anarhichas minor</i>		Schedule 1			X	
Atlantic Wolffish	<i>Anarhichas lupus</i>			Schedule 1			X
Atlantic Cod	<i>Gadus morhua</i>			Schedule 3			
Atlantic Cod (Newfoundland and Labrador population)	<i>G. morhua</i>				X		
Atlantic Bluefin Tuna	<i>Thunnus thynnus</i>				X		
Porbeagle Shark	<i>Lamna nasus</i>				X		
Roundnose Grenadier	<i>Coryphaenoides rupestris</i>				X		
Cusk	<i>Brosme brosme</i>				X		
Smooth Skate (Funk Island Deep population)	<i>Malacoraja senta</i>				X		
Winter Skate (Eastern Scotian Shelf-Newfoundland population)	<i>Leucoraja ocellata</i>				X		
Atlantic Salmon (Anticosti Island population) (Eastern Cape Breton population) (Nova Scotia Southern Upland population) (Outer Bay of Fundy population)	<i>Salmo salar</i>				X		
American Eel	<i>Anguilla rostrata</i>					X	
American Plaice (Newfoundland and Labrador population)	<i>Hippoglossoides platessoides</i>					X	
Atlantic Salmon (South Newfoundland population)	<i>S. salar</i>					X	
Acadian Redfish (Atlantic population)	<i>Sebastes fasciatus</i>					X	
Deepwater Redfish (Northern population)	<i>S. mentella</i>					X	
White Hake (Atlantic and Northern Gulf of St. Lawrence population)	<i>Urophycis tenuis</i>					X	
Lumpfish	<i>Cyclopterus lumpus</i>					X	
Atlantic Salmon (Quebec Eastern North Shore population) (Quebec Western North Shore population) (Inner St. Lawrence population) (Gaspé-Southern Gulf of St. Lawrence population)	<i>S. salar</i>						X
Shortfin Mako Shark (Atlantic population)	<i>Isurus oxyrinchus</i>						X
Basking Shark (Atlantic population)	<i>Cetorhinus maximus</i>						X
Spiny Dogfish (Atlantic population)	<i>Squalus acanthias</i>						X

SPECIES		SARA ^a			COSEWIC ^b		
Common Name	Scientific Name	Endangered	Threatened	Special Concern	Endangered	Threatened	Special Concern
Roughhead Grenadier	<i>Macrourus berglax</i>						X
Thorny Skate	<i>Amblyraja radiata</i>						X
Marine-associated Birds							
Ivory Gull	<i>Pagophila eburnea</i>	Schedule 1			X		
Red Knot <i>rufa</i> subspecies	<i>Calidris canutus rufa</i>	Schedule 1			X		
Buff-breasted Sandpiper	<i>Tryngites subruficollis</i>			Schedule 1			X
Harlequin Duck (Eastern population)	<i>Histrionicus histrionicus</i>			Schedule 1			X
Barrow's Goldeneye (Eastern population)	<i>Bucephala islandica</i>			Schedule 1			X
Ross's Gull	<i>Rhodostethia rosea</i>		Schedule 1			X	
Marine Mammals							
Blue Whale (Atlantic population)	<i>Balaenoptera musculus</i>	Schedule 1			X		
Beluga Whale (St. Lawrence Estuary population)	<i>Delphinapterus leucas</i>	Schedule 1			X		
Beluga Whale (Cumberland Sound population)	<i>D. leucas</i>		Schedule 1			X	
Fin Whale (Atlantic population)	<i>B. physalus</i>			Schedule 1			X
Sowerby's Beaked Whale	<i>Mesoplodon bidens</i>			Schedule 1			X
Polar Bear	<i>Ursus maritimus</i>			Schedule 1			X
Harbour Porpoise (Northwest Atlantic population)	<i>Phocoena phocoena</i>		Schedule 2				X
Humpback Whale (Western North Atlantic population)	<i>Megaptera novaeangliae</i>			Schedule 3			
Beluga Whale (Eastern Hudson Bay population)	<i>D. leucas</i>				X		
Beluga Whale (Ungava population)	<i>D. leucas</i>				X		
Beluga Whale (Eastern High Arctic-Baffin Bay population)	<i>D. leucas</i>						X
Beluga Whale (Western Hudson Bay)	<i>D. leucas</i>						X
Killer Whale (Northwest Atlantic/Eastern Arctic populations)	<i>Orcinus orca</i>						X
Northern Bottlenose Whale (Davis Strait-Baffin Bay-Labrador Sea population)	<i>Hyperoodon ampullatus</i>						X
Atlantic Walrus (Central/Low Arctic population)	<i>Odobenus rosmarus rosmarus</i>						X
Sea Turtles							
Leatherback Sea Turtle (Atlantic population)	<i>Dermochelys coriacea</i>	Schedule 1			X		
Loggerhead Sea Turtle	<i>Caretta caretta</i>	Schedule 1			X		

Source: ^aSARA website (http://www.sararegistry.gc.ca/sar/index/default_e.cfm), accessed May 2018; ^bCOSEWIC website (<https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife.html>), accessed May 2018.

4.6.2.2 Marine-associated Birds

Three marine-associated birds have an *endangered* status under Schedule 1 of SARA: (1) Ivory Gull, (2) Ross's Gull, and (3) Red Knot. These species are considered in this section. The Harlequin Duck (eastern population) and Barrow's Goldeneye (eastern population) are profiled in § 4.4.2.1 of LGL (2016).

Ivory Gull

The Ivory Gull currently has an *endangered* status under Schedule 1 of SARA and COSEWIC and is profiled in § 4.2.9 in C-NLOPB (2008) and in § 4.6 of LGL (2014, 2016).

Ross's Gull

Ross's Gull currently has an *endangered* status under Schedule 1 of SARA and COSEWIC. It nests primarily in northeastern Siberia, but also in smaller numbers in the Canadian Arctic and Greenland (Burger et al. 2018). Most members of this species probably winter in Arctic and sub-Arctic Europe and Asia at the edge of the sea ice. Individuals nesting in the Canadian Arctic that have been tagged with geolocators and satellite transmitters have been tracked to a wintering area that reaches from the Labrador Sea to Orphan Basin (Maftei et al. 2015). As a result, this species is expected to be present in very small numbers in the Study Area.

Red Knot

The Red Knot currently has an *endangered* status under both Schedule 1 of SARA and COSEWIC. This species at risk is profiled in § 4.3.1 of C-NLOPB (2008).

4.6.2.3 Marine Mammals and Sea Turtles

Three marine mammal species/populations and two sea turtle species/populations that have some likelihood of occurrence in the Study Area have either *endangered* or *threatened* status under Schedule 1 of SARA: (1) blue whale (Atlantic population); (2) beluga whale (St. Lawrence Estuary population); (3) beluga whale (Cumberland Sound population); (4) leatherback sea turtle; and (5) loggerhead sea turtle. Profiles of these species are provided in this section. Some of the other marine mammal and sea turtle species/populations that are included in Table 4.19 above (e.g., Atlantic population of fin whale, Sowerby's beaked whale, polar bear) are profiled in § 4.5 of this EA.

Blue Whale (Atlantic Population)

The Atlantic population of blue whale currently has an *endangered* status under Schedule 1 of SARA and COSEWIC. This population is profiled in § 4.6.1.3 of LGL (2014). There are 6

sightings of 7 individual blue whales in the Study Area in the DFO sightings database. Blue whales were observed during summer within the Study Area in the DFO sightings database (see Table 4.17 in § 4.5). Lesage et al. (2016) suggested that underwater seamounts and the deep ocean structures along the shelf edge may be important habitat for blue whales. Blue whales are considered rare in the Study Area (see Table 4.16 in § 4.5).

Beluga Whale (St. Lawrence Estuary Population)

Based on distinct summer distributions and genetic isolation, seven populations of beluga are recognized in Canadian waters. The St. Lawrence Estuary population has *endangered* status under Schedule 1 of SARA (SARA website 2018) and COSEWIC (COSEWIC 2014). The beluga whale is profiled in § 4.6.1.3 of LGL (2014). Beluga whales are considered rare in the Study Area.

It is uncertain what population individuals are from that occur offshore Labrador (COSEWIC 2004, 2014). Beluga occurring offshore of Labrador could represent the St. Lawrence Estuary population, although it is generally thought that individuals from this population make more limited winter movements (COSEWIC 2014). Based on the DFO cetacean sightings database, there were four beluga sightings of 34 individuals during July in the Study Area (see Table 4.17; Figure 4.34).

Beluga Whale (Cumberland Sound Population)

The Cumberland Sound population has *threatened* status under Schedule 1 of SARA (SARA website 2018) and COSEWIC (COSEWIC 2004). Beluga whales are considered rare in the Study Area. It is uncertain what population individuals are from that occur offshore Labrador (COSEWIC 2004, 2014). Although unlikely, it is possible that individuals sighted off Labrador could be from the Cumberland Sound population (C-NLOPB 2008). As noted above, there have been four beluga sightings of 34 individuals during July in the Study Area as recorded in the DFO database (see Table 4.17; Figure 4.34).

Leatherback Sea Turtle (Atlantic Population)

The leatherback sea turtle currently has an *endangered* status under Schedule 1 of SARA. Additionally, the Atlantic population of leatherbacks currently has an *endangered* status under COSEWIC. This species/population of leatherback sea turtle is profiled in § 4.6.1.3 of LGL (2014).

Leatherback sea turtles are considered rare in the Study Area (see Table 4.18 in § 4.5). There are no sightings of leatherback turtles within the Study Area in the DFO sightings database. Recent efforts in Atlantic Canadian waters have yielded new insight into the foraging and movements of leatherback sea turtles using both satellite telemetry and camera tags, providing footage of

leatherbacks searching for, capturing and handling their prey (from the turtle's perspective). This footage revealed that this species finds its prey by entirely visual means and feeds only during daylight hours, predominantly within the top 30 m of the water column (DFO 2016g).

Loggerhead Sea Turtle

The loggerhead sea turtle currently has an *endangered* status under Schedule 1 of SARA. Additionally, the loggerhead turtle has an *endangered* status under COSEWIC. This species is profiled in § 4.5.2 of LGL (2014). There are no records of loggerhead turtles in the Study Area in the DFO sightings database. Loggerhead turtles are likely to be rare in the Study Area (see Table 4.18 in § 4.5).

4.6.3 Data Gaps associated with the Species at Risk VEC

The following data gaps associated with the Species at Risk VEC were identified in the Labrador Shelf SEA (§ 4.2.12 and § 4.3.10 of C-NLOPB 2008):

- Species range, seasonal distribution and stock structure/population size;
- Migration routes, breeding grounds, feeding areas and overall life history/ecology for marine mammals, leatherback turtles, wolffishes and birds;
- Identification of critical habitat, behaviour of critical life stages and effects of ongoing human activities on species and their habitat are data deficient;
- Mortality rates, including ship strikes for whales; and
- Impacts of climate.

All of the above data gaps still exist. Any new information that has been made available since the SEA was completed and for areas that were beyond the scope of the SEA is noted throughout § 4.2, 4.4 and 4.5.

These data gaps limit the assessment of potential interactions between the Project and the Species at Risk VEC until updated species distributional information is available and there is an improved understanding of essential behaviour(s) and reaction to sound exposure. MKI will revise assessments as needed if new data become available and will incorporate any necessary revisions into future EA Updates.

4.7 Sensitive Areas VEC

The Sensitive Areas VEC of the Study Area has been described in the Labrador Shelf SEA (§ 4.11 of C-NLOPB 2008) and two project-specific EA (§ 4.7 of LGL 2014, 2016). An overview of the sensitive areas of the Study Area, based on information from the aforementioned SEA and EAs along with new information, is provided below; sensitive areas listed but not

otherwise described below were previously described in the aforementioned SEA and EAs. Relevant data gaps identified in the SEA are also discussed in terms of current status.

4.7.1 Sensitive Areas associated with the Study Area

Sensitive areas which occur either entirely or partially within the Study Area are as follows (Figure 4.36):

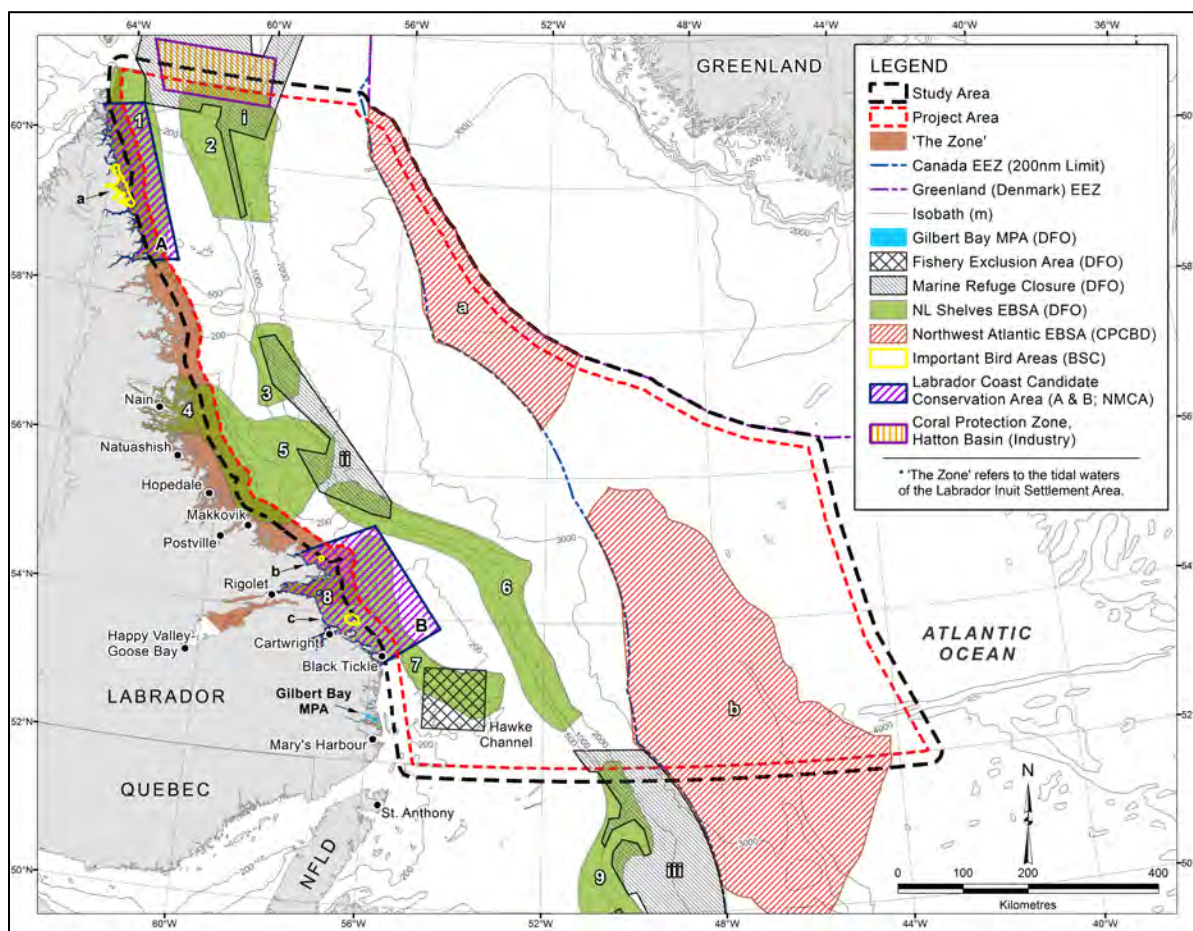


Figure 4.36 Location of Sensitive Areas that Overlap the MKI Study Area.

- Nine NL Shelves Bioregion Ecologically and Biologically Significant Areas (EBSAs): (1) Northern Labrador; (2) Outer Shelf Saglek Bank; (3) Outer Shelf Nain Bank; (4) Nain Area; (5) Hopedale Saddle; (6) Labrador Slope; (7) Labrador Marginal Trough; (8) Hamilton Inlet; and (9) Orphan Spur;
- Two Conference of the Parties to the Convention on Biological Diversity (CPCBD) EBSAs: (A) Labrador Sea Deep Convection Area; and (B) Seabird Foraging Zone in the Southern Labrador Sea;

- Three Marine Refuges: Hatton Basin Conservation Area; Hopedale Saddle Closure; and Northeast Newfoundland Slope Closure;
- One Fishery Exclusion Area: Hawke Channel (also a marine refuge);
- Two candidate National Marine Conservation Areas: Labrador Coast A (northernmost area) and B (southernmost area);
- Coral protection zone off northern Labrador that was established voluntarily by the fishing industry;
- ‘The Zone’;
- Three Important Bird Areas (IBAs): (a) Seven Islands Bay; (b) Quaker Hat Island; and (c) Gannet Islands;
- Gannet Islands Ecological Reserve; and
- One Marine Protected Area (MPA): Gilbert Bay.

The Convention on Biological Diversity (CBD) is an initiative of the United Nations that entered into force in 1993 to support the world’s growing commitment to sustainable development. The first session of the Conference of the Parties of the CBD (CPCBD) occurred in 1994 (CBD 2018). The CPCBD has provided guidance and support for the identification of EBSAs beyond Canada’s EEZ in the Northwest Atlantic. Two CPCBD EBSAs occur within or partially within the Study Area, as noted in the bulleted list above. The Labrador Sea Deep Convection Area is within the northeastern portion of the Study Area. The Labrador Sea is the only site in the Northwest Atlantic where deep winter convection transports seawater constituents, such as carbon dioxide, oxygen and organic carbon, from surficial to deep waters (CBD 2018). This EBSA serves as a mid-water overwintering refuge for pre-adult copepods, *C. finmarchicus*, a keystone zooplankton species for populations on the Labrador Shelf and areas further downstream (CBD 2018). The extent and intensity of deep-sea convection varies inter-annually within this EBSA. Ongoing warming and freshening of subpolar surface waters will likely lead to weaker overall convection, which may result in the propagation of ecological changes throughout the ecosystems of the Northwest Atlantic (CBD 2018). The Seabird Foraging Zone in the Southern Labrador Sea is partially within the southeast portion of the Study Area. This EBSA is important foraging habitat for seabirds, including overwintering Black-legged Kittiwake and Thick-billed Murre, and for breeding Leach’s Storm-petrels (CBD 2018).

DFO utilizes a variety of area-based conservation management measures in Canadian waters, including delineating areas determined to provide marine refuge to fish, mammals and their habitat (DFO 2018c). Bottom-contact fishing activities are prohibited within marine refuges, as are other human activities that are incompatible with the conservation of the refuges’ ecological components of interest (DFO 2018c). Four DFO marine refuges are partially or entirely within the Study Area, as noted in the bulleted list above. The Hawke Channel Marine Refuge is equivalent to the DFO Fishery Exclusion Area of the same name, which was previously described and not discussed further here. The three remaining marine refuges are described below.

The Hatton Basin Conservation Area Marine Refuge has an area of approximately 42,459 km² and has the objective of conserving sensitive benthic areas, particularly cold-water corals and sponges (DFO 2018c). It is located partially within the northernmost portion of the Study Area, and overlaps portions of the Outer Shelf Saglék Bank and Northern Labrador NL Shelves Bioregion EBSAs and the voluntary coral protection zone established by the fishing industry. Significant concentrations of small and large gorgonian corals, sponges, black coral, stony coral and hydrocoral are protected within this Area, along with benthic marine species, many of which utilize the structural habitat for spawning, breeding or nurseries (DFO 2018c). This Area is also the only known overwintering area for northern Hudson Bay narwhal, and serves as important habitat for other marine mammals and high densities of seabirds, including the *endangered* Ivory Gull (DFO 2018c).

The Hopedale Saddle Closure Marine Refuge is entirely located within the central-western portion of the Study Area, overlapping the Outer Shelf Nain Bank, Hopedale Saddle and Labrador Slope NL Shelves Bioregion EBSAs. The goal of this ~15,412 km² Marine Refuge is to protect corals and sponges and contribute to long-term biodiversity conservation (DFO 2018c). This Refuge is an important overwintering area for the *endangered* Eastern Hudson Bay population of beluga along with several other species at risk, and high biological diversity (DFO 2018c).

The Northeast Newfoundland Slope Closure Marine Refuge is partially within the central-southern portion of the Study Area, within the Canadian EEZ and partially overlapping the Orphan Spur NL Shelves Bioregion EBSA. This ~46,833 km² Marine Refuge is intended to protect corals and sponges and contribute to the long-term conservation of biodiversity (DFO 2018c). The bounding coordinates for the Marine Refuge were announced 22 December 2017 and came into effect 1 January 2018 (DFO 2017e).

National Marine Conservation Areas (NMCAs) are marine areas managed for sustainable use and contain smaller zones of high protection, including the seabed, water column and aquatic species therein (Parks Canada 2017). NMCAs may also include wetlands, estuaries, islands and other coastal lands (Parks Canada 2017). The only potential NMCA sites currently off Labrador include Labrador Coast A and B, with sites A and B located off northeastern and southeastern Labrador, respectively (F. Mercier, Parks Canada, A/Manager, Marine Establishment, Protected Areas Establishment Branch, pers. comm., 21 February 2018). Further information regarding these NMCAs is not yet available on the Parks Canada (2017) website.

4.7.2 Data Gaps associated with the Sensitive Areas VEC

The following data gaps associated with the Sensitive Areas VEC were identified in the Labrador Shelf SEA (§ 4.7.1, § 4.11.2.1, § 4.11.4.1, § 4.11.5.2 and § 4.11.9.1 of C-NLOPB 2008):

- Mapping of deep-sea coral distribution and diversity;
- Understanding deep-sea coral and sponge ecology, life history and ecological role(s);
- Impacts of fishing on deep-sea coral communities in Canadian waters;
- Species distributions, life histories, migrations, habitat preference and critical habitats within the candidate National Marine Conservation Areas;
- Complete details regarding spawning, nursery areas, migrations and species distributions within Gilbert Bay, including which species are resident, migratory or seasonal;
- Effect of climate change on species distribution and ecosystems, including offshore areas and IBAs;
- Locations of enhanced production and/or foraging aggregations for marine mammals and seabirds within Hawke Channel and other banks off Labrador;
- Spawning, nursery areas, migrations and species distribution for various banks off Labrador, including Hamilton, Nain and Saglek Banks;
- Understanding the interactions between ecosystems offshore Labrador and other areas, such as the Grand Banks;
- Dated data for various IBAs in Labrador; and
- Species distribution and abundance for certain IBAs in Labrador.

All of the data gaps indicated above still exist, although there have been recent data updates for deep-sea coral and sponge distribution (see § 4.2.1.2; Kenchington et al. 2016), and an Ecological Risk Assessment (ERA) to evaluate the risk posed by bottom contact fisheries on deep-sea coral and sponge communities in eastern Canadian waters has been carried out on several areas mentioned in Kenchington et al. (2016). These areas are being proposed as fisheries closures and extensive consultations on each area are currently underway. The Government of Canada has also recently committed to “establishing a more systematic approach to MPA planning and establishment,” “enhance collaboration for management and monitoring of MPAs,” “increase awareness, understanding and participation of Canadians in the MPA network,” and “link Canada’s network of MPAs to continental and global networks” (DFO 2016h). To this end, several marine refuges were announced in December 2017 within the Newfoundland and Labrador Region (DFO 2018c). Of the 19 marine refuges which occur in the Newfoundland and Labrador Region, four occur within the Study Area, as described above. Any new information that has been made available since the SEA was completed and for areas that were beyond the scope of the SEA is noted throughout § 4.2 and 4.7.1.

The above data gaps constrain the assessment of potential interactions between the Sensitive Areas VEC and the Project, owing particularly to the limited ecological and distributional knowledge of various species which utilize these areas. MKI will continue to monitor for updated information, including the modification of existing and the establishment of new Sensitive Areas in the vicinity of the Study Area, and include newly available data in future EA Updates.

5.0 Effects Assessment

The various aspects of the effects assessment methodology have been recently described in the MKI Labrador Sea EA (§ 5.0 of LGL 2014), and Seitel East Coast Offshore EA (§ 5.0 of LGL 2016).

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.

5.1 Scoping

The C-NLOPB provided a Final Scoping Document (C-NLOPB 2017a; dated 24 January 2017) for the Project which outlined the factors to be considered in the assessment. In addition, various stakeholders were contacted for input (see § 5.1.1 below). Another aspect of scoping for the effects assessment involved reviewing relevant SEA (C-NLOPB 2008) and EA (LGL 2014, 2016) reports.

5.1.1 Consultations

5.1.1.1 MKI's Consultation Approach

MKI's approach to consultation on marine seismic projects is to, whenever possible, 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 communications. The same approach would be followed before, during and after any survey work conducted in 2018–2023. In summary, each year MKI will consult with stakeholders before the survey is permitted, during survey activities, and after survey completion as outlined below.

- Before the survey is permitted: provide Project information, gather information about area fisheries, determine issues or concerns, discuss communications and mitigation measures, and discuss potential solutions;
- During survey activities: provide forward looking acquisition plans for discussion in a weekly meeting, communicate current and projected vessel positions every 12 hours via email, and maintain communication with active stakeholders to ensure concerns are addressed rapidly; and
- After the survey is completed: provide an update on the Project, discuss any issues that arose, and present results of the MMO and FLO reports.

The in-person meetings included the direct participation of MKI's Marine Shore Manager.

5.1.1.2 Program Consultations

Stakeholder groups in Labrador that were initially contacted by either email or phone in January 2017 are listed below.

- Cartwright Town Council;
- Town of Charlottetown;
- Labrador Choice Seafoods Inc., Charlottetown;
- Forteau Town Council;
- Town of Happy Valley-Goose Bay (HV-GB);
- NunatuKavut Community Council, HV-GB;
- Nunacor Development Corporation, HV-GB;
- Torngat Fish Producers Co-operative Society Inc., HV-GB;
- Torngat Secretariat, HV-GB;
- Town of L'Anse au Loup;
- Labrador Fishermen's Union Shrimp Company Ltd., L'Anse au Loup;
- Town of Mary's Harbor;
- Mary's Harbour Fishers' Committee, Mary's Harbour;
- Nunatsiavut Government (Department of Lands and Natural Resources), Nain;
- Nain Inuit Community Government, Nain;
- Town of North West River;
- Community of Pinsent's Arm;
- Town of Port Hope Simpson;
- Sheshatshiu First Nation Innu Band Council; and
- Innu Nation, Sheshatshiu.

The face-to-face consultations held in Mary's Harbour and HV-GB in late January were organized and coordinated by LGL. Topics raised at each meeting after the MKI presentation are bulleted below.

Labrador Fishermen's Union Shrimp Company Ltd. (24 January 2017)

- General concern about the Hawke Channel DFO Fisheries Closure Area.

Mayor of Mary's Harbour (24 January 2017)

- General concern about the Hawke Channel DFO Fisheries Closure Area.

Mary's Harbour Public Information Session (24 January 2017)

- General concern about the Hawke Channel DFO Fisheries Closure Area;
- Comment that an area in the northern part of the Project Area has concentration of corals and could become a marine sensitive area; and
- Discussion about the potential effects of seismic sound on fishes.

Torngat Secretariat (25 January 2017)

- Many questions regarding Marine Mammal Observers, particularly from the perspective of possible employment.

Torngat Fish Co-op (26 January 2017)

- Most discussion focused on the commercial fishery (shrimp, turbot) and how to minimize interaction between the fishery and the seismic operations.

Happy Valley-Goose Bay Public Information Session (26 January 2017)

- Effects of seismic sound on marine life;
- Frequency range of seismic sound;
- How is something determined to be 'environmentally-sensitive';
- What sensitive areas have been identified?

Innu Nation (27 January 2017)

- Questions about the size of the marine mammal/sea turtle safety zone; and
- Questions about employment opportunities.

More details regarding the Labrador consultations in late January 2017 are included in the consultation report in Appendix 1.

Other consultations in Labrador were held in Nain with the Nunatsiavut Government and a public meeting during the weeks of the 6th and 20th of March 2017. Recent consultation meetings, focused on fishing, were held with the Fish, Food and Allied Workers (FFAW) and DFO. Following these, MKI attended a meeting with the crab fleet representatives to discuss and answer question about the forthcoming season. Further meetings are planned with FFAW, Ocean Choice and DFO to review the more detailed plans for the 2018 season. In addition, MKI has distributed the annual newsletter to the established list of stakeholders (see Appendix 2).

In July 2018, MKI contacted the Nunavik Marine Region Impact Review Board (NMRIRB) to advise this group that a seismic EA for the Labrador offshore was being prepared. MKI

understands that beluga harvesting may occur in waters adjacent to the northern extremity of its Project Area. As such a Project Area map and summary of the project were sent to the NMRIRB for their review and feedback. To date, MKI has not received a response from the NMRIRB but will continue to follow-up with this group. Any issues and concerns raised will be addressed in the annual EA Updates.

5.1.1.3 Consultation 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.

5.2 Valued Environmental Components

The VEC approach was used to focus the assessment on those biological resources of most potential concern and value to society. Descriptions of these VECs are provided in § 5.2 of LGL (2016).

5.3 Boundaries

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

5.3.1 Temporal

The temporal boundaries of the Project are May 1 to November 30, 2018–2023.

5.3.2 Spatial

5.3.2.1 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 provided in § 2.1.

5.3.2.2 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.

5.3.2.3 Study Area

The ‘Study Area’ is an area larger than the Project Area that encompasses routine potential effects reported in the literature. The coordinates of the Study Area (WGS84, unprojected geographic coordinates) are provided in § 2.1.

5.3.2.4 Regional Area

The ‘Regional Area’ is an area larger than the Study Area and is typically used when assessing cumulative effects.

5.4 Effects Assessment Procedures

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

1. Preparation of interaction matrices (i.e., interactions of Project activities and the environment);
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.

The following is a summary of the effects assessment procedures used in the EA:

1. The preparation of interaction matrices to identify potential interactions between the various Project activities and the VECs;
2. The assessment of the residual effects (post-mitigation) of the various Project activities on the VECs, based on identified interactions;
 - a. Identification of the potential effect as positive or negative;
 - b. Identification of mitigations to be applied to each potential effect; and
 - c. Provision of ‘ratings’ to the various criteria used in the assessment to describe the residual effect.
 - i. The criteria and their associated ratings used in the assessment include the following:
 - Magnitude (proportion of individuals in the affected area) (4 ratings: negligible, low, medium and high);
 - Geographic Extent (6 ratings: <1 km², 1–10 km², 11–100 km², 101–1,000 km², 1,001–10,000 km², and >10,000 km²);
 - Frequency (6 ratings: <11 events/year, 11–50 events/year, 51–100 events/year, 101–200 events/year, >200 events/year, and continuous);

- Duration (5 ratings: <1 month, 1–12 months, 13–36 months, 37–72 months, and >72 months);
 - Reversibility (2 ratings: reversible and irreversible); and
 - Ecological/Socio-cultural and Economic Context (2 ratings: relatively pristine area and evidence of existing negative effects).
3. The determination of significance of residual effects;
- a. A significant effect is defined as: high magnitude, or medium magnitude for a duration of >1 year over a geographic area >100 km²;
 - b. A level of confidence (low, medium or high) is provided for each determination of significance; and
 - c. If a residual effect is deemed ‘significant’, then ratings of ‘probability of occurrence’ and ‘scientific certainty’ are provided.

Note that professional judgement is applied during the assessment in addition to the consideration of scientific information. More details on the effects assessment procedures are provided in § 5.4 of LGL (2015a,b).

5.5 Mitigation Measures

The effects assessments that follow (see § 5.7) consider the potential effects of the proposed Newfoundland offshore seismic program in light of the specific mitigation measures that will be applied during this Project. The purpose of these measures is to eliminate or reduce the potential effects on VECs. 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. Collectively, they are based on several sources, including:

- Discussions and advice received during consultations for this Project (§ 5.1.1 and Appendix 1), and for other relevant EAs;
- The C-NLOPB Final Scoping Document (C-NLOPB 2017a), and the Environmental Planning, Mitigation and Reporting guidance in Appendix 2 of the Board’s *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2017b);
- DFO’s *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*;
- National and international acts, regulations or conventions, such as the *SARA, Fisheries Act* and Regulations (including the Marine Mammal Regulations [MMR]), *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* (One Ocean 2013);
- Industry best practices; and
- Expert judgement/experience from past surveys.

Proposed mitigations are organized under the following principal categories:

- Survey layout and location;
- Communications and liaison;
- Fisheries avoidance;
- Fishing gear damage program;
- Marine mammal, sea turtle, and seabird monitoring and mitigation; and
- Pollution prevention and emergency response.

Several of the mitigation measures listed under these categories are designed to mitigate potential effects on more than one VEC (e.g., seismic array ramp-up/soft start can, in theory, deter marine mammals, sea turtles, and fish). Table 5.1 summarizes the measures by VEC and type of effect. These measures will be adhered to during each survey year, with necessary adjustments based on monitoring and follow-up. As per § 5.1.4.1 of the Guidelines (C-NLOPB 2017b), a tracking table identifying the status of each of the commitments and mitigation measures made by the proponent during the EA process shall be submitted to the C-NLOPB at least 30 days prior to the commencement of the Project.

There will be full opportunity for adaptive mitigation during MKI's proposed six-year program. If there are any new techniques developed during the six-year period that may help to further mitigate environmental effects, they will be investigated and incorporated into the program if deemed useful. The MMR are currently undergoing amendment, and Schedule 11 of the proposed amended MMR provides approach distances for marine mammals based on species, vehicle, area, and timing (LGL 2017b); if the proposed amendments to the MMR are accepted during the spatial scope of the Project (2018–2023), MKI will adhere to any implications relevant to Project operations. Annual updates of the EA that will be prepared during the six-year scope of the Project will include any relevant new information related to mitigation not provided in the EA.

Table 5.1 Summary of Mitigations Measures by Potential Effect.

VEC, Potential Effects	Primary Mitigations
Fisheries VEC: Interference with fishing vessels/mobile and fixed gear fisheries	<ul style="list-style-type: none"> • Pre-survey communications, liaison and planning to avoid fishing activity • Continuing communications throughout the program • FLOs • SPOC • Advisories and communications • VMS data • Avoidance of actively fished areas • Start-up meetings on ships that discuss fishing activity and communication protocol with fishers
Fisheries VEC: Fishing gear damage	<ul style="list-style-type: none"> • Pre-survey communications, liaison and planning to avoid fishing gear • Use of escort vessel • SPOC • Advisories and communications • FLOs • Compensation program • Reporting and documentation • Start-up meetings on ships that discuss fishing activity, communication protocol with fishers, and protocol in the event of fishing gear damage
Interference with shipping ^a	<ul style="list-style-type: none"> • Advisories and at-sea communications • FLOs (fishing vessels) • Use of escort vessel • SPOC (fishing vessels) • VMS data
Fisheries VEC: Interference with DFO/FFAW research program	<ul style="list-style-type: none"> • Communications and scheduling • 7-day/30-km temporal/spatial avoidance protocol^b
Fish and Fish Habitat, Marine Mammal and Sea Turtle, and Marine-associated Bird VECs: Temporary or permanent hearing damage/disturbance to marine animals (marine mammals, sea turtles, seabirds, fish, invertebrates)	<ul style="list-style-type: none"> • “Pre-watch” (30 minute) of 500 m safety zone using visual and PAM • Delay start-up if any marine mammals or sea turtles are detected within 500 m with visual and PAM • Ramp-up of airguns • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during all daylight periods when airguns are in use • Minimum separation distance of 30 km for simultaneous seismic surveys in the Project Area based on separation distances required in other jurisdictions (i.e., Gulf of Mexico [G. Morrow, PGS, Senior Contract Manager, pers. comm., June 2017] and Greenland [LGL 2012]).
Species at Risk and Sensitive Areas VEC: Temporary or permanent hearing damage/ disturbance to Species at Risk or other key habitats	<ul style="list-style-type: none"> • “Pre-watch” (30 minute) of 500 m safety zone using visual and PAM • Delay start-up if any marine mammals or sea turtles are detected within 500 m with visual and PAM • Ramp-up of airguns • Shutdown of airgun arrays for <i>endangered</i> or <i>threatened</i> marine mammals and sea turtles within 500 m • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. • Use of PAM for cetaceans (details to be provided in EA Updates) • Minimum separation distance of 30 km for simultaneous seismic surveys in the Project Area based on separation distances required in other jurisdictions (see above).
Marine-associated Bird VEC: Injury (mortality) to stranded seabirds	<ul style="list-style-type: none"> • Daily search of seismic and support vessels • Implementation of handling and release protocols • Minimize lighting if safe
Marine-associated Bird VEC: Seabird oiling	<ul style="list-style-type: none"> • Adherence to MARPOL • Adherence to conditions of ECCC-CWS migratory bird permit • Spill contingency and response plans • Use of solid streamer

Note:

^a MKI will engage CTF 84, through Director General Naval Strategic Readiness (DGNSR), to ensure de-confliction with possible Allied submarine activities.

^b DFO does not indicate an official spatial and/or temporal buffer mitigation method for seismic operations in the vicinity of survey stations. MKI will work cooperatively with FFAW/Unifor and DFO in an effort to avoid survey stations prior to their sampling to the best extent possible.

The mitigation categories are described in detail in § 5.5 of LGL (2016) and summarized below.

1. Planning Survey Layout and Location
 - a. Early planning of the layout of survey transect lines helps to reduce the probability of effects of VECs. A certain level of spatial and temporal flexibility associated with this planning serves as a mitigation measure for numerous VECs.
2. Communications and Liaison
 - a. A number of strategies associated with communications and liaison are available to serve as mitigation measures. They are as follows:
 - i. Information exchange
 - ii. Weekly status updates
 - iii. Fisheries Liaison Officers (FLOs)
 - iv. Single Point of Contact (SPOC)
 - v. FFAW/One Ocean petroleum liaison contacts
 - vi. Vessel Monitoring System (VMS) data
 - vii. Notices to shipping
 - viii. Survey start-up sessions
 - ix. Consultation
 - x. Communications follow-up
3. Fisheries Avoidance
 - a. There are a number of examples associated with this category. They are as follows:
 - i. Temporal avoidance of active fishing areas, to the best of the proponent's ability (related to communications with FFAW and fishers)
 - ii. No seismic gear deployment until arrival within the Project Area
 - iii. Spatial and temporal avoidance of active fisheries science surveys
 - iv. Use of a picket vessel
4. Fishing Gear Damage Program
 - a. Each proponent will prepare its own Fisheries Compensation Plan in case the seismic survey activities result in gear/vessel damage and/or loss. This process involves contact with the SPOC. A protocol developed by One Ocean describes responses to a gear conflict to be followed by those on a Project vessel.
5. Marine Mammal/Wildlife Protection
 - a. Some of the following measures related to marine mammals and sea turtles are based on the *Statement of Canadian Practice* (see C-NLOPB 2017b):
 - i. The establishment of a safety zone with at least a 500 m radius measured from the airgun source array
 - ii. Implementation of a pre-start up watch of the safety zone by a qualified and experienced MMO for at least 30 minutes prior to array

start-up. If a marine mammal or sea turtle is detected within the safety zone during the 30-minute pre-start up watch, ramp up cannot commence until at least 30 minutes have passed since the last detection within the safety zone. It is anticipated that PAM for cetaceans will occur during the pre-start up watch.

- iii. If array activation is permitted, based on the pre-start up watch, a gradual ramp up/soft start of the airgun source array may take place over a minimum period of 20 minutes
- iv. The airgun source array(s) will be shut down immediately if a marine mammal or sea turtle with either *endangered* or *threatened* status on Schedule 1 of the SARA is detected within the safety zone. For the Study Area, this currently includes North Atlantic right whales, blue whales, northern bottlenose whales, leatherback sea turtles, and loggerhead sea turtles. Note that MKI also commits to implementing shut downs for all sea turtle species and all beaked whales, including Sowerby's beaked whale.
- v. When seismic surveying ceases during line changes, maintenance or other operational reasons, the airgun source array(s) will either be shut down completely or reduced to a single source element
- vi. Any seabirds that become stranded on vessels during the seismic surveying will be released using the mitigation methods consistent with *Procedures for handling and documenting stranded birds encountered on infrastructure offshore Atlantic Canada* (ECCC-CWS 2017)
- vii. Marine mammal, sea turtle and seabird observations will be made by qualified and experienced environmental observers during operations, including those related to marine mammal behavioural responses to the vessels and airgun source array(s)
- viii. The results of the marine mammal and seabird monitoring program will be included in the EA mitigation and monitoring report; this report will be submitted to the C-NLOPB within six months after completion of the fieldwork, as per C-NLOPB (2017b)

6. Pollution Prevention / Emergency Response

a. Waste Management

- i. Wastes produced during activities, including hazardous and non-hazardous material, will be managed in accordance with MARPOL and the vessel-specific management plan. All solid wastes will be sorted by type, compacted where practical, and stored on board until disposal at an appropriate certified reception facility.

b. Discharge Prevention and Management

- i. Vessel discharges will not exceed those of standard vessel operations and will adhere to all applicable regulations. The primary discharges

include grey water (e.g., wastewater from washing, bathing, laundry and food preparation), black water (e.g., human wastes), bilge water, deck drainage and discharge from machinery spaces.

c. Air Emission Control

- i. 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. Air emissions will be those associated with standard operations of marine vessels in general.

d. Response to Accidental Events

- i. 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 vessels also carry Spill Kits.

e. Use of Streamers with a Solid Core

- i. MKI will use a solid core streamer, thereby removing any risk of flotation fluid leakage.

5.6 Effects of the Environment on the Project

The physical environment is summarized in § 3.0 of this EA and the reader is referred to this section to assist in determining the effects of the environment on the Project. Furthermore, safety issues are assessed in detail during the permitting and program application processes established by the C-NLOPB. Nonetheless, effects on the Project are important to consider, at least on a high level, because they may sometimes cause effects on the environment. For example, accidental spills may be more likely to occur during rough weather.

Given the Project time window of May 1 to November 30 for seismic operations and the requirement of a seismic survey to avoid periods and locations of sea ice, sea ice should have little or no effect on the Project (see § 3.4.1). Icebergs in the spring and early-summer may cause some survey delays if tracks have to be altered to avoid them (see Table 3.10 and Figure 3.7 in § 3.4.2). Within the Project time frame, icebergs may require the vessels to detour in May, June and July when almost 65% of the yearly total of icebergs are expected to occur, based on monthly iceberg distribution data (see Table 3.10 in § 3.4.2).

Most environmental constraints on seismic surveys offshore Labrador are those imposed by wind and wave conditions. If the Beaufort wind scale is seven or greater, there is generally too much noise for seismic data to be of use. A Beaufort wind scale of seven is equivalent to wind speeds of 33 knots (13.9–17.1 m/s), and is associated with wave heights ranging from 4.0–5.5 m. In the

Study Area, these conditions are not uncommon in the late-autumn and winter months. If the sea state exceeds 3.0 m or wind speed exceeds 40 kt (20.6 m/s), then continuation/termination of seismic surveying will be evaluated. Based on multi-year data at eight grid points in the Study Area (see Figure 3.1 in § 3.2), these wave limits are typically approached during the October–April period.

Poor visibility (e.g., due to inclement weather or fog) can constrain helicopter operations and streamer repair. It also may hinder sightings of marine mammals and sea turtles within the 500-m safety zone, other vessels and fishing gear. These constraints are alleviated somewhat by state of the art forecasting, and the use of radar and FLOs to detect fishing vessels and gear. The Project scheduling avoids most of the continuous extreme weather conditions. 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.

Environmental effects on other Project vessels (e.g., escort and supply vessels) are likely less than on the seismic vessel which is constrained by safety of towed gear and data quality issues.

Effects of the biological environment on the Project are unlikely although there are accounts of sharks attacking and damaging streamers.

The Department of National Defense (DND) records indicate that there are at least two possible Unexploded Explosive Ordnance (UXO) sites of concern and one legacy site present in the Study Area (LGL 2017b). Due to the inherent dangers of associated UXO and the fact that the northwest Atlantic Ocean was exposed to many naval engagements during WWII, any suspected UXO encountered during the course of the operations will be geo-referenced, immediately reported to the Coast Guard, and left undisturbed.

Effects of the environment on the Project are predicted to be *not significant* for the reasons discussed above.

5.7 Effects of the Project Activities on the Environment

This effects assessment is organized so that issues generic to any type of ship activity in the Study Area (e.g., seismic operations vessels, fisheries vessels, DFO research vessels, military ships, marine transporters) are discussed first. The detailed effects assessment that follows focuses on the effects of noise (primarily on marine mammals, fish and fisheries) from the airgun array(s) and the towed seismic streamers (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 (§ 5.5) 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.

5.7.1 Generic Activities - Air Quality

The atmospheric emissions from Project activities will be those from the Project vessels' engines, generators, and incinerators. Project atmospheric emissions 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 health or safety concerns associated with Project emissions.

Given that the Project vessels 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 measurable adverse effect on air quality or human health in the Project Area.

5.7.2 Generic Activities - Marine Use

Project-related traffic will include one seismic survey vessel and one escort vessel per survey, up to a maximum of four concurrent seismic vessels during a survey year. A supply vessel will not necessarily be required in all instances. The seismic and support vessels will operate within the Project Area (see Figure 1.1), except when transiting to or from the survey area. The seismic and/or support vessels may operate occasionally to and from the Project Area for re-provisioning, re-fuelling, and crew changes. The escort vessel will be onsite with the seismic vessel when data acquisition is on-going. If the escort vessel is to be unavoidably absent from the operational area and/or is unable to perform its duties for any reason, the seismic operator will perform a risk assessment of their ongoing operations and plan and implement risk mitigation measures to minimize the potential for negative interaction with commercial fishers. The risk assessment and type of mitigation measures expected were previously communicated to MKI by the C-NLOPB (LGL 2017b).

Other ships operating in the area could include freighters, tankers, fishing vessels, research vessels, naval vessels, and private yachts. Mitigation measures (detailed in § 5.5) intended to minimize potential conflicts and any adverse effects with other vessels include the following.

- At sea communications (VHF, HF, Satellite, radar etc.);
- Utilization of FLOs for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- Support vessel to alert other vessels of towed gear in water;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast (e.g., Notice to Mariners, Notice to Airmen);
- 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, and will engage with CTF 84, through DGNSR, to ensure de-confliction with possible Allied submarine activities. Given the expected number of vessels in the Project Area and mitigation measures described above, there should be *negligible* adverse effects on other marine users of the Project Area.

5.7.3 Generic Activities - Waste Handling

Project waste will be generated by about 55–85 personnel. Waste will include the following.

- Gray/black water;
- Galley waste; and
- Solid waste.

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 support 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 be handled and treated appropriately and, therefore, will have *negligible* effect on the environment in the Project Area.

5.7.4 Fish and Fish Habitat VEC

Despite the certainty 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 5.2), the residual effects are predicted to be *negligible* and *not significant*. The seismic program will not result in any direct physical disturbance of the bottom substrate. Also, there is a very low probability of any accidental event (i.e., hydrocarbon release) large enough to cause a significant effect on fish habitat. Therefore, other than its inclusion in Table 5.2, no further reference to the 'fish habitat' component of the Fish and Fish Habitat VEC is made in this assessment subsection. Note that ichthyoplankton, invertebrate eggs and larvae, and macrobenthos are considered part of the 'fish' component of the Fish and Fish Habitat VEC.

5.7.4.1 Sound

The potential effects of exposure to airgun sound on invertebrates and fishes can be categorized as either physical (includes both pathological and physiological) or behavioural. Pathological effects include lethal and sub-lethal damage; physiological effects include temporary primary

and secondary stress responses; and behavioural effects refer to deviations from normal behavioural activity. Physical and behavioural effects are very likely related in some instances and should therefore not be considered as completely independent of one another.

Table 5.2 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 ^a	Pelagic Fish	Groundfish
Sound							
Airgun Array (2D, 3D and 4D)		X	X	X	X	X	X
Seismic Vessel		X	X	X	X	X	X
Supply Vessel		X	X	X	X	X	X
Escort Vessel		X	X	X	X	X	X
Helicopter							
Echo Sounder						X	
Side Scan Sonar						X	
Vessel Lights		X				X	
Vessel/Equipment Presence							
Seismic Vessel and Equipment							
Supply Vessel							
Escort Vessel							
Sanitary/Domestic Waste	X	X		X		X	
Atmospheric Emissions	X	X		X		X	
Garbage ^b							
Helicopter Presence							
Shore Facilities ^c							
Accidental Releases	X	X	X	X	X	X	X
Other Projects and Activities in Regional Area							
Oil and Gas Activities	X	X	X	X	X	X	X
Fisheries	X	X	X	X	X	X	X
Marine Transportation	X	X	X	X	X	X	X
Note: ^a Juveniles are young fish that are no longer planktonic and are often closely associated with the sea bottom. ^b Not applicable as garbage will be brought ashore. ^c There will not be any new onshore facilities. Existing infrastructure will be used.							

Information related to interactions between underwater sound and invertebrates and fishes is available in § 5.7.4 and Appendices 2 and 3 of the MKI project-specific Labrador Sea EA (LGL 2014), and § 5.1.2 of the Labrador Shelf SEA (C-NLOPB 2008). Topics in these subsections and appendices include sound detection and production by marine invertebrates and fishes, and the potential effects of exposure to underwater sound, particularly seismic airgun sound, on marine invertebrates and fishes.

The assessment in this subsection is structured such that the reader should first refer to the interactions table (e.g., Table 5.2) to determine the interactions of the Fish and Fish Habitat VEC with project activities, secondly to the assessment table (e.g., Table 5.3) which contains criteria

ratings, including those for magnitude, geographic extent, and duration, and thirdly to the significance predictions table (e.g., Table 5.4).

Sound Exposure Effects Assessment

It is not practical to assess in detail the potential effects of every type of sound on every species in the Study Area. The best approach in environmental assessment is to provide focus by selecting (1) the sound source with the highest sound level, in this case the seismic airgun sound, and (2) example species that are both representative of the different types of sensitivities to underwater sound and have been scientifically studied with respect to interaction with underwater sound (e.g., snow crab and Atlantic cod).

The primary factors considered in the assessment include (1) distance between airgun array and animal under normal conditions (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 (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 effects on other marine invertebrate and fish species are inferred from the assessment using snow crab and Atlantic cod as representative species of the Fish and Fish Habitat VEC. Potential interactions between the proposed Project activities and the Fish and Fish Habitat VEC are shown in Table 5.2.

Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, several key data gaps remain (Hawkins et al. 2015).

Physical and Physiological Effects

Available experimental data suggest that there may be physical effects on the fertilized eggs of snow crab and on the egg, larval, juvenile and adult stages of cod at very close range (Booman et al. 1996; Christian et al. 2003; Sierra-Flores et al. 2015). Considering the typical source levels associated with commercial seismic airgun arrays, an invertebrate or fish close to the source could be exposed to very high sound levels. While egg and larval stages are unable to actively move away from the sound source, juvenile and adult cod can. 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 an effect. However, there remains a lack of knowledge regarding exposure of benthic organisms to substrate vibration and energy waves associated with the water-substrate interface and substrate. In the case of eggs and larvae, it is likely that the numbers negatively affected by exposure to seismic sound would be negligible

when compared to those succumbing to natural mortality (Saetre and Ona 1996). 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 events (e.g., unique spawning aggregations, particularly in terms of location) and ramp-up of the airgun array should theoretically mitigate the population-level effects of exposure to airgun sound.

Particle motion is the component of underwater acoustic stimuli generated partly by hydrodynamic flow near the acoustic stimulus source and partly by the oscillations associated with the sound pressure waves as they propagate from the acoustic source as a cyclic compression and rarefaction of water molecules (Higgs et al. 2006). Snow crab, thought to be sensitive to the particle motion component of sound only (Popper et al. 2001), will be a considerable distance from the airguns and will not likely be affected by any particle motion in the water column resulting from airgun discharge. However, as stated above, there is a lack of knowledge regarding exposure of benthic organisms to substrate vibration and energy waves associated with the water-substrate interface and substrate.

Limited data regarding physiological effects on fish and invertebrates suggest that these effects are both short-term and most obvious after exposure at close range. The physical effects of exposure to sound with frequencies >500 Hz are *negligible*, based on the available information from the scientific literature. Effects of exposure to <500 Hz sound and marine vessel sound appear to be primarily behavioural and somewhat temporary. The duration of such a temporary effect varies depending on numerous factors, including the species being exposed, the behaviour being exhibited by fishes when exposed to low frequency sound, the characteristics of the sound (e.g., source level, continuous vs. impulsive sound, captive vs. non-captive fishes, etc.). For example, captive fishes exposed to sound from a single airgun by McCauley et al. (2000) exhibited acute startle and alarm responses that ceased 15–30 minutes after cessation of exposure. Pearson et al. (1992) exposed non-captive fishes to sound from a single airgun and these fishes also exhibited startle and alarm responses which subsided 20–60 minutes after exposure. On the other end of the ‘temporary’ spectrum, various studies (Løkkeborg and Soldal 1993; Løkkeborg et al. 2012; Engås et al. 1993, 1996) have investigated behavioural effects on wild fish from a fisheries perspective. The temporary effect observed in these studies appeared to persist for a number of days before ‘normal’ distribution was re-established.

A more comprehensive discussion regarding the physical and physiological effects of exposure to seismic sound on fishes is contained in the appendices of recently completed seismic EAs (e.g., LGL 2015a,b).

Behavioural Effects

Studies suggest that effects on fish behaviour due to exposure to airgun sound are temporary in nature, and that response thresholds for various demersal and pelagic species are quite variable. Numerous studies have reported startle/alarm responses by fish (Pearson et al. 1992;

Fewtrell and McCauley 2012). Pearson et al. (1992) also reported observations of localized distributional shifts, tightening of schools, and random movement and orientation. Løkkeborg et al. (2012) reported differences between species in terms of catchability after being exposed to seismic sound. They observed higher catches in gill nets but lower catches on baited hooks, possibly resulting from increased random movement by the fish causing a higher incidence of fish being caught up in gill nets but a lower incidence of fish targeting baited hooks. There is some thought that the degree of behavioural response by fishes to exposure to anthropogenic sounds such as seismic airgun sound depends on what natural behaviour the fish is exhibiting at the time of exposure. For example, fish exhibiting reproductive and/or feeding behaviour may have a higher response threshold to anthropogenic sound than fish exhibiting migratory behaviour. More study is required to test this hypothesis.

A more comprehensive discussion regarding the behavioural effects of exposure to seismic sound on fishes is contained in the appendices of recently completed seismic EAs (e.g., LGL 2015a,b).

New Literature

Recently published review papers related to the potential effects of exposure to anthropogenic sound on invertebrates and fishes include Aguilar de Soto (2016), Carroll et al. (2016) and Edmonds et al. (2016). Another recently-published paper by Hawkins and Popper (2016) provides a recommended approach to assessing the impact of underwater noise on marine fishes and invertebrates. Hawkins and Popper (2016) point out the existing hurdles that limit one's ability to assess these impacts with more certainty.

A recently released report on a study conducted in Tasmanian waters during 2013–2015 (Day et al. 2016) describes the results of exposure of captive adult southern rock lobsters (*Jasus edwardsii*), including berried females, and adult commercial scallops (*Pecten fumatus*) to seismic sound in a field setting. Sound measurement instrumentation was deployed throughout the experimentation to record both sound pressure and ground borne vibration. The number of airgun pulses per exposure replicate for the lobster and scallop experiments ranged from 110–126, and 51–167, respectively. The lobsters were exposed to two types of passes: (1) a control pass of a non-operating airgun; and (2) a pass of an operating airgun. The scallops were exposed to four types of passes: (1) a control pass of a non-operating airgun; (2) one pass of an operating airgun; (3) two passes of an operating airgun; and (4) four passes of an operating airgun. Maximum received SEL_{cum} for the lobster experiments ranged from 192–199 dB re 1 μPa^2 s, while maximum received SEL_{cum} for the scallop experiments ranged from 189–198 dB re 1 μPa^2 s. Various parameters for the lobsters were measured at four sampling times between Day 0 (exposure day) and Day 120 (120 days post-exposure). Some lobsters were assessed at 365 days post-exposure. Various parameters for the scallops were measured at three sampling times between Day 0 and Day 120.

The key findings of Day et al. (2016) during the lobster experiments include:

1. No mortality observed;
2. Two reflexes, tail extension and righting, showed responses following exposure to airgun sound. Tail extension was reduced in lobsters exposed during the lone summer exposure for 14 days, and righting was compromised in three of the four exposure experiments and persisted to 120 days post-exposure in all experiments and to 365 days post-exposure in the one experiment conducted for that duration;
3. Damage to the statocyst sensory hairs was observed in lobsters exposed in three of the four experiments;
4. Haemolymph biochemistry showed little effect from exposure;
5. Counts of the number of circulating haemocytes showed a significant reduction in all four experiments; and
6. Embryos exposed to airgun sound and subsequently hatched showed neither qualitative nor quantitative effects.

The key findings of Day et al. (2016) during the scallop experiments include:

1. Acute mass mortality was not observed but repeated exposure significantly increased mortality. The risk of mortality increased with time, based on the fact that the majority of mortality was recorded at the Day 120 sample points;
2. Substantial disruptions in haemolymph biochemistry were observed. A range of electrolytes, minerals and metabolites showed disrupted levels through to Day 120 post-exposure;
3. Haemolymph pH was affected in two of the three experiments. A slight but persistent alkalosis was observed at Day 14 post-exposure;
4. Scallops demonstrated a reduction of classic behaviours during exposure. In addition, it seemed that airgun exposure elicited a novel velar flinch behaviour; and
5. Scallop reflexes were affected, with exposures resulting in faster recessing times and some indication that righting time was reduced.

Day et al. (2016) concluded that until the full scope of these observed changes and their ecological effects are thoroughly investigated, caution must be taken against extrapolating the results of this study.

Assessment of Effects of Exposure to Sound

Table 5.3 provides the details of the assessment of the residual effects of exposure to Project-related sound on the Fish and Fish Habitat VEC. MKI seismic vessels from simultaneous 3D and 2D surveys will maintain a minimum separation distance (>30 km) when operating airgun arrays in the Project Area. This should decrease the probability of synergistic effects on fishes and invertebrates. Relative to the effects predictions made for a single 2D or 3D seismic survey, the potential residual effects on the Fish and Fish Habitat VEC related to sound

from three simultaneous 3D seismic surveys and one 2D seismic survey (worst-case scenario) is predicted to occur over a larger area (i.e., maximum geographic extent of 1001–10,000 km² vs. 101–1000 km²). With mitigation measures in place (see Table 5.1), residual effects on the Fish and Fish Habitat VEC associated with sound from the Project during simultaneous 3D and 2D seismic surveys are predicted to range from *low to medium* in magnitude for a duration of <1 month to 1–12 months over an area of <1 km² to 1001–10,000 km². Based on these criteria ratings, the *reversible* residual effects of underwater sound on the Fish and Fish Habitat VEC are predicted to be *not significant*. The level of confidence associated with this prediction is *low to medium* (Table 5.4) given the scientific data gaps.

5.7.4.2 Effects Assessment of other Routine Project Activities

Vessel Lights

As indicated in Tables 5.2–5.4, vessel lights may attract plankton and pelagic fishes towards the upper water column. However, seismic vessels are typically travelling at a high enough rate so that the attraction effect is not spatially static. Therefore, the overall effect of vessel lights on the Fish and Fish Habitat VEC is somewhat neutral. Therefore, the effects of vessel lights associated with MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.4). The level of confidence associated with this prediction is *medium to high* (Table 5.4).

Sanitary/Domestic Waste

Table 5.3 provides the details of the assessment of the effects of exposure to Project-related sanitary and domestic waste on the Fish and Fish Habitat VEC, including appropriate mitigation measures. As indicated in § 5.7.3, appropriate treatment of wastes produced by the Project will result in residual effects that are *negligible* in magnitude for a duration of <1 month to 1–12 months over a geographic area of <1 km² (Table 5.3). Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic wastes produced during MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.4). The level of confidence associated with this prediction is *high* (Table 5.4).

Table 5.3 Assessment of Effects of Project Activities on the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat								
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
Sound								
Airgun Array (2D, 3D and 4D)	Physical effects (N); Disturbance (N)	Ramp-up of array; Spatial & temporal avoidance	0-2	1-5	6	1-2	R	2
Seismic Vessel	Disturbance (N)	Spatial & temporal avoidance	0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)	Spatial & temporal avoidance	0-1	1-2	1	1	R	2
Escort Vessel	Disturbance (N)	Spatial & temporal avoidance	0-1	1-2	6	1-2	R	2
Echo Sounder	Disturbance (N)	Spatial & temporal avoidance	0-1	1	6	1	R	2
Side Scan Sonar	Disturbance (N)	Spatial & temporal avoidance	0-1	1	6	1	R	2
Vessel Lights	Attraction (Neutral)	-	-	-	-	-	-	-
Sanitary/Domestic Waste	Pathological effects (N); Contamination (N)	Treatment	0	1	4	1-2	R	2
Atmospheric Emissions	Pathological effects (N); Contamination (N)	Equipment maintenance	0	1	6	1-2	R	2
Accidental Releases	Pathological effects (N); Contamination (N)	Prevention protocols; Response	0-1	1-2	1	1	R	2
Key:								
Magnitude:			Frequency:			Reversibility:		Duration:
0 = Negligible			1 = <11 events/yr			R = Reversible		1 = <1 month
1 = Low			2 = 11-50 events/yr			I = Irreversible		2 = 1-12 months
2 = Medium			3 = 51-100 events/yr			(refers to population)		3 = 13-36 months
3 = High			4 = 101-200 events/yr					4 = 37-72 months
			5 = >200 events/yr					5 = >72 months
			6 = Continuous					
Geographic Extent:			Ecological/Socio-cultural and Economic Context:					
1 = <1-km ²			1 = Relatively pristine area or area not affected by human activity					
2 = 1-10-km ²			2 = Evidence of existing effects					
3 = 11-100-km ²								
4 = 101-1,000-km ²								
5 = 1,001-10,000-km ²								
6 = >10,000-km ²								

Table 5.4 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 of Predicted Residual Environmental Effects		Likelihood ^a	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D)	NS	1-2	-	-
Seismic Vessel	NS	2-3	-	-
Supply Vessel	NS	2-3	-	-
Escort Vessel	NS	2-3	-	-
Echo Sounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Vessel Lights	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2-3	-	-
<p>Key:</p> <p>Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km².</p> <p>Residual environmental Effect Rating:</p> <p>S = Significant Negative Environmental Effect</p> <p>NS = Not-significant Negative Environmental Effect</p> <p>P = Positive Environmental Effect</p> <p>Level of Confidence: based on professional judgment:</p> <p>1 = Low</p> <p>2 = Medium</p> <p>3 = High</p> <p>Scientific Certainty: based on scientific information and statistical analysis or professional judgment:</p> <p>1 = Low</p> <p>2 = Medium</p> <p>3 = High</p> <p>Note:</p> <p>^a Considered only in the case where 'significant negative effect' is predicted.</p>				

Atmospheric Emissions

Table 5.3 provides the details of the assessment of the effects of exposure to Project-related atmospheric emissions on the Fish and Fish Habitat VEC, including appropriate mitigation measures. As indicated in § 5.7.1, atmospheric emission levels produced by the Project will be similar to those produced by other marine vessels not directly related to the Project. Residual effects of Project-related atmospheric emissions will be *negligible* in magnitude for a duration of <1 month to 1–12 months over a geographic area of <1 km². Based on these criteria ratings, the *reversible* residual effects of atmospheric emissions produced during MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.4). The level of confidence associated with this prediction is *high* (see Table 5.4).

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 refers 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 5.2, 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 mitigation measures in place (see Table 5.3), 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 km²* (see Table 5.3). 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 MKI's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (see Table 5.4). The level of confidence associated with this prediction is *medium to high* (see Table 5.4).

5.7.5 Fisheries VEC

The potential interactions of the Project activities and the Fisheries VEC are indicated in Table 5.5. DFO and joint DFO/Industry Research Surveys are included in the assessment of the Fisheries VEC.

Table 5.5 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)
Sound			
Airgun Array (2D, 3D and 4D)	X	X	X
Seismic Vessel	X	X	X
Supply Vessel	X	X	X
Escort Vessel	X	X	X
Helicopter			
Echo Sounder	X		
Side Scan Sonar	X		X
Vessel Lights			
Vessel/Equipment Presence			
Seismic Vessel/Gear	X	X	X
Supply Vessel	X	X	X
Escort Vessel	X	X	X
Sanitary/Domestic Waste	X	X	X
Atmospheric Emissions			
Garbage^a			
Helicopter Presence			
Shore Facilities^b			
Accidental Releases	X	X	X
Other Projects and Activities in Regional Area			
Oil and Gas Activities	X	X	X
Marine Transportation	X	X	X
Note:			
^a Not applicable as garbage will be brought ashore.			
^b There will not be any new onshore facilities. Existing infrastructure will be used.			

Behavioural changes relating to catchability of commercial species, and conflict with harvesting activities, fishing gear and lost fishing time have been raised as potential issues either during consultations and issues scoping for this assessment (§ 5.1.1) or during consultations for recent EAs for offshore Newfoundland and Labrador (e.g., § 5.1.1 of LGL 2016). Conflicts between seismic vessels and associated gear and fishing activities/gear have occurred in the past in

Atlantic Canada when seismic vessels were operating in areas with high levels of fishing activity. This is particularly relevant in relation to fixed gear, such as crab pots and gillnets within the Study Area. Other potential sources of interference from seismic activities may include temporal and spatial conflicts with DFO and DFO/Industry research surveys if both are being conducted concurrently in the same general area, and an accidental release of petroleum hydrocarbons, which may result in tainting (or perceived tainting) and affect product quality and marketing.

The primary means of mitigating potential impacts on the Fishery VEC is to avoid active fishing areas, particularly fixed gear zones. For the commercial fisheries, compensation for damaged gear provides a means of final mitigation of impacts, in the event a conflict occurs (e.g., accidental contact of fishing gear with the survey airgun array, seismic vessel or streamers). Information regarding mitigation measures, including those associated with the Fisheries VEC, is provided in § 5.5.

The document *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2017b) provides guidance aimed at minimizing any impacts of petroleum industry geophysical surveys on commercial fish harvesters and other marine users. The mitigations provided below are also relevant to DFO and joint DFO/Industry research surveys. Development of the guidelines was based on best practices applied during previous geophysical surveys in Atlantic Canada, as well as guidelines from other national jurisdictions.

The following subsections assess the potential effects of Project activities on the Fisheries VEC.

5.7.5.1 Sound

The potential for impacts on fish harvesting are dependent on the location and timing of the surveying activities in relation to fishing areas, and the type of fishing gear used in any given season. If the survey work is situated away from active fishing areas or occurs 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 § 5.7.4.1. 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 may 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 § 5.7.4.1.

While some of the behavioural effects studies report decreases in catch rates near seismic survey areas, there is some disagreement on the duration and geographical extent of the effect.

Mitigations are discussed in § 5.5. The primary measures intended to minimize the effects of Project activities on the Fisheries VEC include:

- Good communication between the Operator and fishers/researchers;
- Spatial and temporal avoidance of areas where concentrated fishing is occurring; and
- Deployment of at least one FLO on each seismic vessel.

It is imperative that detailed temporal and spatial information regarding seismic and fishing/research surveying operations be exchanged between the various parties. This will allow the establishment of temporal and spatial separation plan, as has been successfully done with DFO Newfoundland and Labrador in past seasons.

Relative to the effects predictions for a single 2D or 3D seismic survey, the potential residual effects on fisheries related to sound from three simultaneous 3D seismic surveys and one 2D seismic survey is predicted to occur over a larger area (i.e., maximum geographic extent of $1001\text{--}10,000\text{ km}^2$ vs. $101\text{--}1000\text{ km}^2$). With mitigation measures in place (see § 5.5 and above), residual effects on the Fisheries VEC associated with sound from the Project during simultaneous 3D seismic surveys and one 2D seismic survey are predicted to range from *low to medium* in magnitude for a duration of *<1 month to 1–12 months* over an area of *<1 km² to 1001–10,000 km²* (Table 5.6). Based on these criteria ratings, the *reversible* residual effects of underwater sound on the Fisheries VEC are predicted to be *not significant*, and the level of confidence associated with this prediction is *low to medium* (Table 5.7) given the scientific data gaps.

5.7.5.2 Vessel/Equipment Presence

Commercial fish harvesting activities occur throughout the May–November temporal scope period for the proposed Project. Fishing with fixed gear (e.g., pot fishery for snow crab) poses the highest potential for conflict. During 2D/3D/4D seismic surveying, operations will be conducted continuously unless weather or technical issues cause interruptions. The length of the seismic streamers (maximum of 12,000 m) used during MKI's seismic operations during 2018–2023 will restrict the maneuverability of the seismic vessel, such that other mobile 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 area. Gear deployment will be conducted within the Project Area only. If conflict events occur resulting in gear damage or loss, compensation will be paid.

Table 5.6 Assessment of Effects of Project Activities on the Fisheries VEC.

Valued Environmental Component: Fisheries								
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
Sound								
Airgun Array (2D, 3D and 4D)	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	1-2	1-5	6	1-2	R	2
Seismic Vessel	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1-2	R	2
Supply Vessel	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	1	1	R	2
Escort Vessel	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1-2	R	2
Echo Sounder	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1	R	2
Side Scan Sonar	Disturbance (N); Effect on catch rate (N)	Spatial & temporal avoidance; communication	0	1	6	1	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Conflict with gear (N) ^a	FLO; communication	0-1	1-3	6	1-2	R	2
Supply Vessel	Conflict with gear (N) ^a	FLO; communication	0-1	1-3	1	1	R	2
Escort Vessel	Conflict with gear (N) ^a	FLO; communication	0-1	1-3	6	1-2	R	2
Sanitary/Domestic Wastes	Taint (N); Perceived taint (N)	Treatment	0-1	1	4	1-2	R	2
Accidental Releases	Taint (N); Perceived taint (N)	Preventative protocols; response plan; communications	0-1	1-2	1	1	R	2
Key:								
Magnitude: 0 = Negligible 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								
Note: ^a This is considered negligible since, if a conflict occurs, compensation will eliminate any economic impact.								

Table 5.7 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
Sound				
Airgun Array (2D, 3D and 4D)	NS	1-2	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Echo Sounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Vessel/Equipment Presence				
Seismic Vessel (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Accidental Releases	NS	2-3	-	-
<p>Key:</p> <p>Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km².</p> <div style="display: flex; justify-content: space-between;"> <div> <p>Residual environmental Effect Rating:</p> <p>S = Significant Negative Environmental Effect</p> <p>NS = Not-significant Negative Environmental Effect</p> <p>P = Positive Environmental Effect</p> <p>Level of Confidence: based on professional judgment:</p> <p>1 = Low</p> <p>2 = Medium</p> <p>3 = High</p> <p>Note:</p> <p>^a Considered only in the case where 'significant negative effect' is predicted.</p> </div> <div> <p>Probability of Occurrence: based on professional judgment:</p> <p>1 = Low Probability of Occurrence</p> <p>2 = Medium Probability of Occurrence</p> <p>3 = High Probability of Occurrence</p> <p>Scientific Certainty: based on scientific information and statistical analysis or professional judgment:</p> <p>1 = Low</p> <p>2 = Medium</p> <p>3 = High</p> </div> </div>				

Mitigations relevant to Fisheries VEC are discussed in § 5.5. Mitigations measures intended to minimize the effects of vessel and equipment presence on the Fisheries VEC include:

- Good communication between the Operator and fishers/researchers;
- Spatial and temporal avoidance of areas where concentrated fishing is occurring;
- Deployment of at least one FLO on each seismic vessel;
- Single Point of Contact (SPOC); and
- Compensation for gear damage and/or loss.

With application of the mitigations discussed in § 5.5 and above, the residual effects of vessel and equipment presence on the Fisheries VEC are predicted to have a *negligible to low* magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 to 11–100 km²* (see Table 5.6). Based on these criteria ratings, the *reversible* residual effects of vessel/gear presence associated with MKI's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (see Table 5.7). The level of confidence associated with this prediction is *high* (see Table 5.7).

5.7.5.3 Sanitary/Domestic Wastes

As indicated in § 5.7.3, appropriate treatment of wastes produced by the Project will result in residual effects that are *negligible to low* in magnitude for a duration of *<1 month to 1–12 months* over a geographic area of *<1 km²* (see Table 5.6). Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic wastes produced during MKI's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (see Table 5.7). The level of confidence associated with this prediction is *high* (see Table 5.7).

5.7.5.4 Accidental Releases

In the event of an accidental release of hydrocarbons (e.g., fuel spill), there is the 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, 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 an actual or perceived tissue tainting. 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 (C-NLOPB 2017b). Compensation protocols based on C-NLOPB Guidelines (C-NLOPB 2017b) are described in § 3.2.5.5 of the Eastern Newfoundland SEA (C-NLOPB 2014).

With application of the mitigations discussed above, the residual effects of accidental hydrocarbon releases on the Fisheries VEC are predicted have a *negligible to low* magnitude for a duration of *<1 month* over a geographic area of *<1 to 1–10 km²* (see Table 5.6). Based on these criteria ratings, the *reversible* residual effect of accidental releases associated with MKI's proposed 2D/3D/4D seismic program on the Fisheries VEC is predicted to be *not significant* (see Table 5.7). The level of confidence associated with this prediction is *medium to high* (see Table 5.7).

5.7.6 Marine-associated Bird VEC

All potential interactions of the Project activities and the Marine-associated Bird VEC are indicated in Table 5.8. The routine Project activity that has the highest probability of affecting marine-associated birds is ‘vessel lights’.

Table 5.8 Potential Interactions between Project Activities and the Marine-associated Bird VEC.

Project Activities	Valued Environmental Component: Marine-associated Birds
Sound	
Airgun Array (2D, 3D and 4D)	X
Seismic Vessel	X
Supply Vessel	X
Escort Vessel	X
Helicopter	X
Echo Sounder	X
Side Scan Sonar	X
Vessel Lights	X
Vessel/Equipment Presence	
Seismic Vessel and Equipment	X
Supply Vessel	X
Escort Vessel	X
Sanitary/Domestic Waste	X
Atmospheric Emissions	X
Garbage^a	
Helicopter Presence	X
Shore Facilities^b	
Accidental Releases	X
Other Projects and Activities in Regional Area	
Oil and Gas Activities	X
Fisheries	X
Marine Transportation	X
Note:	
^a Not applicable as garbage will be brought ashore.	
^b There will not be any new onshore facilities. Existing infrastructure will be used.	

5.7.6.1 Sound

The effect of exposure to anthropogenic underwater sound on birds has not been well studied. Subsections 5.7.6.1 of LGL (2015a), and LGL (2015b) describe the interaction between birds and sound.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related sound on the Marine-associated Bird VEC. With mitigation measures in place (see Table 5.1), residual effects of three simultaneous seismic surveys and one 2D seismic survey on seabirds are

predicted to range from *negligible to low* in magnitude for a duration of *<1 month to 1–12 months* over an area of *<1 to 1–10 km²*. Based on these criteria ratings, the *reversible* residual effects of simultaneous seismic surveys on the Marine-associated Bird VEC are predicted to be *not significant*. The level of confidence associated with this prediction is *medium to high* (Table 5.10).

Table 5.9 Assessment of Potential Effects of Project Activities on the Marine-associated Bird VEC.

Valued Environmental Component: Marine-associated Birds								
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
Sound								
Airgun Array (2D, 3D and 4D)	Disturbance (N)	Ramp up of array	0-1	1-2	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Supply Vessel	Disturbance (N)		0	1	1	1	R	2
Escort Vessel	Disturbance (N)		0	1	6	1-2	R	2
Helicopter	Disturbance (N)		0-1	2	1	1	R	2
Echosounder	Disturbance (N)		0-1	1	6	1	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1	R	2
Vessel Lights	Attraction (N)	Reduce lighting (if possible); Monitoring; Seabird handling and release	1	1-3	2-3	1-2	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0	1-3	6	1-2	R	2
Supply Vessel	Disturbance (N)		0	1	1	1	R	2
Escort Vessel	Disturbance (N)		0	1	6	1-2	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment	0	1	4	1-2	R	2
Atmospheric Emissions	Air Contaminants (N)	Equipment maintenance	0	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1-2	R	2
Accidental Releases	Mortality (N)	Solid streamer; spill response	1-2	1-2	1	1	R	2
Key:								
Magnitude:		Frequency:	Reversibility:		Duration:			
0 = Negligible		1 = <11 events/yr	R = Reversible		1 = <1 month			
1 = Low		2 = 11-50 events/yr	I = Irreversible		2 = 1-12 months			
2 = Medium		3 = 51-100 events/yr	(refers to population)		3 = 13-36 months			
3 = High		4 = 101-200 events/yr			4 = 37-72 months			
		5 = >200 events/yr			5 = >72 months			
		6 = Continuous						
Geographic Extent:		Ecological/Socio-cultural and Economic Context:						
1 = <1 km ²		1 = Relatively pristine area or area not affected by human activity						
2 = 1-10 km ²		2 = Evidence of existing effects						
3 = 11-100 km ²								
4 = 101-1,000 km ²								
5 = 1,001-10,000 km ²								
6 = >10,000 km ²								

Table 5.10 Significance of the Potential Residual Effects of the Project Activities on the Marine-associated Bird VEC.

Valued Environmental Component: Marine-associated Birds				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood ^a	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D)	NS	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel Lights	NS	2-3	-	-
Vessel/Equipment Presence				
Seismic Vessel and Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Accidental Releases	NS	2	-	-
<p>Key:</p> <p>Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km².</p> <div> <div> Residual environmental Effect Rating: S = Significant Negative Environmental Effect NS = Not-significant Negative Environmental Effect P = Positive Environmental Effect </div> <div> Probability of Occurrence: based on professional judgment: 1 = Low Probability of Occurrence 2 = Medium Probability of Occurrence 3 = High Probability of Occurrence </div> </div> <div> <div> Level of Confidence: based on professional judgment 1 = Low 2 = Medium 3 = High </div> <div> Scientific Certainty: based on scientific information and statistical analysis or professional judgment: 1 = Low 2 = Medium 3 = High </div> </div> <p>Note: ^a Considered only in the case where 'significant negative effect' is predicted.</p>				

5.7.6.2 Vessel Lighting

Artificial lighting on ships at sea, offshore oil and gas drilling and production structures, coastal communities, and oceanic island communities is known to interact with marine-associated birds (see Table 5.8) and has often been implicated in the stranding of nocturnally-active seabirds and nocturnally-migrating land- and water-birds (Montevecchi et al. 1999; Gauthreaux and

Belser 2006; Montevecchi 2006; Ronconi et al. 2015). Subsection 5.7.6.2 of LGL (2015a,b) describes the interaction between birds and artificial light.

Bird attraction to artificial lighting at sea may be mitigated in a variety of ways. Recovering grounded seabirds and returning them to sea after their plumage has sufficiently dried greatly reduces mortality (Telfer et al. 1987; Le Corre et al. 2002; Abgrall et al. 2008; Rodríguez and Rodríguez 2009; ECCC 2017b). Reducing, shielding or eliminating skyward radiation from artificial lighting also appears to reduce the number of stranded birds (Reed et al. 1985; Rodríguez and Rodríguez 2009; Miles et al. 2010). A preliminary study of the effect of replacing white and red lights with green lights on an offshore natural gas production platform suggested that there was a reduction in the number of nocturnally-migrating birds attracted to the artificial lighting (Poot et al. 2008).

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related vessel lighting on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, artificial light produced by the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *low* in magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 to 11–100 km²*. Based on these criteria ratings, the *reversible* residual effects of artificial light associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *medium to high* (see Table 5.10).

5.7.6.3 Effects Assessment of other Routine Project Activities

Vessel/Equipment Presence

The potential effects of the physical presence of vessels and seismic gear are likely to be minimal. Seabirds may be attracted to the seismic, escort or supply vessel while prospecting for fish wastes associated with fishing vessels. Since there is little or no food made available by these vessels, seabirds are temporarily interested in the vessels and soon move elsewhere in search of food. Seabirds sitting on the water in the path of these vessels can easily evade the vessels and any equipment associated with the vessels.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related vessel/equipment presence on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, the presence of vessels and equipment associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* in magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 to 11–100 km²*. Based on these criteria ratings, the *reversible* residual effects of the presence of vessels and equipment associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Sanitary/Domestic Waste

Sanitary waste generated by the vessels will be macerated before subsurface discharge (see § 5.7.3). While it is possible that seabirds, primarily gulls, may be attracted to the sewage particles, the small amount discharged below surface over a limited period of time will not likely increase the far-offshore gull populations. Thus, any increase in gull predation on Leach's Storm-Petrels, as suggested by Wiese and Montevecchi (1999), is likely to be minimal. If this event occurs, the number of smaller seabirds involved will likely be low.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related sanitary and domestic waste on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, sanitary/domestic waste associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* in magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 km²*. Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic waste associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Atmospheric Emissions

Although atmospheric emissions could, in theory, affect the health of some resident seabirds, these effects will be *negligible* considering that emissions consisting of potentially harmful materials will be low and will rapidly disperse to undetectable levels. As indicated in § 5.7.1, atmospheric emission levels produced by the Project will be similar to those produced by other marine vessels not related to the Project.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related atmospheric emissions on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, atmospheric emissions associated with the Project are predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* in magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 to 1–10 km²*. Based on these criteria ratings, the *reversible* residual effects of atmospheric emissions associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Helicopter Presence

The potential effects of helicopters on the marine environment are mainly related to the sound they generate (see a review of the effects of sound on seabirds above) and not their physical presence.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related helicopter presence on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, helicopter presence associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible to low* in magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 to 1–10 km²*. Based on these criteria ratings, the *reversible* residual effects of the presence of helicopters associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Accidental Releases

All seabirds expected to occur in the Study Area, except Arctic Tern, spend considerable time resting on the water. Birds that spend most of their time on water, such as the murres, Dovekie and Atlantic Puffin, are the species most likely to incur negative effects from an accidental release of hydrocarbons. Northern Fulmar, the shearwaters and storm-petrels are attracted to sheens. The visual appearance of a hydrocarbon sheen would resemble a sheen of biological origin and may initially attract such species (Nevitt 1999). However, these species also search for food by olfaction, relying on the smell of chemicals found in their foods, such as dimethyl sulfide (e.g., Leach's Storm-Petrel; Nevitt and Haberman 2003). Upon investigation of a visually identified hydrocarbon sheen, such birds would find that its odour does not resemble that of any food item (Hutchison and Wenzel 1980). As a result, these birds would be unlikely to come in contact with a sheen during foraging. However, flocks of seabirds resting on the water would not necessarily leave the water if they drifted into an area with hydrocarbons.

An exposure to a surface release of hydrocarbons under calm conditions may harm or kill individual birds. Morandin and O'Hara (2016) demonstrated that it requires only a small amount of oil (e.g., 10 ml) to affect the feather structure of Common Murre and Dovekie with potential to lethally reduce thermoregulation. Such modifications to feather structure cause a loss of insulation, which in turn can result in mortality. However, the potential of accidental releases of hydrocarbons during the proposed seismic program is low and the evaporation/dispersion rate of any released hydrocarbons would be high.

Table 5.9 provides the details of the assessment of the effects of exposure to Project-related accidental releases of hydrocarbons on the Marine-associated Bird VEC, including appropriate mitigations. As indicated in Table 5.9, accidental releases of hydrocarbons associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *low to moderate* in magnitude for a duration of *<1 month* over a geographic area of *<1 to 1–10 km²*. Based on these criteria ratings, the *reversible* residual effects of the accidental release of hydrocarbons associated with MKI's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

5.7.7 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 (C-NLOPB 2008), previous EAs for seismic programs offshore Newfoundland and Labrador (e.g., LGL 2014, 2015a,b), and literature reviews (e.g., Richardson et al. 1995; Gordon et al. 2004; Stone and Tasker 2006; Nowacek et al. 2007; Southall et al. 2007; Abgrall et al. 2008; Gomez et al. 2016). Only new or updated information from these documents have been included in the impact assessment of the Project activities on marine mammals and sea turtles.

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, 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 5.11.

Table 5.11 Potential Interactions of the Project Activities and the Marine Mammal and Sea Turtle VEC.

Valued Environmental Component - Marine Mammal and Sea Turtle					
Project Activities	Toothed Whales	Baleen Whales	Pinnipeds	Polar Bear	Sea Turtles
Sound					
Airgun Array (2D, 3D and 4D)	X	X	X	X	X
Seismic Vessel	X	X	X	X	X
Supply Vessel	X	X	X	X	X
Escort Vessel	X	X	X	X	X
Helicopter	X	X	X	X	X
Echo Sounder	X	X	X	X	X
Side Scan Sonar	X	X	X	X	X
Vessel/Equipment Presence					
Seismic Vessel/Gear (2D, 3D and 4D)	X	X	X	X	X
Supply Vessel	X	X	X	X	X
Escort Vessel	X	X	X	X	X
Vessel Lights					
Helicopter Presence	X	X	X	X	X
Sanitary/ Domestic Wastes	X	X	X	X	X
Atmospheric Emissions	X	X	X	X	X
Accidental Releases	X	X	X	X	X
Garbage ^a					
Shore Facilities ^b					
Other Projects and Activities in Regional Area					
Oil and Gas Activities	X	X	X	X	X
Fisheries	X	X	X	X	X
Marine Transportation	X	X	X	X	X
Note:					
^a Not applicable as garbage will be brought ashore.					
^b There will not be any new onshore facilities. Existing infrastructure will be used.					

5.7.7.1 Sound

The potential effects of sound from airgun arrays on marine mammals and sea turtles constitute a common concern associated with seismic programs. Airgun arrays used during marine seismic operations introduce strong sound pulses into the water. These sound pulses could have several types of effects on marine mammals and sea turtles, and are the main issues 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 only a review of new information regarding the potential effects of airgun sounds on marine mammals and sea turtles. More comprehensive reviews of the relevant background information for marine mammals and sea turtles are provided in § 5.7.7.1 and Appendices 4 and 5 of LGL (2015a,b), § 5.3.1 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.5.1.5 and 4.5.1.6 of the Southern Newfoundland SEA (C-NLOPB 2010). The characteristics of airgun sounds are also summarized in Appendix 4 of LGL (2015a,b). Descriptions of the hearing abilities of marine mammals and sea turtles are also provided in Appendices 4 and 5, respectively, of LGL (2015a,b).

The potential effects of airgun sounds considered in this assessment include: (1) masking of natural sounds; (2) behavioural disturbance; (3) non-auditory physical or physiological effects; and (4) 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; Peng et al. 2015). Although the possibility cannot be entirely excluded, it is unlikely that the program would result in any cases of 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, behavioural effects may occur but effects are generally expected to be localized and short-term.

Masking

Erbe et al. (2015) recently reviewed communication masking in marine mammals. Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Guan et al. (2015) indicated that, in very shallow water environments (<15 m), the airgun inter-pulse sound field can exceed ambient noise levels by as much as 9 dB during relatively quiet conditions. The inter-pulse noise levels can also be related to the distance to the source, probably as a result of higher reverberant conditions in shallow water. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales occurring 2,000 km from a seismic source. However, based on past and current reviewed research, the potential for masking of marine mammal calls and/or important environmental cues from the proposed seismic program is considered low. Thus, masking is unlikely to be a significant issue for either marine mammals or sea turtles exposed to the sounds from the proposed seismic survey.

In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated sound levels, shift their peak frequencies, or otherwise change their vocal behaviour in response to airgun sounds (e.g., Blackwell et al. 2015) and shipping (e.g., Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Heiler et al. 2016; O'Brien et al. 2016; Parks et al. 2016a,b). Nonetheless, for humpback whales, Dunlop (2015) suggested a potential for masking with an increase in anthropogenic noise. Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. Harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016).

Disturbance

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. 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 (Nowacek et al. 2015).

Although baleen whales generally tend to avoid operating airguns, avoidance radii are variable. Stone (2015) examined data from 1,196 seismic surveys in the UK and adjacent waters and reported significant responses to airgun arrays of 500 in³ or more in volume for minke and fin whales. This included lateral displacement, change in swimming or surfacing behaviour, and indications that cetaceans remained near the water surface. Dunlop et al. (2015, 2016) reported that humpback whales responded to a vessel operating a 20 in³ airgun by decreasing their dive time and speed of southward migration. However, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway during ongoing seismic surveys outside of the fjord. Similarly, no large changes in grey whale movement, respiration, or distribution patterns were observed during a 4D seismic survey off Sakahlin Island, Russia (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a two-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible avoidance response to high sound levels in the area (Muir et al. 2016). Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, given that spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). Bowhead whales continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2015). Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2015).

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 mysticetes and some other odontocetes. Small and medium-sized odontocetes, including beaked whales, showed a significant response (e.g., lateral displacement, localized avoidance, or change in behaviour) to large airgun arrays of 500 in³ or more in volume, with the exception of Risso’s dolphin (Stone 2015). When investigating the auditory effects of multiple underwater impulses on bottlenose dolphins, Finneran et al. (2015) reported that at the highest exposure condition (peak sound pressure levels from 196–210 dB re 1 µPa), two of three dolphins tested exhibited anticipatory behavioural reactions to impulse sounds presented at fixed time intervals. Preliminary data from the Gulf of Mexico showed a correlation between reduced sperm whale acoustic activity during periods with airgun operations (Sidorovskaia et al. 2014). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbour porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013).

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. Stone (2015) found that grey seals were displaced by large airgun arrays of 500 in³ or more in volume as indicated by the lower detection rate during periods of seismic activity. Lallas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3,090 in³ airgun array in New Zealand during 2009. The results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds. When Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses, only mild behavioural responses were observed.

Based on available data, it is likely that sea turtles would exhibit behavioural changes and/or localized avoidance near a seismic vessel. In addition, Nelms et al. (2016) suggested that sea turtles could be excluded from critical habitats. However, turtles are considered rare in the Study Area.

Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels. Historically, research has focused on the low-frequency component of ship noise. Recent studies have also examined the medium- to high-frequency components of ship noise on

small toothed whales (Hermannsen et al. 2014; Dyndo et al. 2015; Li et al. 2015). Hermannsen et al. (2014) reported that the noise from vessels passing at a distance of 1,190 m can result in a reduction of the hearing range of >20 dB for harbour porpoise (at 1 and 10 kHz) and >30 dB (at 125 kHz) from vessels passing at a distance of 490 m or less. Dyndo et al. (2015) showed that low levels of high frequency components in vessel noise can result in stereotyped porpoising behavioural responses in harbour porpoise in almost 30% of passages. Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016) and porpoise (Teilmann et al. 2015). A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016).

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.

Hearing Impairment

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. Temporary Threshold Shift (TTS) has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (recently reviewed in Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage (i.e., Permanent Threshold Shift [PTS]), in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

There is recent evidence supporting the idea that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (e.g., Finneran 2015; Kastelein et al. 2015, 2016; Supin et al. 2016). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioural tests, Finneran et al. (2015) reported no measurable TTS in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun. However, auditory evoked potential measurements were more variable, with one dolphin showing a small (9 dB) threshold shift at 8 kHz.

Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbour porpoise. Several studies on TTS in porpoises indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes (e.g., Kastelein et al. 2015; Tougaard et al. 2016). Popov et al. (2017) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state).

Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2014, 2015).

When Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 μ Pa, no low-frequency TTS was observed. Hermannsen et al. (2015) concluded that there is little risk of hearing damage to pinnipeds and porpoises when using a single airgun in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns.

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 immediate area around the airguns. However, monitoring studies show that some sea turtles exhibit localized movement away from approaching airguns.

According to Nowacek et al. (2013), current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. 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 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 theoretically occur include stress (e.g., Lyamin et al. 2016), 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. Nonetheless, 10 cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016).

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. For the last two decades, the U.S National Marine Fisheries Service regulated that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 $\mu\text{Pa}_{\text{rms}}$. The corresponding limit for seals was set at 190 dB re 1 $\mu\text{Pa}_{\text{rms}}$ (NMFS 1995, 2000). According to NMFS, these sound levels were the received levels above which one cannot be certain that there will be no injurious effects, auditory or otherwise, to marine mammals. Since these regulations came into effect, it has been common for marine seismic surveys conducted in U.S. waters and some areas of Canada (Canadian Beaufort Sea and 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 $\mu\text{Pa}_{\text{rms}}$. 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.

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 were taken into account in certain environmental impact statements and small-take authorizations. However, new guidance for assessing the effects of anthropogenic sound on marine mammals has now been released by NMFS (2016). The new noise exposure criteria for marine mammals account for the now-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such as airgun pulses, the thresholds use dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat} . Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). DFO has not yet adopted any noise exposure criteria (DFO 2015c; Theriault and Moors-Murphy 2015).

For marine seismic programs in Newfoundland and Labrador, the C-NLOPB (2017b) requires 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 discussed in detail below.

Typical source levels of survey and support vessel navigational echosounder instruments are generally 180–200 dB re 1 μ Pa @ 1m_{rms}. The echosounder emits a single-beam at frequencies of 33 kHz and 200 kHz. While the seismic vessel(s) will not have a side scan sonar, support vessels associated with the program may employ some type of multibeam sonar. Depending on water depth and the level of precision required, multibeam echosounders operate at 100–700 kHz with maximum source levels of 200–215 dB re 1 μ Pa @ 1m_{rms}. The effects of underwater sound from vessels, the echo sounder, and the side scan sonar are not further discussed as their effects are generally considered minimal relative to sounds from airgun arrays.

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 and Sowerby's beaked whales). The killer whale and harbour porpoise have special status under COSEWIC (the harbour porpoise is also listed as threatened under Schedule 2 of SARA), but are not expected to occur in large numbers in the Project Area. Until recently (July 2016), the received sound level of 180 dB re 1 μ Pa_{rms} criterion was accepted by NMFS as a level that below which there is no physical effect on toothed whales. The new PTS onset acoustic thresholds for impulsive sounds for mid-frequency (MF) cetaceans consist of a peak SPL_{flat} of 230 dB and a SEL_{cum} of 185 dB. The PTS onset thresholds for high-frequency (HF) cetaceans are a peak SPL_{flat} of 202 dB and a SEL_{cum} of 155 dB. NMFS assumes that disturbance effects for toothed whales may occur at received sound levels at or above 160 dB re 1 μ Pa_{rms}. However, there is no good scientific basis for using this 160 dB criterion for odontocetes, rather 170 dB re 1 μ Pa_{rms} is likely a more realistic indicator of the isopleth within which disturbance is possible, at least for delphinids.

Hearing Impairment and Physical Effects

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on toothed whales that are *negligible* to *low* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *1–10 km²*. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI's proposed

2D/3D/4D seismic program on toothed whales are predicted to be *not significant* (Table 5.13). The level of confidence associated with this prediction is *medium* (Table 5.13).

Table 5.12 Assessment of Effects of Project Activities on Marine Mammals.

Valued Environmental Component: 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
Sound								
Airgun Array (2D, 3D and 4D)	Hearing Impairment (N) Physical Effects (N)	Pre-watch; Ramp-up; Delay start ^a ; Shutdown ^b	0-1	1-2	6	1-2	R	2
Airgun Array (2D, 3D and 4D)	Disturbance (N)	Pre-watch; Ramp-up; Delay start ^a ; Shutdown ^b	1-2	1-5	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1-2	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Helicopter	Disturbance (N)		0-1	1-2	1	1	R	2
Echo Sounder	Disturbance (N)		0-1	1	6	1-2	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1-2	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1-3	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0	1	1	1	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment; containment	0	1	4	1-2	R	2
Atmospheric Emissions	Surface Contaminants (N)	Low sulphur fuel	0	1	6	1-2	R	2
Accidental Releases	Injury/Mortality (N)	Solid streamer ^c ; Spill response	1	1-2	1	1	R	2
Key:								
Magnitude:			Frequency:		Reversibility:		Duration:	
0 = Negligible			1 = <11 events/yr		R = Reversible		1 = <1 month	
1 = Low			2 = 11-50 events/yr		I = Irreversible		2 = 1-12 months	
2 = Medium			3 = 51-100 events/yr		(refers to population)		3 = 13-36 months	
3 = High			4 = 101-200 events/yr				4 = 37-72 months	
			5 = >200 events/yr				5 = >72 months	
			6 = Continuous					
Geographic Extent:			Ecological/Socio-cultural and Economic Context:					
1 = <1 km ²			1 = Relatively pristine area or area not negatively affected by human activity					
2 = 1-10 km ²			2 = Evidence of existing negative effects					
3 = 11-100 km ²								
4 = 101-1,000 km ²								
5 = 1,001-10,000 km ²								
6 = >10,000 km ²								
Note:								
^a Ramp-up will be delayed if any marine mammal is sighted within the 500 m safety zone.								
^b The airgun arrays will be shutdown if an <i>endangered</i> (or <i>threatened</i>) marine mammal is sighted within 500 m of the array.								
^c Solid streamers will be used for all seismic surveys								

Table 5.13 Significance of Potential Residual Environmental Effects of Project Activities on the Marine Mammal VEC.

Valued Environmental Component: Marine Mammals				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood^a	
	Residual Environmental Effect Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D) – hearing/physical effects	NS	2	-	-
Airgun Array (2D, 3D and 4D) – behavioural effects	NS	1-2	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echo Sounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter Presence	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2	-	-
<p>Key:</p> <p>Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km².</p> <p>Residual Environmental Effect Rating: S = Significant Negative Environmental Effect NS = Not-significant Negative Environmental Effect P = Positive Environmental Effect</p> <p>Level of Confidence: based on professional judgment: 1 = Low 2 = Medium 3 = High</p> <p>Note: ^a Considered only in the case where 'significant negative effect' is predicted.</p> <p>Probability of Occurrence: based on professional judgment: 1 = Low Probability of Occurrence 2 = Medium Probability of Occurrence 3 = High Probability of Occurrence</p> <p>Scientific Certainty: based on scientific information and statistical analysis or professional judgment: 1 = Low 2 = Medium 3 = High</p>				

Disturbance

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual disturbance effects on toothed whales that are *low to medium* in magnitude for a duration of *<1 month to 1–12 months* over a geographic area of *<1 to 1001–10,000 km²*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI's proposed 2D/3D/4D seismic program on toothed whales are predicted to be *not significant* (see Table 5.13). Given the data gaps in baseline scientific data and the uncertainties of the effects of multiple simultaneous seismic surveys, the level of confidence associated with this prediction is *low to medium* (see Table 5.13).

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., North Atlantic right, blue, and fin whale). Until recently, as with toothed whales, the 180 dB re 1 $\mu\text{Pa}_{\text{rms}}$ criterion was used by NMFS when estimating the area within which hearing impairment and/or physical effects may occur for baleen whales (although there are no data to support this criterion for baleen whales). The new PTS onset acoustic thresholds for impulsive sounds for low-frequency (LF) cetaceans consist of a peak SPL_{flat} of 219 dB and a SEL_{cum} of 183 dB. For all baleen whale species, NMFS assumes that disturbance effects (avoidance) may occur at sound levels greater than 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$.

Hearing Impairment and Physical Effects

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on baleen whales that are *negligible to low* in magnitude for a duration of *<1 month to 1–12 months* over a geographic area of *<1 to 1–10 km²*. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI's proposed 2D/3D/4D seismic program on baleen whales are predicted to be *not significant* (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Disturbance

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals. As indicated in Table 5.12, sound produced as a result of the

proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual disturbance effects on baleen whales that are *low to medium* in magnitude for a duration of *<1 month to 1–12 months* over a geographic area of *<1 to 1001–10,000 km²*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI’s proposed 2D/3D/4D seismic program on baleen whales are predicted to be *not significant* (see Table 5.13). Given the data gaps in baseline scientific data and the uncertainties of the effects of multiple simultaneous seismic surveys, the level of confidence associated with this prediction is *low to medium* (see Table 5.13).

Pinnipeds and Polar Bears

Until recently, the 190 dB re 1 $\mu\text{Pa}_{\text{rms}}$ criterion was used by NMFS when estimating the area within which hearing impairment and/or physical effects may occur for pinnipeds (and polar bears). The new PTS onset acoustic thresholds for impulsive sounds for pinnipeds in water (PW) consist of a peak SPL_{flat} of 218 dB and a SEL_{cum} of 185 dB. For all pinnipeds, NMFS assumes that disturbance effects (avoidance) may occur at sound levels greater than 160 dB re 1 $\mu\text{Pa}_{\text{rms}}$. However, seals are not expected to be abundant within the Study Area, particularly during the time period when seismic operations will likely occur. Similarly, polar bears are expected to occur in the Study Area in very low numbers and will most likely be associated with ice.

Hearing Impairment and Physical Effects

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on seals that are *negligible to low* in magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 to 1–10 km²*. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI’s proposed 2D/3D/4D seismic program on seals are predicted to be *not significant* (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Disturbance

Table 5.12 provides the details of the assessment of the effects of exposure to Project-related sound on marine mammals. As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual disturbance effects on seals (and polar bears) that are *low to medium* in magnitude for a duration of *<1 to 1–12 months* over a geographic area of *<1 to 101–1000 km²*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI’s proposed 2D/3D/4D seismic program on

seals (and polar bears) are predicted to be *not significant* (see Table 5.13). The level of confidence associated with this prediction is *medium* (see Table 5.13).

Assessment of Effects of Sound on Sea Turtles

Sea turtles have received very little research attention when compared to marine mammals and fishes (Nelms et al. 2016). Although it is possible that exposure to airgun sounds could cause either mortality or mortal injuries in sea turtles close to the source, this has not been demonstrated and seems highly unlikely (Popper et al. 2014). Nonetheless, Popper et al. (2014) proposed sea turtle mortality/mortal injury criteria of 210 dB SEL or >207 dB_{peak} for sounds from seismic airguns. The effects of underwater sound from vessels, the echo sounder, and the side scan sonar are not further discussed as potential effects are considered minimal relative to airguns.

Hearing Impairment and Physical Effects

Table 5.14 provides the details of the assessment of the effects of exposure to Project-related sound on sea turtles. As indicated in Table 5.14, sound produced as a result of the proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual hearing impairment/physical effects on sea turtles that are *negligible* to *low* in magnitude for a duration of <1 to 1–12 months over a geographic area of <1 to 1–10 km². Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with MKI's proposed 2D/3D/4D seismic program on sea turtles are predicted to be *not significant* (Table 5.15). The level of confidence associated with this prediction is *medium* (Table 5.15).

Disturbance

Table 5.14 provides the details of the assessment of the effects of exposure to Project-related sound on sea turtles. As indicated in Table 5.14, sound produced as a result of the proposed Project (airgun array sound during three concurrent 3D surveys and a 2D survey being the worst-case scenario) is predicted to have residual disturbance effects on sea turtles that are *low* in magnitude for a duration of <1 to 1–12 months over a geographic area of <1 to 101–1000 km². Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with MKI's proposed 2D/3D/4D seismic program on sea turtles are predicted to be *not significant* (Table 5.15). The level of confidence associated with this prediction is *medium* (Table 5.15).

5.7.7.2 Helicopter Sound

Information on interactions between helicopter sound and marine mammals and sea turtles is available in § 5.8.7.2 of the MKI Labrador SEA EA (LGL 2014), § 5.7.7.2 of the WesternGeco

Eastern Newfoundland EA (LGL 2015a) and WesternGeco Southeastern Newfoundland EA (LGL 2015b), and § 5.3.1 of the Eastern Newfoundland SEA (C-NLOPB 2014).

Table 5.14 Assessment of Effects of Project Activities on the Sea Turtle VEC.

Valued Environmental Component: 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
Sound								
Airgun Array (2D, 3D and 4D)	Hearing Impairment (N); Physical Effects (N)	Pre-watch; Ramp-up; Delay start ^a ; Shutdown ^b	0-1	1-2	6	1-2	R	2
Airgun Array (2D, 3D and 4D)	Disturbance (N)	Pre-watch; Ramp-up; Delay start ^a ; Shutdown ^b	1	1-4	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1-2	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Helicopter	Disturbance (N)		0-1	1-2	1	1	R	2
Echo Sounder	Disturbance (N)		0-1	1	6	1-2	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1-2	R	2
Vessel Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1-3	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0	1	1	1	R	2
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment; containment	0	1	4	1-2	R	2
Atmospheric Emissions	Surface Contaminants (N)	Low sulphur fuel	0	1	6	1-2	R	2
Accidental Releases	Injury/Mortality (N)	Solid streamer ^c ; Spill response	1	1-2	1	1	R	2
Key:								
Magnitude:			Frequency:			Reversibility:		Duration:
0 = Negligible			1 = <11 events/yr			R = Reversible		1 = <1 month
1 = Low			2 = 11-50 events/yr			I = Irreversible		2 = 1-12 months
2 = Medium			3 = 51-100 events/yr			(refers to population)		3 = 13-36 months
3 = High			4 = 101-200 events/yr					4 = 37-72 months
			5 = >200 events/yr					5 = >72 months
			6 = Continuous					
Geographic Extent:			Ecological/Socio-cultural and Economic Context:					
1 = <1 km ²			1 = Relatively pristine area or area not negatively affected by human activity					
2 = 1-10 km ²			2 = Evidence of existing negative effects					
3 = 11-100 km ²								
4 = 101-1,000 km ²								
5 = 1,001-10,000 km ²								
6 = >10,000 km ²								
Note:								
^a Ramp-up will be delayed if a sea turtle is sighted within the 500 m safety zone.								
^b The airgun arrays will be shutdown if an <i>endangered</i> or <i>threatened</i> sea turtle is sighted within 500 m of the array.								
^c A solid streamer will be used for all seismic surveys.								

Table 5.15 Significance of Potential Residual Environmental Effects of Project Activities on Sea Turtles.

Valued Environmental Component: Sea Turtles				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood^a	
	Residual Environmental Effect Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D) – hearing/physical effects	NS	2	-	-
Airgun Array (2D, 3D and 4D) – behavioural effects	NS	2	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echo Sounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter Presence	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2	-	-
<p>Key:</p> <p>Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km².</p> <p>Residual Environmental Effect Rating: S = Significant Negative Environmental Effect NS = Not-significant Negative Environmental Effect P = Positive Environmental Effect</p> <p>Level of Confidence: based on professional judgment: 1 = Low 2 = Medium 3 = High</p> <p>Note: ^a Considered only in the case where 'significant negative effect' is predicted.</p> <p>Probability of Occurrence: based on professional judgment: 1 = Low Probability of Occurrence 2 = Medium Probability of Occurrence 3 = High Probability of Occurrence</p> <p>Scientific Certainty: based on scientific information and statistical analysis or professional judgment: 1 = Low 2 = Medium 3 = High</p>				

Tables 5.12 and 5.14 provide the details of the assessment of the effects of exposure to Project-related helicopter sound on marine mammals and sea turtles, respectively, including appropriate mitigations. As indicated in Tables 5.12 and 5.14, sound produced by helicopters associated with the proposed Project is predicted to have residual disturbance effects on marine mammals and sea turtles that are *negligible* to *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1* to *1–10 km²*. Based on these criteria ratings, the *reversible* residual disturbance effects of helicopter sound associated with MKI's proposed 2D/3D/4D seismic program on marine mammals and sea turtles are predicted to be *not significant* (see Tables 5.13 and 5.15). The level of confidence associated with this prediction is *high* (see Tables 5.13 and 5.15).

5.7.7.3 Vessel/Equipment Presence

Information on interactions between vessel/equipment presence and marine mammals and sea turtles is available in § 5.7.7.3 of the WesternGeco Eastern Newfoundland EA (LGL 2015a) and WesternGeco Southeastern Newfoundland EA (LGL 2015b), § 5.3.1 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.5.9.3 of the Southern Newfoundland SEA (C-NLOPB 2010). This section includes only a review of new information regarding the potential effects of vessel/equipment presence on marine mammals and sea turtles.

During the proposed seismic program, there will be one seismic ship and an escort vessel on site during most of the program. A supply vessel will also regularly be present during the program. There is some risk for collision between marine mammals and vessels, but given the slow surveying speed (~5 knots; 9.3 km/h) of the seismic vessel (and its support vessels), this risk is likely to be minimal in spite of the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species (McKenna et al. 2015). Wiley et al. (2016) also concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. Marine mammal responses to ships are presumably responses to noise.

Sea turtles may also become entangled with seismic gear, such as cables, buoys, or streamers (Nelms et al. 2016) or collide with the vessel.

Tables 5.12 and 5.14 provide the details of the assessment of the effects of exposure to Project-related vessel/equipment presence on marine mammals and sea turtles, respectively, including appropriate mitigations. As indicated in Tables 5.12 and 5.14, vessel/equipment presence associated with the proposed Project is predicted to have residual effects on marine mammals and sea turtles that are *negligible* to *low* in magnitude for a duration of *<1* to *1–12 months* over a geographic area of *<1 km²* to *11–100 km²*. Based on these criteria ratings, the *reversible* residual effects of vessel/equipment presence associated with MKI's proposed 2D/3D/4D seismic program on marine mammals and sea turtles are predicted to be *not significant* (see Tables 5.13 and 5.15). The level of confidence associated with this prediction is *high* (see Tables 5.13 and 5.15).

5.7.7.4 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 support vessels. Any effects from these interactions are predicted to be *negligible* (see Tables 5.13 and 5.15).

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 support vessels. 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 § 5.8.7.4 of the MKI Labrador Sea EA (LGL 2014), § 5.7.7.4 of the WesternGeco Eastern Newfoundland EA (LGL 2015a), § 5.7.7.5 of the WesternGeco Southeastern Newfoundland EA (LGL 2015b), § 5.3 of the Eastern Newfoundland SEA (C-NLOPB 2014), § 4.6.4.5 and 4.6.4.6 of the Southern Newfoundland SEA (C-NLOPB 2010). Dupuis and Ucan-Marín (2015) and Helm et al. (2015) also reviewed the effects of oil on marine mammals and/or sea turtles. Whales and seals generally do not exhibit large behavioural or physiological responses to limited surface oiling, incidental exposure to contaminated food, or ingestion of oil. However, lung disease, adrenal toxicity, and low reproductive success were reported for bottlenose dolphins exposed to oil during the Deepwater Horizon spill (Schwacke et al. 2014; Lane et al. 2015; Venn-Watson et al. 2015). Acoustic data suggests that sperm whales foraged farther away from the spill site than before the spill, whereas Ziphiidae returned to the spill site to feed (Sidorovskaia et al. 2016). Sea turtles are thought to be more susceptible to the effects of oiling than marine mammals, but effects are believed to be primarily sublethal. Biomarkers showed that loggerhead turtles remained in the oiled areas after the Deepwater Horizon spill (Vander Zanden et al. 2016).

Tables 5.12 and 5.14 provide the details of the assessment of the effects of exposure to Project-related accidental releases of hydrocarbons on marine mammals and sea turtles, respectively, including appropriate mitigations. As indicated in Tables 5.12 and 5.14, accidental releases of hydrocarbons associated with the proposed Project are predicted to have residual effects on marine mammals and sea turtles that are *low* in magnitude for a duration of *<1 month* over a geographic area of *<1 to 1–10 km²*. Based on these criteria ratings, the *reversible* residual effects of accidental releases of hydrocarbons associated with MKI's proposed 2D/3D/4D seismic program on marine mammals and sea turtles are predicted to be *not significant* (see Tables 5.13 and 5.15). The level of confidence associated with this prediction is *medium* (see Tables 5.13 and 5.15).

5.7.8 Species at Risk VEC

Biological summaries of all species with an *endangered* or *threatened* status under Schedule 1 of the SARA and with reasonable likelihood of occurrence in the Study Area were provided in § 4.6, while overviews of species with *special concern* status under Schedule 1 of SARA were provided in § 4.2, § 4.4 and § 4.5 on fish and fish habitat, marine-associated birds and marine mammals and sea turtles, respectively. No critical habitat for any of these species/populations has been identified within the Study Area. As indicated in Table 4.16 in § 4.6, SARA Schedule 1 species/populations of relevance to the Study Area include:

- Northern, spotted and Atlantic wolffishes;
- Ivory Gull, Ross's Gull, Red Knot *rufa* subspecies, Buff-breasted Sandpiper, Harlequin Duck (Eastern population) and Barrow's Goldeneye (Eastern population);
- Blue whale (Atlantic population), beluga whale (St. Lawrence Estuary and Cumberland Sound populations), fin whale (Atlantic population), Sowerby's beaked whale and polar bear; and
- Leatherback sea turtle (Atlantic population) and loggerhead sea turtle.

Species/populations currently without status on Schedule 1 of SARA but listed on Schedules 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 this assessment of potential effects on the Species at Risk VEC. Instead, potential effects on these species/populations have been assessed in the appropriate VEC assessment section (i.e., § 5.7.4 [Fish and Fish Habitat], § 5.7.6 [Marine-associated Birds] and § 5.7.7 [Marine Mammals and Sea Turtles]) of this EA.

If species/populations currently without status do become listed on Schedule 1 of SARA during the temporal scope of the Project (2018–2023), the Proponent will re-assess these species/populations considering the prohibitions of SARA (including SARA sections 32(1) [Killing, harming, etc., listed wildlife species], 33 [damage or destruction of residence], and 58(1) [Destruction of critical habitat]), 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 ECCC. Potential interactions between Project activities and the Species at Risk VEC are indicated in Table 5.16. Only those species/populations with either *endangered* or *threatened* status under Schedule 1 of SARA (see Table 4.20) are included in the interactions table (Table 5.16). The potential effects of activities associated with MKI's seismic program are not expected to contravene the aforementioned prohibitions of SARA.

Table 5.16 Potential Interactions of Project Activities and the Species at Risk VEC.

Valued Environmental Component: Species at Risk				
Project Activities	Northern Wolffish	Ivory Gull	Blue Whale	Leatherback Sea Turtle
	Spotted Wolffish	Ross's Gull	Beluga Whale	Loggerhead Sea Turtle
Sound				
Airgun Array (2D, 3D and 4D)	X	X	X	X
Seismic Vessel	X	X	X	X
Supply Vessel	X	X	X	X
Escort Vessel	X	X	X	X
Helicopter		X	X	X
Echosounder	X	X	X	X
Side Scan Sonar	X	X	X	X
Vessel Lights		X		
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)		X	X	X
Supply Vessel		X	X	X
Escort Vessel		X	X	X
Sanitary/ Domestic Waste	X	X	X	X
Atmospheric Emissions	X	X	X	X
Garbage^a				
Helicopter Presence		X	X	X
Shore Facilities^b				
Accidental Releases	X	X	X	X
Other Projects and Activities in Regional Area				
Oil and Gas Activities	X	X	X	X
Fisheries	X	X	X	X
Marine Transportation	X	X	X	X
Note: ^a Not applicable as garbage will be brought ashore. ^b There will not be any new onshore facilities. Existing infrastructure will be used.				

5.7.8.1 Fish Species at Risk

The mitigation measure of ramping up the airgun array over a 30-minute period is expected to minimize the potential effects on wolffishes. As per the detailed effects assessment contained in § 5.7.4, physical effects of Project activities on the various life stages of wolffishes will have *negligible* to *low* magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1 km²* (Table 5.17). Based on these criteria ratings, the residual physical effects of activities associated with MKI's proposed seismic program on wolffishes are predicted to be *not significant* (Table 5.18). The level of confidence associated with this prediction is *high* (Table 5.18).

Table 5.17 Assessment of Effects of Project Activities on the Species at Risk VEC.

Valued Environmental Component: Species At Risk								
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
Sound								
Airgun Array (2D, 3D and 4D)	Disturbance (N) Hearing Impairment (N) Physical Effects (N)	Ramp-up; delay start ^a , shutdown ^b	0-2	1-5	6	1-2	R	2
Seismic Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1-2	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1-2	6	1-2	R	2
Helicopter	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1	R	2
Echosounder	Disturbance (N)		0-1	1	6	1	R	2
Side Scan Sonar	Disturbance (N)		0-1	1	6	1	R	2
Vessel Lights	Attraction (N); Mortality (N)	Reduce lighting (if safe); release protocols	0-1	1-2	2-3	1-2	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1-3	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Escort Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Sanitary/Domestic Waste	Increased food (N/P)	-	0-1	1	4	1-2	R	2
Atmospheric Emissions	Surface contaminants (N)	-	0	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1	R	2
Accidental Releases	Injury/Mortality (N)	Solid Streamer ^c ; Spill Response	0-2	1-2	1	1	R	2
Key:								
Magnitude:			Frequency:			Reversibility:		Duration:
0 = Negligible			1 = <11 events/yr			R = Reversible		1 = <1 month
1 = Low			2 = 11-50 events/yr			I = Irreversible		2 = 1-12 months
2 = Medium			3 = 51-100 events/yr			(refers to population)		3 = 13-36 months
3 = High			4 = 101-200 events/yr					4 = 37-72 months
			5 = >200 events/yr					5 = >72 months
			6 = Continuous					
Geographic Extent:			Ecological/Socio-cultural and Economic Context:					
1 = <1 km ²			1 = Relatively pristine area or area not negatively affected by human activity					
2 = 1-10 km ²			2 = Evidence of existing negative effects					
3 = 11-100 km ²								
4 = 101-1,000 km ²								
5 = 1,001-10,000 km ²								
6 = >10,000 km ²								
Note:								
^a Ramp-up will be delayed if a sea turtle is sighted within the 500 m safety zone.								
^b The airgun arrays will be shutdown if an <i>endangered</i> (or <i>threatened</i>) marine mammal or sea turtle is sighted within 500 m of the array.								
^c Solid streamers will be used for all seismic surveys.								

Table 5.18 Significance of Potential Residual Environmental Effects of Project Activities on the Species at Risk VEC.

Valued Environmental Component: Species At Risk				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood ^a	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D)	NS	1-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Accidental Releases	NS	2-3	-	-
<p>Key:</p> <p>Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km².</p> <p>Residual Environmental Effect Rating: S = Significant Negative Environmental Effect NS = Not-significant Negative Environmental Effect P = Positive Environmental Effect</p> <p>Level of Confidence (based on professional judgment): 1 = Low 2 = Medium 3 = High</p> <p>Probability of Occurrence (based on professional judgment): 1 = Low Probability of Occurrence 2 = Medium Probability of Occurrence 3 = High Probability of Occurrence</p> <p>Scientific Certainty (based on scientific information and statistical analysis or professional judgment): 1 = Low 2 = Medium 3 = High</p> <p>Note: ^a Considered only in the case where 'significant negative effect' is predicted.</p>				

Behavioural effects of Project activities on the various life stages of wolffishes are predicted to be *negligible to low* in magnitude for a duration of *<1 month to 1–12 months* over a geographic area of *<1 to 1001–10,000 km²* (see Table 5.17). Based on these criteria ratings, the residual behavioural effects of activities associated with MKI's seismic program on wolffishes are predicted to be *not significant* (see Table 5.18). The level of confidence associated with this prediction is *low to medium* (see Table 5.18) given the scientific data gaps.

5.7.8.2 Marine-associated Bird Species at Risk

Ivory Gull, Ross's Gull and Red Knot foraging behaviour would not likely expose them to underwater sound, and these species are unlikely to occur in the Study Area, particularly during the time when seismic surveys are likely to be conducted. Furthermore, Ivory Gulls, Ross's Gulls and Red Knots are not known to be prone to stranding on vessels. The mitigation measures of monitoring the seismic vessel, releasing stranded birds (in the unlikely event that an Ivory Gull, Ross's Gull or Red Knot did strand on the vessel) and ramping up the airgun array will minimize the potential effects on these seabird species at risk. With mitigation measures in place and as per the detailed effects assessment in § 5.7.6, the predicted effects of the Project on Ivory Gull, Ross's Gull and Red Knot will range from *negligible* to *medium* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *11–100 km²* (see Table 5.17). Based on these criteria ratings, the predicted effects of activities associated with MKI's proposed seismic program on Ivory Gull, Ross's Gull and Red Knot are predicted to be *not significant* (see Table 5.18). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.18).

5.7.8.3 Marine Mammal and Sea Turtle Species at Risk

Based on available information, blue and beluga whales, and leatherback and loggerhead sea turtles are not expected to occur regularly in the Study Area. No critical habitat for these species/populations has been identified in the Study Area. Mitigation and monitoring designed to minimize potential effects of airgun array noise on SARA-listed marine mammals and sea turtles will include:

- Ramp-up of the airgun array over a 30 min period;
- Monitoring by MMO(s) (with assistance from a FLO) during daylight hours that the airgun array is active and the 30 minutes pre-ramp up;
- Shutdown of the airgun array when an *endangered* or *threatened* marine mammal or sea turtle is detected within the 500 m safety zone;
- Delay of ramp-up if any marine mammal or sea turtle is detected within the 500 m safety zone.
- Use of PAM to detect cetaceans (details to be provided in EA Updates).

With these mitigation measures in place and as per the detailed effects assessment in § 5.7.7, the predicted effects of the Project on blue whales, beluga whales, leatherback sea turtles and loggerhead sea turtles will range from *negligible* to *medium* in magnitude for a duration of *<1 month* to *1–12 months* over a geographic area of *<1* to *1001–10,000 km²* (see Table 5.17). Based on these criteria ratings, the predicted effects of activities associated with MKI's proposed seismic program on blue whales, beluga whales, leatherback sea turtles, and loggerhead sea turtles are predicted to be *not significant* (see Table 5.18). The level of confidence associated with this prediction is *low* to *medium* (see Table 5.18) given the data gaps.

5.7.9 Sensitive Areas VEC

An overview of sensitive areas located either entirely or partially within the Study Area was provided in § 4.7. The habitat preferences of biota potentially inhabiting these sensitive areas, including invertebrates, fishes, marine mammals, sea turtles and marine-associated birds, were detailed in § 4.2 to 4.5, and species at risk were described in § 4.6.

Based on the conclusions of § 5.7.4 to 5.7.8, the residual effects of activities associated with MKI's seismic program on the Sensitive Areas VEC within the Study Area are predicted to be *not significant*. The level of confidence associated with this prediction is *medium*.

5.8 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 resulting from the MKI seismic program activities in the Project Area. This includes the residual effects of three concurrent 3D surveys and a 2D survey being conducted by MKI (see § 2.0). Considering the size of the Project Area, the likely considerable separation of the concurrent surveys, and the predictions of significance presented in § 5.7, the within-Project cumulative residual effects associated with concurrent MKI seismic surveys are predicted to be *not significant*. The level of confidence associated with this prediction ranges from low to high, depending on the Project activity and VEC.

It is also necessary to assess cumulative effects when considering other non-Project activities that are occurring or planned for the Regional Area. These activities include:

- Fisheries (commercial and research survey fishing);
- Marine transportation (e.g., cargo, defense, yachts, cruise ships); and
- Offshore oil and gas industry activities.

Duinker et al. (2012), in their review of work to date on the scientific dimensions of cumulative effects assessment (CEA), concluded that it is particularly difficult to properly implement CEA in project-specific EAs. They made several recommendations regarding revisions to guidance materials for science in CEA, including the following:

- A much richer and nuanced conceptual framework for a cumulative effect is required in order to describe how effects become cumulative;
- Clearer guidance regarding CEA analytical methods is required; and
- Better definitions of thresholds, without which it is really impossible to judge the significance of cumulative effects.

Duinker et al. (2012) concluded by saying that lack of competent CEA impairs our ability to determine the degree to which particular activities jeopardize the sustainability of VECs, and that improvements in CEA practice are desperately needed.

Until more robust methods of CEA are developed, the qualitative method used for EAs to date is again applied in this EA.

5.8.1 Fisheries

Fishing has been discussed and assessed in detail in § 4.3 and § 5.7.5. 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 seabirds that may strand on vessels) and thus, there will be *negligible* cumulative mortality effect. There is some potential for cumulative disturbance effect (e.g., fishing vessel noise) but there will be directed attempts by both industries to mitigate such effects by avoiding each other's active areas and times as much as possible. The seismic surveying will also spatially and temporally avoid DFO research vessels during multi-species trawl surveys. Any cumulative effects associated with fisheries are predicted to be *not significant*. The level of certainty associated with this prediction is *medium*.

5.8.2 Marine Transportation

The seismic survey vessels will not contribute much to overall marine traffic levels. 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. Thus, potential for cumulative effects with other shipping is predicted to be *low* and *not significant*. The level of certainty associated with this prediction is *medium*.

5.8.3 Other Oil and Gas Activities

Potential offshore oil and gas industry activities offshore Newfoundland and Labrador during 2018, based on current completed 'in-effect' and relevant EAs listed on the C-NLOPB public registry (www.cnlopb.nl.ca) include the following:

- Seitel Canada Ltd. East Coast Offshore Seismic Program, 2016–2025;
- CGG Services (Canada) Inc. Newfoundland Offshore 2D, 3D and 4D Seismic Program, 2016–2025;
- ExxonMobil Canada Ltd. Eastern Newfoundland Offshore Geophysical, Geochemical, Environmental and Geotechnical Program, 2015–2024;
- Suncor Energy Eastern Newfoundland Offshore Area 2D/3D/4D Seismic Program, 2014–2024;

- Bridgeport Holdings Ltd. and JEBSCO Seismic Company North Flemish Pass Gravity Survey, 2015–2019;
- MG3 (Survey) UK Limited Offshore Labrador Geochemical and Seabed Sampling Program, Newfoundland and Labrador Offshore Area, 2015–2024;
- HMDC Ltd. 2D/3D/4D Seismic Projects for the Hibernia Oil and Gas Production Field, 2013 to Remaining Life of Field;
- GXT Technology Canada Ltd. GrandSPAN Marine 2D Seismic, Gravity and Magnetic Survey, 2014–2018;
- TGS NOPEC Geophysical Company ASA and Multiklient Invest AS Offshore Labrador Seafloor and Seabed Sampling Program, Newfoundland and Labrador Offshore Area, 2014–2019;
- Husky Energy Jeanne d’Arc Basin/Flemish Pass Regional Seismic Program, 2012–2020;
- Statoil (now Equinor) Canada Limited 2011–2019 Jeanne d’Arc and North Ridge/Flemish Pass Basin Geophysical Program;
- ExxonMobil Canada Properties Hebron Development Project;
- Hibernia Drill Centres Construction and Operations Program, 2009–2036; and
- Husky Energy Delineation/Exploration Drilling Program for Jeanne d’Arc Basin Area, 2008–2020.

There is potential for cumulative effects with other seismic programs that could operate in future years (see above list). Different seismic programs could potentially be operating in relatively close proximity. During these periods, VECs may be exposed to noise from more than one of the seismic survey programs. It will be in the interests of the different parties to arrange for good coordination between programs in order to provide sufficient buffers and to minimize acoustic interference. Assuming maintenance of sufficient separation of seismic vessels operating concurrently in the Project Area, cumulative effects of seismic sound on fish and fish habitat, fisheries, marine-associated birds, marine mammals, sea turtles, species at risk and sensitive areas are predicted to be *not significant*. However, there are uncertainties regarding this prediction, particularly regarding effects of masking on marine mammals from sound produced during multiple seismic surveys. The potential for temporal and spatial overlap of future activity of seismic programs (2018 and beyond) in the area will be considered in the EA update process. Uncertainty due to the large Study Area will be reduced as specific survey designs that likely cover smaller areas become available.

As discussed in this EA, negative effects (auditory, physical, and behavioural) on key sensitive VECs, such as marine mammals, appear unlikely beyond a localized area from the sound source. In addition, all programs will use mitigation measures such as ramp-ups, delayed startups, shutdowns of the airgun arrays, and spatial separation between seismic surveys.

Cumulative effects associated with other oil and gas activities in the Regional Area are predicted to be *not significant*. The level of certainty associated with this prediction is *low to medium*.

The cumulative effects associated with this Project will be re-visited in each subsequent EA Update.

5.9 Mitigation Measures and Follow-up

Project mitigation measures are summarized in this section, both in the text and in Table 5.19. MKI will adhere to mitigation and monitoring requirements detailed in Appendix 2 of the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2017b) including those in the *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment*.

Fishers who may be operating in the area will be notified of the timing and location of planned activities by means of a CCG “Notice to Mariners”. If necessary, individual fixed gear fishers will be contacted to arrange mutual avoidance. Any incidents of contact with fishing gear with any identifiable markings will be reported to the C-NLOPB within 24 h of the contact (in accordance with the C-NLOPB Incident Reporting and Investigation Guidelines). Fishing gear may only be retrieved from the water by the gear owner (i.e., fishing license owner). This includes buoys, radar reflectors, ropes, nets, pots, etc., associated with fishing gear and/or activity. If gear contact is made during seismic operations, it should not be retrieved or retained by the seismic vessel. There are conditions that may warrant gear being retrieved or retained if it becomes entangled with seismic gear, however, further clarification on rules and regulations regarding fishing gear should be directed to the Conservation and Protection Division of Fisheries and Oceans Canada (NL Region). MKI will advise the C-NLOPB prior to compensating and settling all valid lost gear/income claims promptly and satisfactorily.

MKI will also ensure that a “Notice to Mariners” would be issued for all underwater activities and any significant surface ventures as defined by the DND in LGL (2017b), such as the use of flares, buoys or unconventional night lighting. Although there are currently no plans for such activities, a “Notice to Airmen” would also be issued for all activities that could affect air safety, such as the use of balloons, Unmanned Aerial Vehicles (UAVs) or tethered airborne devices.

Specific mitigations to minimize potential conflicts and any negative effects with other vessels include:

- Timely and clear communications (VHF, HF Satellite, etc.);
- Utilization of FLOs during 2D/3D/4D seismic programs for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- Utilization of experienced, qualified MMO(s);
- Posting of advisories with the Canadian Coast Guard;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact (SPOC).

Table 5.19 Summary of Mitigations Measures by Potential Effect.

VEC, Potential Effects	Primary Mitigations
Fisheries VEC: Interference with fishing vessels/mobile and fixed gear fisheries	<ul style="list-style-type: none"> • Pre-survey communications, liaison and planning to avoid fishing activity • Continuing communications throughout the program • FLOs • SPOC • Advisories and communications • VMS data • Avoidance of actively fished areas • Start-up meetings on ships that discuss fishing activity and communication protocol with fishers
Fisheries VEC: Fishing gear damage	<ul style="list-style-type: none"> • Pre-survey communications, liaison and planning to avoid fishing gear • Use of escort vessel • SPOC • Advisories and communications • FLOs • Compensation program • Reporting and documentation • Start-up meetings on ships that discuss fishing activity, communication protocol with fishers, and protocol in the event of fishing gear damage
Interference with shipping ^a	<ul style="list-style-type: none"> • Advisories and at-sea communications • FLOs (fishing vessels) • Use of escort vessel • SPOC (fishing vessels) • VMS data
Fisheries VEC: Interference with DFO/FFAW research program	<ul style="list-style-type: none"> • Communications and scheduling • 7-day/30-km temporal/spatial avoidance protocol ^b
Fish and Fish Habitat, Marine Mammal and Sea Turtle, and Marine-associated Bird VECs: Temporary or permanent hearing damage/disturbance to marine animals (marine mammals, sea turtles, seabirds, fish, invertebrates)	<ul style="list-style-type: none"> • “Pre-watch” (30 minute) of 500 m safety zone using visual and PAM • Delay start-up if any marine mammals or sea turtles are detected within 500 m with visual and PAM • Ramp-up of airguns • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during all daylight periods when airguns are in use • Minimum separation distance of 30 km for simultaneous seismic surveys in the Project Area based on separation distances required in other jurisdictions (i.e., Gulf of Mexico [G. Morrow, PGS, Senior Contract Manager, pers. comm., June 2017] and Greenland [LGL 2012]).
Species at Risk and Sensitive Areas VEC: Temporary or permanent hearing damage/ disturbance to Species at Risk or other key habitats	<ul style="list-style-type: none"> • “Pre-watch” (30 minute) of 500 m safety zone using visual and PAM • Delay start-up if any marine mammals or sea turtles are detected within 500 m with visual and PAM • Ramp-up of airguns • Shutdown of airgun arrays for <i>endangered</i> or <i>threatened</i> marine mammals and sea turtles within 500 m • Use of experienced, qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. • Use of PAM for cetaceans (details to be provided in EA Updates) • Minimum separation distance of 30 km for simultaneous seismic surveys in the Project Area based on separation distances required in other jurisdictions (see above).
Marine-associated Bird VEC: Injury (mortality) to stranded seabirds	<ul style="list-style-type: none"> • Daily search of seismic and support vessels • Implementation of handling and release protocols • Minimize lighting if safe
Marine-associated Bird VEC: Seabird oiling	<ul style="list-style-type: none"> • Adherence to MARPOL • Adherence to conditions of ECCC-CWS migratory bird permit • Spill contingency and response plans • Use of solid streamer

Note:

^a MKI will engage CTF 84, through Director General Naval Strategic Readiness (DGNSR), to ensure de-confliction with possible Allied submarine activities.

^b DFO does not indicate an official spatial and/or temporal buffer mitigation method for seismic operations in the vicinity of survey stations. MKI will work cooperatively with FFAW/Unifor and DFO in an effort to avoid survey stations prior to their sampling to the best extent possible.

MKI will also coordinate with the FFAW|Unifor and DFO to avoid any potential conflicts with fishing and research surveys that may be operating in the area. MKI commits to ongoing communications with other operators with active seismic programs within the general vicinity of its seismic program to minimize the potential for cumulative effects on VECs.

As stated earlier in this EA, there will be full opportunity for adaptive mitigation during MKI's proposed six-year program. If there are any new techniques developed during the six-year period that may help to further mitigate environmental effects, they will be investigated and incorporated into the program if deemed useful. Annual updates of the EA that will be prepared during the six-year scope of the Project will include any relevant new information related to mitigation not provided in the EA.

Mitigation measures designed to reduce the likelihood of effects on marine mammals and sea turtles will include ramp ups (during all periods of day and night), no initiation of airgun array if a marine mammal or sea turtle is detected 30 min prior to ramp up within 500 m safety zone of the energy source, and shutdown of the energy source if an *endangered* or *threatened* whale or sea turtle is detected within the 500 m safety zone. Prior to the onset of the seismic survey, the airgun array will be gradually ramped up, with the intention of providing a warning to marine fauna before they are exposed to the higher sound levels from the full airgun array. One airgun will be activated first and then the volume of the array will be increased gradually over a recommended 30-min period. An MMO aboard the seismic ship will watch for marine mammals and sea turtles 30 min prior to ramp up. If a marine mammal or sea turtle is detected within 500 m of the array, then ramp up will not commence until the animal has moved beyond the 500 m zone or 30 min have elapsed since the last detection. MKI will also operate a single airgun (lowest volume) during line changes and require that a ramp up occurs during the transition from the single airgun to the full array, which exceeds the requirement under the *Statement of Canadian Practice*. The observers will watch for marine mammals and sea turtles during daylight periods and note the location and behaviour of these animals. Visual monitoring and PAM will be implemented. The aspects of the monitoring and mitigation plan include the use of the ship's bridge for MMOs from which to conduct observations (i.e., good sight lines all around the vessel), and the use of reticle binoculars and other distance estimators to accurately estimate the location of the animal with respect to the safety zone. The seismic array will be shut down whenever marine mammals or sea turtles with either *endangered* or *threatened* status under Schedule 1 of *SARA* are detected within the safety zone. Additionally, shut downs will be implemented for all beaked whales that are detected within the 500-m safety zone, which exceeds the requirements in the *Statement of Practice*. The planned monitoring and mitigation measures will minimize the already low probability of exposure of marine animals to sounds strong enough to induce hearing impairment. Any dead or distressed marine mammals or sea turtles will be recorded and reported to the C-NLOPB.

Any seabirds that become stranded on a vessel 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.), and *Procedures for Handling and Documenting Stranded Birds Encountered on Infrastructure Offshore Atlantic Canada [Draft May 2017]* (ECCC 2017b). Data collection for seabirds at sea will be in accordance with Gjerdrum et al. (2012). It is understood by MKI that an ECCC-CWS *Migratory Birds Permit* will be required and that it will be secured as it has been in the past. MKI will adhere to the conditions stipulated on the CWS permit. In the unlikely event that marine mammals, sea turtles or seabirds are injured or killed by Project equipment or accidental releases of hydrocarbons, a report will immediately be filed with the appropriate agencies (ECCC-CWS, C-NLOPB) and the need for follow-up monitoring will be assessed.

Marine mammal and seabird observations will be made during ramp-ups and data acquisition periods, as well as at other times on an opportunistic basis. As per the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2017b), monitoring protocols for marine mammals and sea turtles will be consistent with those developed by LGL and outlined in Moulton and Mactavish (2004). Seabird data collection protocols will be consistent with those provided by CWS in Gjerdrum et al. (2012). Data will be collected by qualified and experienced MMOs and a monitoring report will be submitted to the C-NLOPB.

MKI will also coordinate with DFO, St. John's, and the FFAW|Unifor to avoid any potential conflicts with either survey vessels that may be operating in the area or survey stations in the area (e.g., Industry-DFO-FFAW|Unifor Collaborative Post-Season Trap Survey for Snow Crab). MKI commits to ongoing communications with other operators with active seismic programs within the general vicinity of its seismic program to minimize the potential for cumulative effects on the VECs.

5.10 Assessment Summary

A summary of the significance ratings of residual effects of MKI's proposed seismic program on the environment are shown in Table 5.20. Confidence levels are also provided in the table. In summary, the residual effects of MKI's proposed seismic program on the VECs are predicted to be *not significant*.

Table 5.20 Significance of Potential Residual Environmental Effects of MKI's Proposed Seismic Program on VECs in the Study Area.

Valued Environmental Components: Fish and Fish Habitat, Fisheries, Marine-associated Birds, Marine Mammals and Sea Turtles, Species at Risk, Sensitive Areas				
Project Activity	Significance of Predicted Residual Environmental Effects		Likelihood^a	
	Significance Rating	Level of Confidence	Probability of Occurrence	Scientific Certainty
Sound				
Airgun Array (2D, 3D and 4D)	NS	1-3	-	-
Seismic Vessel	NS	2-3	-	-
Escort vessel	NS	2-3		
Supply Vessel	NS	2-3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Escort Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Accidental Releases	NS	2-3	-	-
<p>Key:</p> <p>Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km².</p> <div style="display: flex; justify-content: space-between;"> <div> <p>Residual environmental Effect Rating:</p> <p>S = Significant Negative Environmental Effect</p> <p>NS = Not-significant Negative Environmental Effect</p> <p>P = Positive Environmental Effect</p> <p>Level of Confidence: based on professional judgment:</p> <p>1 = Low</p> <p>2 = Medium</p> <p>3 = High</p> <p>Note:</p> <p>^a Considered only in the case where 'significant negative effect' is predicted.</p> </div> <div> <p>Probability of Occurrence: based on professional judgment:</p> <p>1 = Low Probability of Occurrence</p> <p>2 = Medium Probability of Occurrence</p> <p>3 = High Probability of Occurrence</p> <p>Scientific Certainty: based on scientific information and statistical analysis or professional judgment:</p> <p>1 = Low</p> <p>2 = Medium</p> <p>3 = High</p> </div> </div>				

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Appendix 1
Consultation Report

Labrador

As part of the EA of Multiklient Invest's (MKI) proposed 2017–2026 seismic program, consultations were undertaken with relevant Labrador government agencies, representatives of the fishing industry and other interest groups. The objectives of these consultations were to describe the proposed seismic program, identify any issues and concerns, and gather additional information relevant to the EA process.

MKI has been operating in the Labrador Sea offshore since 2011, and communication with interested groups has been maintained over this time. Relevant agencies, municipal governments and industry stakeholder groups contacted by either phone or email in mid-January 2017 are listed below. The link to MKI's Project Description document on the C-NLOPB website was provided to the contacted consultees.

- Cartwright Town Council;
- Town of Charlottetown;
- Labrador Choice Seafoods Inc, Charlottetown;
- Forteau Town Council;
- Town of Happy Valley-Goose Bay (HV-GB);
- NunatuKavut Community Council, HV-GB;
- Nunacor Development Corporation, HV-GB;
- Torngat Fish Producers Co-operative Society Inc., HV-GB;
- Torngat Secretariat, HV-GB;
- Town of L'Anse au Loup;
- Labrador Fishermen's Union Shrimp Company Ltd., L'Anse au Loup;
- Town of Mary's Harbor;
- Mary's Harbour Fishers' Committee, Mary's Harbour;
- Nunatsiavut Government (Department of Lands and Natural Resources), Nain;
- Nain Inuit Community Government, Nain;
- Town of North West River;
- Community of Pinsent's Arm;
- Town of Port Hope Simpson;
- Sheshatshiu First Nation Innu Band Council; and
- Innu Nation, Sheshatshiu.

During the period of 24–27 January 2017, both face-to-face meetings and public information sessions were held in two Labrador communities: (1) Mary's Harbour and (2) Happy Valley-Goose Bay (HV-GB). Table 1 provides more information on these consultations. Other consultations in Labrador were held in March 2017. Recent consultation meetings, focused on fishing, were held with the Fish, Food and Allied Workers (FFAW) and DFO. Following these, MKI attended a meeting with the crab fleet representatives to discuss and answer question about

the forthcoming season. Further imminent meetings are planned with FFAW, Ocean Choice and DFO to review the more detailed plans for the 2018 season.

Table 1. Labrador Consultations

Date	Community	Type of Consultation	Consultee
January 24, 2017	Mary's Harbour	Face-to-Face	Labrador Fishermen's Union Shrimp Company Ltd. (LFUSCL)
January 24, 2017	Mary's Harbour	Face-to-Face	Mayor
January 24, 2017	Mary's Harbour	Public Information Session	Public
January 25, 2017	HV-GB	Face-to-Face	Torngat Secretariat
January 26, 2017	HV-GB	Face-to-Face	Torngat Fish Co-op
January 26, 2017	HV-GB	Public Information Session	Public
January 27, 2017	HV-GB	Face-to-Face	Innu Nation

Issues and Concerns

Comments and responses received to date from various stakeholders are provided below.

Mary's Harbour

Labrador Fishermen's Union Shrimp Company Ltd. (LFUSCL)

LFUSCL's Fisheries Advisor attended the consultation meeting with MKI. He expressed general concerns about the Hawke Channel DFO Fisheries Closure Area and indicated that he would return at the public information session that evening to further discuss the proposed program with other community members.

Mayor

Like the LFUSCL's Fisheries Advisor, the Mayor of Mary's Harbour (and FFAW Inshore Council Member – Henley Harbour to Cartwright) expressed general concerns about the Hawke Channel DFO Fisheries Closure Area and indicated that he would return at the public information session that evening to further discuss the proposed program with other community members. This was agreed to be the best forum for an open discussion.

Public Information Session

Following a presentation by MKI's representative, attending participants had comments and questions. The main concern regarded plans for the Hawke Channel DFO Fisheries Closure Area. MKI indicated that it has no intention of collecting seismic data in this area. Their activities are driven by interest in the data and this does not appear to be an area of interest.

Question: How large are the areas up for bids?

Response: Typically 3,000–4,000 km².

Question: Do you get all the data from a ship or any from satellite?

Response: All the data is collected from a ship.

Question: How deep are you looking?

Response: A deep well could be 5 km deep.

Question: How deep are the streamers? Are they at the surface?

Response: The streamers are 20 m below the surface. Only the tail buoys at the end of the streamers are at the surface.

Question: In the past, we've asked you guys to stay outside of The Box (Hawke Channel DFO Fisheries Closure Area).

Response: We won't be looking to acquire in The Box. There is no anticipated interest or activity planned in The Box.

Question: The area in the northern part of the project area might have some corals. It could become a marine sensitive area.

Response: Nalcor has a desire to get some information in the northern portion of the Project Area so that educated decisions can be made in the future if an area is closed and inaccessible down the line.

Question: The work planned, it seems far off The Box.

Response: Yes, and most interest moving forward will be 3D-based. So it's a much smaller area being surveyed and over Exploration Licences.

Question: Is the work you are showing close to past work, like the Petro-Canada work in the 70s?

Response: We did some work there in the past, but there is little interest now.

Question: Husky, Chevron and another company bid on blocks that did nothing. Could they get extensions? Is the money lost?

Response: They did not ask for extensions. The money is indeed lost. That's part of the gamble. It's a numbers game.

Question: The biggest concern is what is the ping doing to the fish?

Response: Unless the fish are very near to the source, the main effect tends to be minor movement away from the source and vessel. We coordinate our activities to minimize the impact on the fisheries. There is a fund, the Environmental Studies Research Funds (ESRF), that funds this type of study, including a study on snow

crab. The data will come out soon. Also, the EA will include a summary of studies looking at the impact of seismic on fish.

Question: Any work on shrimp? That could be a more important species moving forward. Is there any movement up the water column?

Response: Not yet, but some species show temporary vertical movement up and down the water column.

Question: How fast does the ship steam when collecting data?

Response: The sails at a speed of 4–5 knots when acquiring data.

Question: Anything at the end to float the streamer?

Response: Yes, there are tail buoys with GPS at the end so we can position the streamers properly.

Question: Do you have a website that you have this on?

Response: All of the documents relevant to the program, including consultations, comments and responses are on the C-NLOPB website.

Happy Valley-Goose Bay

Torngat Secretariat

Following MKI's presentation, representatives of the Torngat Secretariat offered comments and questions, mainly regarding marine mammal observers (MMOs). In general, it was acknowledged that the program was similar to other recent seismic programs offshore Labrador. Questions/comments from the representatives and MKI's responses are provided below:

Question: Who do you use for trained MMOs? Local and trained observers?

Response: We will try to get all NL personnel. In the past, we always had an Inuit MMO onboard. There is no reason Inuit MMOs can't act as MMOs with the right training.

Question: Who did you get last year as MMO contractor?

Response: RPS. Most of the MMOs were from NL. One was from Nova Scotia.

Comment: Ensure we maintain our communication as the program moves forward.

Torngat Fish Co-op

Following MKI's presentation, representatives of the Torngat Fish Co-op offered comments and questions. Questions/comments from the representatives and MKI's responses are provided below:

Comment: In our area, there is no affiliation with the FFAW. In the past, we reported to the Single Point of Contact (SPOC).

Comment: In earlier programs, there was an interaction with our fishery, there was no communication, no SPOC. But from that issue, the communication improved and things are good now.

Question: Your plan in our area isn't until the end of July?

Response: Yes, the ice would prevent us from coming earlier.

Comment: Our fishing is focused between your areas of interest for 2D and 3D this year, so we see no conflict.

Comment: Hopedale to Nain is the main turbot area, focused on the shelf and coming closer inshore.

Comment: Your plans work out well for us this year.

Comment: There is a quota for the inshore shrimp fishery for Areas 4 and 5. That's for July through September.

Comment: Our board meeting is at the end of March. If there is updated program information, it would be nice to receive it before this time so that we can pass on the information.

Response: MKI agreed to provide the Torngat Fish Co-op, when submitting the application, with an updated map indicating plans and more defined areas of interest for 2017.

Public Information Session

Five people attended the HV-GB public meeting. Many questions and discussions were asked at the prior to MKI's presentation. Most of the discussions and concerns were not oriented at the proposed program, but focused primarily on general concerns regarding the global need and desire for energy development projects, notably Muskrat Falls, and the resulting destruction of the environment.

Question: How close to shore do you come?

Response: Most of the activity is at least 60–70 miles offshore.

Question: Most of the fishing activity is more inshore.

Response: Yes and we are in constant communication with them. We wouldn't come up until about the last week of July because of ice.

Question: Is it similar to GPR (Ground Penetrating Radar)?

Response: Yes and no. Seismic involves sound waves rather than radio waves. The sound waves are low frequency waves.

Question: Is it like an explosion?

Response: Back in the day, seismic exploration used to use explosives.

Question: What is the frequency range?

Response: Seismic uses frequencies in the order of 2 Hz to 150–250 Hz.

Question: What kind of effect on sea life?

Response: In general, the effects on sea life are behavioural in nature. This usually involves small and temporary localized displacements. There haven't been any long-term effects recorded in past seismic programs. The EA will include summaries of the known literature on the effects of seismic activity on fish, invertebrates, marine mammals and seabirds.

Question: Are there times of year you can't go?

Response: There are no restrictions with respect to wildlife, within the temporal scale of the approved program. Most of the limitations are a result of ice and weather conditions.

Question: Did the Strategic Environmental Assessment (SEA) approve the activity?

Response: With the right mitigation measures in place, the SEA did not indicate any significant effects to populations from seismic exploration.

Question: How do you determine what is environmentally sensitive?

Response: Through consultations with the public, stakeholder groups and regulators.

Question: Would you be willing to wait for stakeholders to voice an opinion?

Response: We will follow the process. This is what meetings like these are for, for stakeholders to voice an opinion.

Question: So the environmental assessment is just starting?

Response: Yes.

Question: Can you still work off the old EAs?

Response: Yes, until they expire.

Comment: The problem is that we lose our power as you move out to sea. Nalcor is poisoning that area with its activities. Is the gas more important than the fish?

Question: Who makes sure mitigations are followed?

Response: Observers onboard the vessel.

Question: Who pays for them? Are they on your payroll?

Response: Ultimately, we end up paying for everything, yes.

Comment: All these energy development projects are destroying the planet. You're destroying the environment and the planet.

Question: What's the public involvement? How can I determine the parameters of the EA?

Response: We have to follow guidelines set by the C-NLOPB.

Comment: We don't want any more oil.

Comment: I'm concerned about the fish and invertebrates that can't move away. Fish don't stand a chance. Seismic will kill fish eggs and larvae.

Response: The assessment recognizes that some injury or mortality to fish eggs and larvae could occur during seismic surveys, but only if the eggs and larvae were very close to the airguns. The potential numbers would be very low and have no impact on populations.

Comment: I have a copy of a letter sent to President Obama signed by 75 research scientists saying that seismic is bad and should not be happening.

Response: Our guess is that this letter is related mainly to right whale critical habitat and the risk that it would pose to this endangered population in and near its critical habitat. The proposed survey does not occur over an area having been identified as critical to a marine mammal species. There are no sensitive areas offshore Labrador like there is for right whale in the U.S. Atlantic offshore. The endangered status of right whales, however, is recognized in the assessment and mitigation measures such as ramp up and shutdowns will be put in place.

[Note: MKI was not shown the letter during the meeting. MKI followed up by e-mail with the participant to get a copy of the letter in question. The letter in question was not the one originally thought (dated 14 April 2016), but an earlier version (dated 5 March 2015) that did not include references to studies supporting the statements. While some scientific statements presented in the letter appear factual, they are mostly taken out of context where controlled exposure laboratory studies of invertebrates have been extrapolated to field conditions. Other statements, however, present hypothetical statements that have not been documented during past seismic surveys such as "surveys could increase the risk of calves being separated from their mothers, the effects of which can be lethal".]

Comment: Maybe seismic isn't serious, but drilling is.

Question: Any sensitive areas identified?

Response: Hawke Channel DFO Fisheries Closure Area has been identified by groups consulted as a sensitive area and it will be avoided, but there are no other specific exclusion zones identified within the Project Area.

Innu Nation

Following MKI's presentation, the representative of Innu Nation offered comments and questions. These are provided below:

Question: What size is the exclusion zone again?

Response: It is 500 m. It applies to the pre-ramp up watch and during airgun activities for endangered and threatened species.

Question: Will there be opportunities for work, including observers?

Response: Yes, but the Benefit Plan will deal with this. Essentially, the EA and the Benefit Plan are two separate things. With regards to local benefits, there are other positions available on the vessel as well, in addition to observers.

Agency/Stakeholder Individuals Involved in the Labrador Face-to-Face Consultations

The individuals associated with the Labrador agencies, managers and fishing industry participants consulted during the preparation of MKI's Environmental Assessment are indicated below. Further Labrador consultations are planned for March 2017.

Labrador Fishermen's Union Shrimp Company Ltd. (LFUSCL)

Claude Rumbolt, Fisheries Advisor

Mary's Harbour Mayor

Alton Rumbolt, Mayor; Chair of Mary's Harbour Fishers Committee; FFAW Inshore Council Member (Henley Harbour to Cartwright)

Mary's Harbour (Public Meeting)

Three participants at the Riverlodge Hotel meeting room.

Torngat Secretariat

Victoria Neville, Fisheries Research Program Director
Robyn Morris, Policy Analyst

Torngat Fish Co-op

Keith Watts, General Manager; Torngat Joint Fisheries Board (Nunatsiavut Appointee)
Ron Johnson, Assistant General Manager

Town of Happy Valley-Goose Bay

Five participants at the Labrador Friendship Centre.

Innu Nation

Paula Reid, Environmental Advisor

Appendix 2

Multiklient Invest AS Seismic Programs Offshore Newfoundland and Labrador 2018 Newsletter

Resumption of the Program in 2018

This news update is to inform stakeholders and other interested parties of the continuation of MKI's current seismic program, started in 2011, in waters offshore Newfoundland and Labrador. The Project Area is within the regulatory jurisdiction of the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and it is expected that the Ramform Hyperion, Ramform Sterling and Sanco Atlantic will be acquiring data between June and October 2018

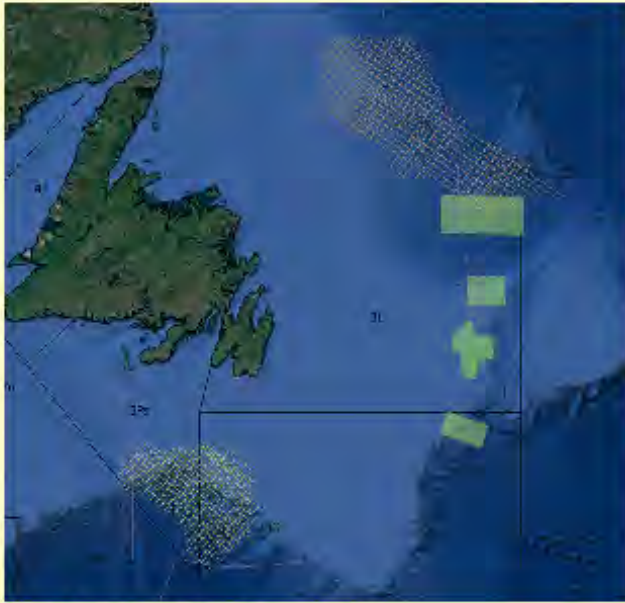


Figure 2: Provisionally planned areas for 2018

Ongoing Communication

As a component of the ongoing communications between MKI and local fisheries organizations, MKI will be providing weekly briefing materials including information such as updated schedules, maps, and/or revised timelines.

Employment Opportunities

Employment opportunities associated with this year's operating season have been considered and it has been determined that there will be possible hiring opportunities as part of the maritime crew. The recruitment process through a local agency will commence in the coming weeks and interested parties should look out for notices posted in community employment offices and other advertisements



Figure 1: Seismic Vessels due to work in the province during 2018

How to Access Environmental Information about the Project

The Environmental Assessment (EA) for the Multiklient Invest AS Newfoundland Seismic Program 2018-2023 along with additional documentation including the Annual EA Update can be accessed on the C-NLOPB website (www.cnlopb.ca).

From the C-NLOPB homepage, click on the "Environment" link near the bottom of the page. Then click on the "Project-Based Environmental Assessment" link. Click on the "Active" link. Once this page has opened, scroll down to the project titled "Multiklient Invest AS Newfoundland Seismic Program 2018-2023" and click on the link. Here you can find all environmental documents related to this project.

The EA provides a comprehensive and detailed overview of the project. The overview includes: information on the Physical and Biological Environment, including Fisheries, Fish and Fish Habitat, Marine Mammals and Species at Risk, and a Cumulative Effects Assessment.

Upon the completion of every acquisition season an Environmental Report is supplied to the C-NLOPB and other government agencies. This report summarizes the marine mammal observations, bird observations and interactions with fishing

Contact Information

If you have any inquiries regarding the Multiklient Invest AS Newfoundland Seismic Program 2018-2023 please feel free to contact:

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