Environmental Assessment of Seitel's East Coast Offshore Seismic Program, 2016-2025

Prepared by



Prepared for



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Environmental Assessment of Seitel's East Coast Offshore Seismic Program, 2016-2025

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1.0 Introduction

This document is an Environmental Assessment (EA) of Seitel Canada Ltd.'s (Seitel) proposed 2016-2025 two dimensional (2D), three dimensional (3D), and/or four dimensional (4D) marine seismic program in the Newfoundland and Labrador offshore area (the Project). The 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 Atlantic Accord Implementation Act* and § 134(1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (Accord Acts). This EA has been guided by the Final Scoping Document (C-NLOPB 2015), as well as by advice and information received, and issues identified through various communications and consultations with other agencies, interest groups, stakeholders and beneficiaries.

The temporal scope of the Project is a 10-year period (2016-2025) with seismic operations potentially occurring between May 1 and November 30 in any given year. The Project Area identified in Figure 1.1 includes Northern and Southern Grand Banks, the Flemish Cap and the shelf region off NE Newfoundland and Labrador, as well as offshore slope and deep water regions associated with the shelf (e.g., Flemish Pass, Orphan Basin, parts of the Labrador and Newfoundland basins). Seitel is proposing to conduct seismic surveys in one or more years within the 2016-2025 timeframe.

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

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

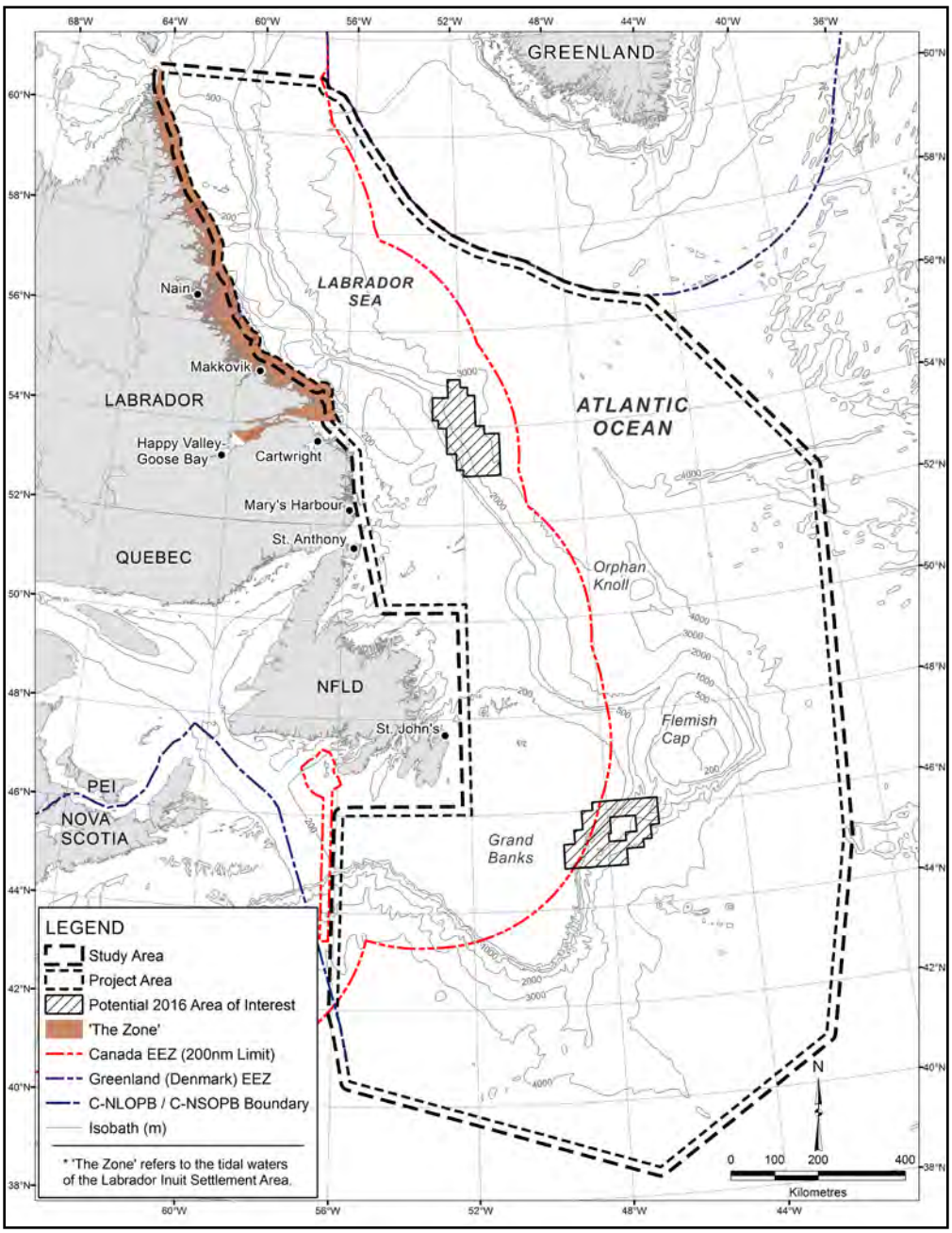


Figure 1.1 Locations of Project Area, Study Area and Potential 2016 Areas of Interest for Seitel's Proposed East Coast Offshore Seismic Program, 2016-2025.

Seitel will follow guidelines issued by the C-NLOPB, the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012), 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

Seitel Canada Ltd. is a leading provider of seismic data and related geophysical services to the oil and gas industry in North America. Seismic data are a crucial tool in mapping the earth's subsurface and revealing the potential for hydrocarbon accumulations. Seitel's products and services are used by oil and gas companies to assist in the exploration for and development and management of oil and gas reserves. Seitel Canada Ltd. is based in Calgary, AB.

1.3 Canada-Newfoundland and Labrador Benefits

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

Seitel will manage the seismic operations from St. John's, Newfoundland and Labrador. Seitel agrees that, whenever possible, 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 and in compliance with Seitel's policies and procedures, meet or exceed all regulatory requirements and are competitive in terms of fair market price. All contractors and subcontractors working for Seitel in Newfoundland and Labrador must also apply these principles in their operations.

1.4 Contacts

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2.0 Project Description

The official name of the Project is Seitel's East Coast Offshore Seismic Program, 2016-2025. Seitel is proposing to conduct one or more 2D, 3D and/or 4D seismic surveys within its proposed Project Area (see Figure 1.1) between 2016 and 2025, starting as early as May 1 2016. It is possible that Seitel will concurrently conduct two surveys in any given year. The possible combinations of concurrent seismic survey types in any given year are 2D and 2D, and 2D and 3D. The timing of the surveys is subject to Seitel's priorities and circumstances, weather conditions, contractor availability, and regulatory approvals.

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 extent of the Project Area is 2,116,780 km^2. As indicated in Figure 1.1, a larger proportion of the Project Area lies outside of Canada's Exclusive Economic Zone (EEZ) (~62%) than inside the EEZ (~38%). Water depths within the Project Area range from <100 m to >4,000 m (see Figure 1).

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

- 60.957°N, 64.222°W (western extreme);
- 61.008°N, 57.586°W (northern extreme);
- 60.701°N, 56.742°W;
- 57.818°N, 52.301°W;
- 56.249°N, 45.067°W;
- 52.437°N, 40.213°W (eastern extreme);
- 44.940°N, 41.220°W;
- 40.962°N, 42.495°W;
- 38.579°N, 47.250°W (southern extreme);
- 40.526°N, 55.474°W;
- 41.895°N, 55.850°W;
- 46.004°N, 55.814°W;
- 46.017°N, 52.000°W;
- 50.365°N, 52.004°W;
- 50.367°N, 54.601°W;
- 52.563°N, 55.389°W;
- 53.535°N, 55.517°W;
- 55.608°N, 59.275°W;

- 57.254°N, 60.938°W; and
- 59.434°N, 63.044°W.

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

- 61.082°N, 64.484°W (western extreme);
- 61.131°N, 57.316°W (northern extreme);
- 60.838°N, 56.506°W;
- 57.970°N, 52.121°W;
- 56.402°N, 44.900°W;
- 52.480°N, 39.929°W (eastern extreme);
- 44.918°N, 40.970°W;
- 40.857°N, 42.303°W;
- 38.400°N, 47.230°W (southern extreme);
- 40.410°N, 55.653°W;
- 41.873°N, 56.089°W;
- 46.123°N, 56.008°W;
- 46.201°N, 52.259°W;
- 50.188°N, 52.284°W;
- 50.227°N, 54.775°W;
- 52.540°N, 55.682°W;
- 53.454°N, 55.808°W;
- 55.581°N, 59.592°W;
- 57.217°N, 61.261°W; and
- 59.365°N, 63.374°W.

The temporal boundaries of the Project are May 1 to November 30 during 2016-2025. The duration of a seismic survey in any given year may range from 60-210 days.

2.2 Project Overview

The proposed Project is a ship-borne geophysical program that may include ~10,000 km of 2D seismic survey lines in 2016. Specific data acquisition plans for 2D, 3D and/or 4D surveys during 2017-2025 are not yet determined.

For the proposed 2D survey in 2016, the seismic survey vessel would be either the MV *Aquila Explorer* (see § 2.2.5 for more details) or a similar vessel. The seismic survey vessel(s) used during subsequent 2D/3D/4D surveys are currently unknown but 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.

For some of the survey operations, Seitel proposes to use Ocean Bottom Nodes (OBNs) instead of towed streamers to acquire imaging data. More details on OBNs are provided in § 2.2.8.

Gravity and magnetic surveys will also be conducted. These passive surveys will be conducted either from the seismic vessel or a fixed-wing aircraft.

The C-NLOPB's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) will be used as the basis for the marine mammal monitoring and mitigation program for the seismic surveys. Dedicated Marine Mammal Observers (MMOs) will monitor for marine mammals and sea turtles and implement mitigation measures as appropriate. 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 an Endangered or Threatened (as listed on Schedule 1 of *SARA*) marine mammal or sea turtle is detected within the safety zone. These measures are designed to minimize disturbance to marine life, particularly marine mammals and 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) provided by the Fish, Food and Allied Workers Union (FFAW) will be on board the seismic vessel to ensure implementation of communication procedures intended to minimize conflict with the commercial fishery. When Seitel is conducting operations in the Labrador offshore, another FLO representing Inuit/Nunatsiavut interests will also be on board the seismic vessel.

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 quality 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 already indicated in § 2.1, the seismic surveys will be conducted between May 1 and November 30 of any given year from 2016-2025. The approximate duration of the 2016 2D seismic survey, should it proceed, is 60-90 days.

2.2.3 Site Plans

In 2016, it is possible that ~10,000 km of 2D data will be acquired. The 2D seismic survey lines will be primarily orientated ESE-WNW or SSW-NNE with an approximate 10-50 km separation between adjacent lines. The survey line lengths are estimated to range from 100 to 1,000 km. Two general areas of interest for 2016 activities are shown in Figure 1.1. Note that the delineations of these two areas are approximations, and that activities could occur outside of the boundaries (but still within the Project Area) shown in Figure 1.1.

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 a FLO and MMOs on board. All project personnel will have the required certifications as specified by the relevant Canadian legislation and the C-NLOPB.

2.2.5 Seismic Vessel

In 2016, Seitel will use either the MV *Aquila Explorer* (Figure 2.1) or a similar vessel. The MV *Aquila Explorer* was built in 1981 and subsequently converted in Singapore in 2006/2007. It is under Panamanian flag. The vessel is 71 m long, 17.5 m wide, and has a maximum draft of 5.45 m. The vessel is equipped with two MAK 6M 453 AK 1770 Kw engines and has a maximum cruising speed of 11 knots (20.4 km/h). Typical seismic surveying speed is 4.5-5 knots (8.3-9.3 km/h). For seismic surveys during 2017-2025, vessel specifics will be provided once the vessel has been identified.

2.2.6 Seismic Energy Source Parameters

The sound sources of the proposed 2D/3D/4D survey program will consist of either one or two airgun arrays. If the latter, the airgun arrays will operate in a flip-flop arrangement. The total volume of an airgun array will range from 3,000-8,000 in^3. The airgun array(s) will be deployed at depths ranging from 6-15 m. The airguns will be operated with compressed air at pressures ranging from of 2,000-2,500 psi. The peak-to-peak sound source level will be ~100-200 bar-m (~260-266 dB re 1 $\mu Pa \cdot m_{pp}$). Detailed specifications of the airgun array will be provided once the 2016 project design is completed and parameters are selected.

2.2.7 Seismic Streamers

If seismic surveying is conducted in 2016, the survey vessel will tow a single solid streamer ranging in length from 6-12 km at depths ranging from 9-25 m.



Figure 2.1 MV *Aquila Explorer.*

2.2.8 Ocean Bottom Nodes

As already indicated above, Seitel proposes to use cableless Ocean Bottom Nodes (OBNs in conjunction with towed streamers for some of its seismic surveys during 2017-2025. The OBNs contain a single hydrophone and 3 geophones configured for multi-component acquisition and are not linked to one another via a cabled system Each wireless (cableless) OBN will have a footprint ranging between 0.20-0.25 m^2, and as many as 10,000 could be deployed in a 2D project or 3D grid configuration on the sea bottom at any one time. The OBNs can be deployed and retrieved by either Remotely Operated Vehicle (ROV) or rope. These units are completely autonomous to operate on the seabed until retrieved and can be left unattended for up to 100 days. The supply vessel will also serve as the platform for ROV operations.

2.2.9 Gravity and Magnetic Surveys

Gravity and magnetic surveys may also be conducted in the Project Area during the proposed program. These passive surveys will be conducted either from the seismic vessel or a fixed-wing aircraft. Gravity survey data are used in conjunction with 2D/3D seismic data to determine the location of gravity anomalies that may indicate the presence of hydrocarbon deposits. Magnetic survey data are used to determine the extent of sedimentary basins and to differentiate between igneous rock and sedimentary rock. Gravity/magnetic survey sizes typically range between 10,000 and 20,000 km^2.

2.2.10 Logistics/Support

2.2.10.1 Vessels

Seitel prefers that primary support and supply be provided by a local vessel but vessel plans are undetermined at this stage. As a minimum, it is anticipated that one local vessel will accompany the seismic vessel in the picket vessel role. The picket vessel will be used to scout ahead of the seismic vessel for fishing vessels and gear, as well as for hazards such as ice and floating debris.

2.2.10.2 Helicopters

The MV *Aquila Explorer* or a similar vessel is equipped with a helicopter deck suitable for helicopters like the Sikorsky S-92. Crew changes will be either by helicopter, ship-to-ship transfer, or ship-to-shore transfers.

2.2.10.3 Shore Base, Support and Staging

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

2.2.11 Waste Management

Waste management will be consistent with industry best practices in offshore Newfoundland and Labrador. Seitel follows MARPOL 73/78 Annex IV: Pollution by Sewage from Ships, and Annex V: Pollution by Garbage from Ships.

2.2.12 Air Emissions

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

2.2.13 Accidental Events

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

2.3 Mitigation and Monitoring

Project mitigation measures are discussed later in the EA (see § 5.5), some of which will 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 dedicated MMOs and FLOs, and a fisheries compensation program. In addition, the MMOs will conduct a monitoring and release program for seabirds which may strand on Project vessels. Seabird monitoring will include systematic counts based on protocols issued by the Canadian Wildlife Service (CWS).

2.4 Project Site Information

The Project is located in the offshore areas east of Newfoundland and Labrador, and south of Newfoundland. It includes Northern and Southern Grand Banks, the Flemish Cap and the shelf region off NE Newfoundland and Labrador, as well as offshore slope and deep water regions associated with the shelf (e.g., Flemish Pass, Orphan Basin, parts of the Labrador and Newfoundland basins) (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 (C-NLOPB 2008)[1], the Eastern Newfoundland SEA (C-NLOPB 2014)[2], the Southern Newfoundland SEA (C-NLOPB 2010)[3] as well as in three relevant project-specific EAs, MKI's Labrador Sea Seismic Program, 2014-2018 (LGL 2014)[4], WesternGeco's Eastern Newfoundland Offshore Seismic Program, 2015-2024 (LGL 2015a)[5], and WesternGeco's Southeastern Newfoundland Offshore Seismic Program, 2015-2024 (LGL 2015b)[6]. Reviews of the physical and biological environments, based on the three SEAs, the three project-specific EAs and newly available information, are provided in § 3.0 and 4.0 of this EA, respectively.

Figure 2.2 shows the extent to which the proposed Seitel Project and Study areas overlap the study areas associated with the three SEAs and the three project-specific EAs indicated above (~82%).

[1] Available at http://www.cnlopb.ca/sea/labrador.php
[2] Available at http://www.cnlopb.ca/sea/eastern.php
[3] Available at http://www.cnlopb.ca/sea/southern.php
[4] Available at http://www.cnlopb.ca/assessments/mkilabsseareport.php
[5] Available at http://www.cnlopb.ca/assessments/westgecoeast3.php
[6] Available at http://www.cnlopb.ca/assessments/westgecose3.php

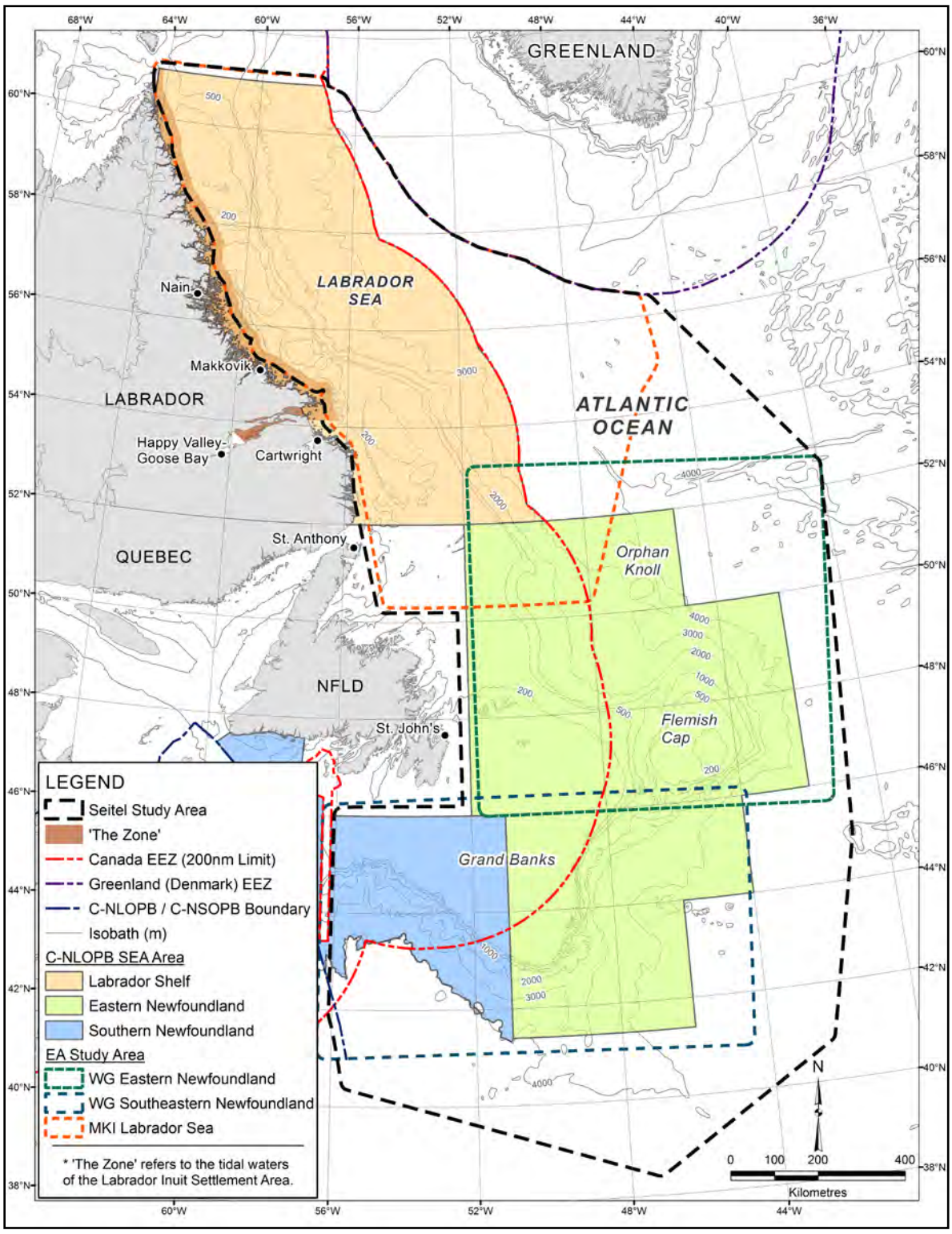


Figure 2.2 Location of Seitel's Project and Study Areas Relative to Study Areas Associated with Relevant SEAs and EAs.

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 (C-NLOPB 2008, 2010, 2014) and LGL (2014,2015a,b). The proposed seismic surveys could be conducted in areas with water depth ranging from <100 to >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 relatively good compared to the late fall/winter/early spring period, should decrease the risk of any 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 Labrador Shelf SEA (C-NLOPB 2008), the Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), relevant project-specific EAs (LGL 2014, 2015a,b), 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 Valued Environmental Components (VECs), which are as follow:

- 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 as well as 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, Seitel consulted with stakeholders in St. John's with an interest in the Project. The results of those consultations are presented in § 5.1.1 and Appendix 1.

Seitel consulted with the following stakeholders based in St. John's.

- Fisheries and Oceans Canada;
- Environment Canada;
- Nature Newfoundland and Labrador (NNL);
- One Ocean;
- Fish, Food and Allied Workers Union/Unifor;
- Association of Seafood Producers (ASP);
- Ocean Choice International (OCI);
- Groundfish Enterprise Allocation Council (GEAC) Ottawa;
- Canadian Association of Prawn Producers;
- Clearwater Seafoods;
- Icewater Seafoods; and
- Newfound Resources Ltd. (NRL).

During December 2015, Seitel also distributed its information package to the following stakeholders in Labrador.

- Nunasiavut Government (Happy Valley-Goose Bay; HVGB);
- Nunasiavut Government (Department of Lands and Natural Resources in Nain);
- Government of Newfoundland and Labrador – Labrador Affairs, and Aboriginal Affairs (HVGB);
- NunatuKavut Community Council (HVGB);
- Nunacor Development Corporation (HVGB);
- Nain Inuit Community Government (Nain);
- Postville Inuit Community Government (Postville);
- Rigolet Inuit Community Government (Rigolet);
- Sheshatshiu First Nation Innu Band Council (Sheshatshiu);
- Innu Nation (Sheshatshiu);
- Innu Development Limited Partnership (Sheshatshiu);
- Sivunivut Inuit Community Corporation Inc. (North West River);
- Mushua First Nation Innu Band Council (Natuashish);
- Innu Nation (Natuashish);
- Makkovik Inuit Community Government (Makkovik);
- Hopedale Inuit Community Government (Hopedale);
- Labrador Fishermen's Union Shrimp Company Ltd. (L'Anse au Loup);
- Labrador Choice Seafoods Inc. (Charlottetown);
- Cartwright Town Council;
- Town of Charlottetown;
- Forteau Town Council;

- Town of HVGB;
- Torngat Fish Producers Co-operative Society Ltd. (HVGB);
- Torngat Secretariat (HVGB);
- Town of L'Anse au Loup;
- Town of Mary's Harbour;
- Town of North West River;
- Community of Pinsent's Arm; and
- Town of Port Hope Simpson.

Any face-to-face meetings and public sessions requested by the Labrador stakeholders will be conducted in late-February/early-March 2016. The Nunatsiavut Government indicated that it would rather delay consultations in Labrador until the EA had been posted on the C-NLOPB website for at least 10 days. Results of the Labrador consultations will be included in the Addendum to the EA that is prepared to address EA reviewer comments.

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 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 will also rely on information contained in the Labrador Shelf SEA (C-NLOPB 2008), the Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), and the three relevant project-specific EAs prepared in 2015 (LGL 2014, 2015a,b).

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 behaviour and distribution with and without airguns operating. Systematic seabird counts will also be conducted during the seismic surveys. 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 2015) required 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), the Eastern Newfoundland SEA (§ 4.1 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 2.0 of C-NLOPB 2010), and three relevant EAs (§ 3.0 of LGL 2014, 2015a,b). 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 SEAs and site-specific EAs.

3.1 Bathymetry and Geology

The bathymetry and geology of the Study Area is highly variable. The following areas reflect the bathymetric and geological variability within the Study Area:

1. Labrador Shelf (deep saddles (>200 m) separate several shallow offshore banks (<200 m), depths increase to >3,000 m in Labrador Basin beyond outer shelf);
2. Orphan Knoll (rising steeply from 3,000 to 1,800 m);
3. Orphan Basin proper (1,200 to 3,500 m);
4. Sackville Spur (≤1,000 m);
5. Flemish Pass (deep water >1,000 m confined between the Grand Banks and the Flemish Cap (~130 m));
6. Northeast Newfoundland Shelf (200 to 300 m);
7. Northeast Newfoundland Shelf Slope and Flemish Cap Shelf (>200 to 2,000 m);
8. Flemish Pass (deep water in excess of 1,000 m confined between the Grand Banks and the Flemish Cap (~130 m);
9. Jeanne d'Arc Basin (≤200 m);
10. Grand Banks of Newfoundland, including Grand Bank, Whale Bank, Green Bank, and the eastern portion of St. Pierre Bank (<200 m, and generally 50 to 100 m, with the exception of portions of St. Pierre Bank and the southeast shoal of Grand Bank, which are <50 m);
11. Halibut Channel, situated between St. Pierre Bank and Green Bank, and Haddock Channel, situated between Green Bank and Whale Bank (>300 to 2,000 m);
12. Lilly Canyon - Carson Canyon, along the 200 m isobaths of the southeast slope of Grand Bank (>200 m);
13. Laurentian Basin (500 to ~4,000 m);
14. Newfoundland Basin (2,000 to 5,000 m); and
15. Newfoundland Seamounts (peaks >2,500 m, with most >3,500 m).

The surficial geology of the Study Area has been described in the Labrador Shelf, Southern Newfoundland, and Eastern Newfoundland SEAs (C-NLOPB 2008, 2010, 2014), and ranges from fine (mud and clay) to extremely coarse (boulders and bedrock). Surficial sediments in the area are primarily hemi-pelagic, ice-rafted, and from glacial plume deposits (Toews and Piper 2002).

3.2 Climatology

Marine seismic surveys are influenced by weather conditions, both from routine operational and environmental safety perspectives. During routine activities, data quality can be affected by weather, particularly wind and wave conditions. This subsection, based on the Labrador Shelf, Southern Newfoundland, and Eastern Newfoundland SEAs (C-NLOPB 2008, 2010, 2014) and recent EAs (LGL 2014a, 2015a, b), provides a general overview of climatic conditions in the Study Area, including wind, waves, temperature, precipitation, visibility, and weather systems, with a more detailed description of extreme events.

The wind and wave climatology of the Study Area was prepared using the 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 eight grid points to represent the Study Area: (1) grid point 14710 near Saglek Bank; (2) grid point 13643 in Hopedale Saddle; (3) grid point 17801 in Orphan Basin; (4) grid point 13451 on the Flemish Cap; (5) grid point 11595 on the Grand Banks; (6) grid point 05000 in the Laurentian Basin; (7) grid point 03889 on the Tail of the Banks; and (8) grid point 11154 in the Newfoundland Basin (Table 3.1, Figure 3.1). Continuous wind and wave hindcast data for grid points 14710 and 13643 are one-hour time steps from January 1954 to December 2005 (C-NLOPB 2008). Hindcast data for grid points 17801, 13451, 11595, and 03889 are one-hour time steps from January 1954 to December 2011 (C-NLOPB 2014). Hindcast data for grid point 05000 are one-hour time steps from January 1954 to December 2010 (Oceans 2014). Hindcast data for grid point 11154 are three-hour time steps from January 1954 to December 2010 (Oceans 2014).

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
Orphan Basin	17801	51.0°N	49.0°W
Flemish Cap	13451	48.0°N	44.0°W
Grand Banks	11595	47.0°N	50.0°W
Laurentian Basin	05000	43.5°N	54.5°W
Tail of the Banks	03889	43.0°N	50.0°W
Newfoundland Basin	11154	44.0°N	45.0°W

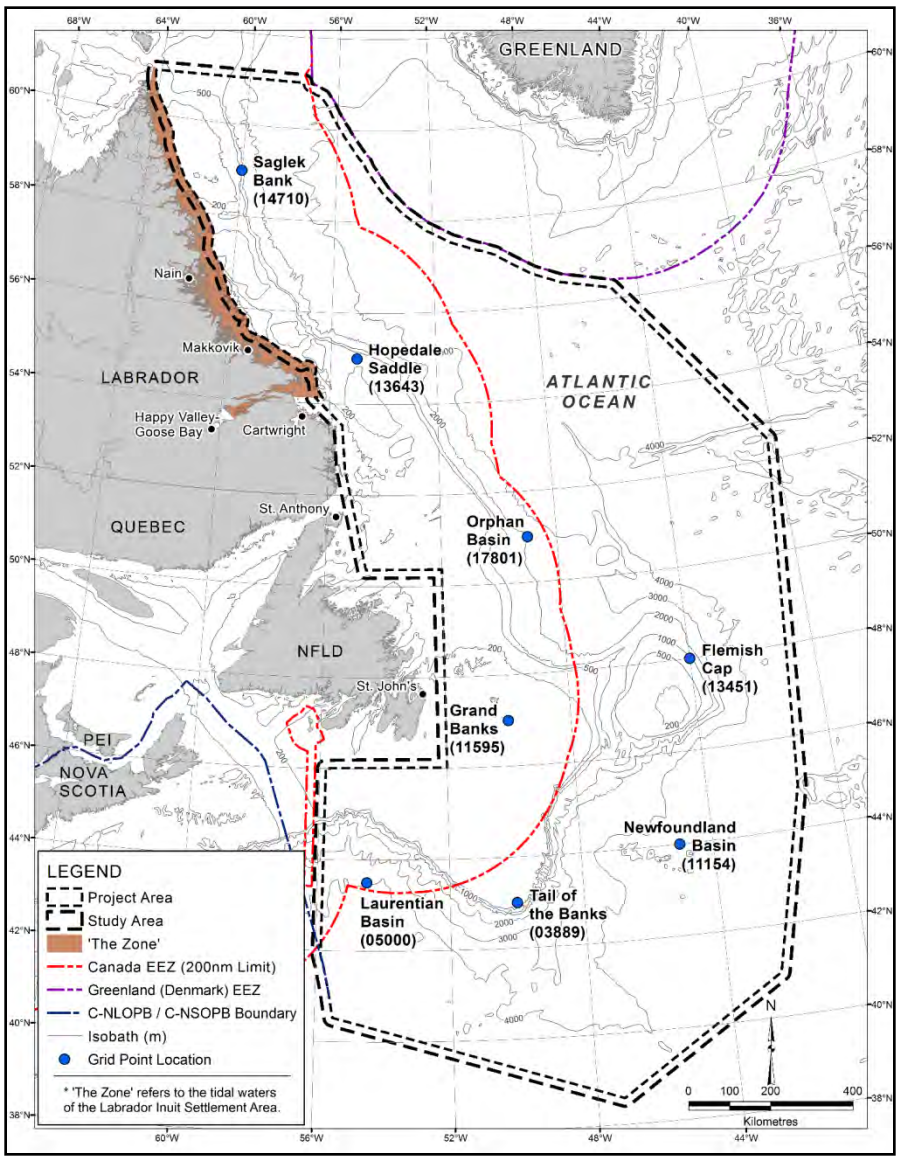


Figure 3.1 Location of MSC50 Grid Points and Regions used in the Physical Environment Analyses.

3.2.1 Wind

Much of the Study Area experiences primarily southwest to west winds throughout the year; however, there is a strong annual cycle in wind directions. West to northwest winds are the most frequent on the Labrador Shelf. Offshore Newfoundland, west to northwest winds are prevalent during the winter months but 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. Low pressure systems crossing south of Newfoundland are more intense during the winter months, thus wind speeds tend to peak during this season. Mean hourly wind speeds for

grid points within the Study Area are presented in Table 3.2. Mean wind speeds are low during the summer and peak during the winter in all regions. From May to November, the highest mean wind speeds occur during November and the lowest during July, ranging from 9.1 to 11.1 m/s and 4.8 to 6.7 m/s, respectively.

Table 3.2 Mean Hourly Wind Speed Statistics for Offshore Newfoundland and Labrador.

Month	Mean Wind Speed (m/s)							
	Saglek Bank (14710)	Hopedale Saddle (13643)	Orphan Basin (17801)	Flemish Cap (13451)	Grand Banks (11595)	Laurentian Basin (05000)	Tail of the Banks (03889)	NF Basin (11154)
Jan	9.7	10.3	12.4	12.5	11.0	11.2	10.3	10.8
Feb	8.5	9.4	12.0	12.2	10.8	11.2	10.3	10.8
Mar	8.2	8.9	11.0	11.0	9.8	10.3	9.4	10.0
Apr	7.3	7.7	9.6	9.3	8.4	9.0	8.3	8.9
May	6.1	6.2	8.1	8.1	7.1	7.5	6.9	7.4
Jun	5.4	5.5	7.1	7.4	6.6	6.8	6.2	6.8
Jul	4.8	4.8	6.6	6.7	6.2	6.3	5.7	6.1
Aug	5.4	5.4	7.0	7.1	6.6	6.7	5.9	6.3
Sep	7.0	7.1	8.6	8.6	7.7	7.9	7.1	7.3
Oct	8.6	8.6	10.0	10.1	8.9	9.1	8.2	8.4
Nov	9.6	9.6	11.1	10.8	9.7	10.1	9.1	9.5
Dec	10.3	10.5	12.0	11.9	10.6	11.2	10.1	10.5

Sources: C-NLOPB 2008, 2014; Oceans 2014.

3.2.2 Waves

During autumn and winter in much of the Study Area, the predominant direction of the combined significant wave heights is from the west, corresponding to a high frequency of occurrence of wind waves during these months. During March and April, the wind waves remain primarily westerly, while the swell begins to back to southerly. During the summer, the mean direction of the combined significant wave heights is from the southwest, as a result of both southwesterly wind waves and southwesterly swell. During September and October, the wind waves veer again to the west and become the predominant component of the combined significant wave heights.

The wave climate of the Grand Banks is dominated by extratropical storms (discussed in § 3.2.5), primarily during October through March. Tropical storms may occur during the early-summer and early-winter, but most often occur from late-August through October.

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.

Wave conditions are described 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 roughly approximates the characteristic height observed visually. Significant wave heights for grid points within the Study Area are presented in Table 3.3. From May to November, the highest waves occur during November and the lowest during July in all regions, ranging from 2.7 to 3.8 m and 1.2 to 1.8 m, respectively.

Table 3.3 Combined Significant Wave Height Statistics for Offshore Newfoundland and Labrador.

Month	Significant Wave Height (m)							
	Saglek Bank (14710)	Hopedale Saddle (13643)	Orphan Basin (17801)	Flemish Cap (13451)	Grand Banks (11595)	Laurentian Basin (05000)	Tail of the Banks (03889)	NF Basin (11154)
Jan	2.8	3.2	4.3	4.9	3.7	4.0	3.9	4.3
Feb	2.2	3.1	3.6	4.6	3.3	3.9	3.8	4.3
Mar	2.1	2.7	3.3	4.0	2.8	3.5	3.4	3.7
Apr	1.9	2.4	2.9	3.2	2.5	2.9	2.8	3.1
May	1.5	1.7	2.3	2.5	2.2	2.2	2.2	2.3
Jun	1.4	1.5	1.9	2.1	1.9	1.9	1.8	2.0
Jul	1.2	1.3	1.7	1.8	1.7	1.7	1.6	1.7
Aug	1.3	1.4	1.8	2.0	1.8	1.8	1.7	1.8
Sep	1.8	2.0	2.6	2.7	2.3	2.3	2.3	2.4
Oct	2.3	2.6	3.2	3.4	2.9	2.8	2.8	2.9
Nov	2.7	3.0	3.7	3.8	3.2	3.3	3.2	3.4
Dec	2.9	3.4	4.3	4.5	3.8	4.0	3.8	4.0

Sources: C-NLOPB 2008, 2014; Oceans 2014.

Maximum wave height is defined as the greatest vertical distance between a wave crest and adjacent trough. Maximum wave heights for grid points within the Study Area are presented in Table 3.4. From May to November, the most severe sea states occur from September through November.

Table 3.4 Combined Maximum Wave Height Statistics for Offshore Newfoundland and Labrador.

Month	Maximum Wave Height (m)							
	Saglek Bank (14710)	Hopedale Saddle (13643)	Orphan Basin (17801)	Flemish Cap (13451)	Grand Banks (11595)	Laurentian Basin (05000)	Tail of the Banks (03889)	NF Basin (11154)
Jan	10.0	12.6	15.9	14.8	11.5	14.1	12.0	15.4
Feb	11.2	11.1	13.4	15.8	13.3	13.3	13.3	14.1
Mar	9.0	11.4	12.1	15.6	10.4	12.6	12.6	13.1
Apr	6.5	10.4	11.5	11.7	10.3	11.2	11.5	10.2
May	5.5	8.5	10.9	11.8	9.6	10.2	8.5	9.2
Jun	6.9	7.0	8.7	11.4	9.1	9.7	8.7	7.7
Jul	4.3	4.5	6.3	6.8	6.0	6.7	5.9	7.1
Aug	4.9	5.7	11.1	9.8	8.5	10.1	9.7	7.9
Sep	6.6	10.0	12.1	12.9	12.8	13.0	10.9	11.3
Oct	9.4	10.5	12.7	13.8	10.5	12.7	11.9	12.0
Nov	11.2	11.6	13.1	14.2	10.7	11.8	12.1	12.0
Dec	12.1	10.7	15.1	16.5	12.1	12.6	12.1	12.9

Sources: C-NLOPB 2008, 2014; Oceans 2014.

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. 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-NOLPB 2008, 2014; Oceans 2014).

3.2.3.1 Extreme Value Estimates for Winds from the Gumbel Distribution

Extreme wind speed estimates were calculated 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, 2014; Oceans 2014). 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 extreme 1-hour wind speed estimates for grid points within the Study Area are presented in Table 3.5. The calculated annual 100-year extreme 1-hour wind speed ranged from 29.9 to 35.8 m/s. From May to November, the highest 100-year extreme 1-hour wind speeds occur from September to November, while the lowest occur during June and July (C-NLOPB 2014; Oceans 2014).

Table 3.5 Extreme Wind Speed Estimates for Offshore Newfoundland and Labrador.

Return Period (years)	Wind Speed (m/s)							
	Saglek Bank (14710)	Hopedale Saddle (13643)	Orphan Basin (17801)	Flemish Cap (13451)	Grand Banks (11595)	Laurentian Basin (05000)	Tail of the Banks (03889)	NF Basin (11154)
1	nd	nd	21.9	23.8	21.5	24.9	21.8	23.9
10	26.5	27.0	30.9	31.1	29.7	28.5	29.2	27.4
50	29.0	29.4	34.3	34.4	33.3	30.8	32.6	29.8
100	29.9	30.3	35.8	35.8	34.8	31.8	34.0	30.8

Sources: C-NLOPB 2008, 2014; Oceans 2014.

3.2.3.2 Extreme Value Estimates for Waves from a Gumbel Distribution

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. A storm with a return period of 100 years means that the calculated significant wave height will occur once every 100 years, averaged over a long period of time. From May to November, the highest 100-year extreme significant wave heights occur during October and November, while the lowest extreme significant wave heights occur during July (C-NLOPB 2014; Oceans 2014).

Table 3.6 Extreme Significant Wave Height Estimates for Offshore Newfoundland and Labrador.

Return Period (years)	Significant Wave Height (m)							
	Saglek Bank (14710)	Hopedale Saddle (13643)	Orphan Basin (17801)	Flemish Cap (13451)	Grand Banks (11595)	Laurentian Basin (05000)	Tail of the Banks (03889)	NF Basin (11154)
1	ND	nd	11.5	12.8	9.9	11.0	10.4	10.6
10	10.6	11.2	13.7	15.5	11.9	12.8	12.4	12.8
50	12.1	12.6	15.5	17.7	13.6	14.1	14.0	14.2
100	12.7	13.1	16.3	18.6	14.3	14.6	14.7	14.8

Sources: C-NLOPB 2008, 2014; Oceans 2014.

3.2.4 Weather Variables

For offshore Newfoundland, data related to air temperature, sea surface temperature, and visibility were compiled using the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). A subset of global marine surface observations from ships, drilling rigs, and buoys in the Study Area, covering the period from January 1950 to December 2012, was used in the

analyses for the Orphan Basin, Flemish Cap, Grand Banks and Tail of the Banks (C-NLOPB 2014). A subset of observations covering the period from January 1980 to December 2013 was used in the analyses for the Laurentian Basin and the Newfoundland Basin (Oceans 2014).

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 to 2010 (EC 2015a). Data related to sea surface temperatures were compiled using the Bedford Institute of Oceanography (BIO) hydrographic database (BIO 2009). A subset of data from hydrographic bottles, CTD casts, Batfish tows, and bathythermographs, covering the period from 1910 to 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 a particular region during that month.

The temperature data indicate that from May to November, the air is warmest during August and coldest during May in all regions. Sea surface temperature is also warmest during August and coldest during May in all regions.

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 phenomena, 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.

Table 3.7 Mean Monthly Air Temperatures for Offshore Newfoundland and Labrador.

Month	Air Temperature (°C)							
	Nain	Cartwright	Orphan Basin	Flemish Cap	Grand Banks	Laurentian Basin	Tail of the Banks	NF Basin
Jan	-17.6	-14.3	-1.4	3.1	0.4	1.9	5.3	6.4
Feb	-17.4	-13.5	-2.9	2.6	-0.1	0.8	4.7	6.0
Mar	-12.5	-8.7	-0.4	3.4	0.7	1.4	5.5	6.8
Apr	-4.6	-1.8	1.3	5.1	2.3	4.0	7.2	9.6
May	1.5	3.3	3.5	7.0	4.4	6.9	9.5	11.1
Jun	6.4	8.6	6.6	9.2	7.6	10.6	12.3	13.6
Jul	10.1	12.3	10.1	12.4	12.1	16.0	16.7	17.6
Aug	11.0	12.7	11.7	14.2	14.6	18.3	18.9	18.7
Sep	7.5	9.0	10.3	13.3	12.8	16.2	16.8	17.1
Oct	2.1	3.7	6.6	10.4	9.2	12.3	13.4	14.0
Nov	-4.4	-2.0	3.7	7.8	5.6	8.6	10.4	11.2
Dec	-11.8	-8.8	1.1	5.4	2.5	4.8	7.5	8.5

Sources: EC 2015a; C-NLOPB 2014; Oceans 2014.

Table 3.8 Mean Monthly Sea Surface Temperatures for Offshore Newfoundland and Labrador.

Month	Sea Surface Temperature (°C)						
	Labrador Shelf	Orphan Basin	Flemish Cap	Grand Banks	Laurentian Basin	Tail of the Banks	NF Basin
Jan	-0.6	0.9	4.8	0.9	4.3	10.9	11.7
Feb	0.7	0.34	3.8	0.0	3.2	10.3	10.2
Mar	-0.4	0.7	4.1	0.1	2.9	10.2	9.9
Apr	-1.4	1.2	4.8	0.7	3.7	11.8	9.9
May	nd	2.5	6.3	2.6	6.1	13.1	11.8
Jun	1.7	4.8	8.4	5.5	10.3	15.2	14.0
Jul	4.6	8.4	11.4	10.3	15.3	19.2	17.5
Aug	6.0	11.3	13.7	14.0	18.3	21.1	20.3
Sep	3.4	10.6	13.7	13.5	17.0	20.1	18.8
Oct	2.3	7.7	11.4	10.5	13.4	17.9	16.3
Nov	1.0	4.7	9.2	6.8	10.0	15.8	14.9
Dec	-0.6	2.5	6.5	3.5	7.0	12.8	13.2

Sources: C-NLOPB 2014; Oceans 2014; Husky 2010; LGL 2010.

3.2.4.2 Visibility

The frequency distributions of visibility states for regions within the Study Area are presented in Tables 3.9 to 3.15. The visibility states have been defined as very poor (less than 1 km for the Labrador Sea, Laurentian Basin, and Newfoundland Basin, and less than 0.5 km for all other regions), poor (1 to 2 km for the Labrador Sea, Laurentian Basin, and Newfoundland Basin, and 0.5 to 2 km for all other regions), fair (2 to 10 km), and good (greater than 10 km).

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. By April, the sea surface temperature south of Newfoundland is cooler than the surrounding air, and the presence of advection fog increases from April through July. 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 narrow, and by September the air temperature begins to fall below the sea surface temperature and the occurrence of fog decreases. During the May to November period, October has the lowest occurrence of reduced visibility since the air temperature has, on average, decreased below the sea surface temperature, but it 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. There is less seasonal variation in visibility in the Labrador Sea, as well as in the Newfoundland Basin and further south of the Grand Banks.

During the May to November period, September and October have the lowest occurrence of reduced visibility since the air temperature has, on average, decreased below the sea surface temperature, but it 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. [Meteorological convention defines seasons by quarters; e.g., winter is December, January, February, etc.]

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

Month	Frequency of Occurrence (%)			
	Very Poor (< 1 km)	Poor (1 – 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

Source: Husky 2010.

Table 3.10 Frequency of Occurrence of Visibility States for Orphan Basin.

Month	Frequency of Occurrence (%)			
	Very Poor (< 0.5 km)	Poor (0.5 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	3.7	7.6	59.3	29.3
February	3.5	8.7	55.7	32.1
March	6.7	10.9	54.8	27.6
April	9.5	11.4	52.3	26.8
May	14.2	10.3	43.4	32.1
June	20.2	14.1	36.8	28.9
July	27.2	14.3	33.3	25.2
August	15.3	9.4	37.2	38.0
September	8.4	5.7	38.3	47.6
October	4.9	6.2	44.3	44.5
November	5.0	7.2	48.3	39.6
December	4.5	7.5	54.5	33.5
Annual	10.1	9.4	46.5	34.0

Source: C-NLOPB 2014.

Table 3.11 Frequency of Occurrence of Visibility States for the Flemish Cap.

Month	Frequency of Occurrence (%)			
	Very Poor (< 0.5 km)	Poor (0.5 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	2.5	5.2	48.9	43.4
February	2.8	5.2	49.3	42.7
March	4.4	7.0	45.6	43.1
April	7.8	8.5	41.4	42.4
May	10.8	8.6	37.9	42.7
June	17.6	11.5	35.9	35.0
July	26.0	14.0	30.5	29.6
August	15.4	8.8	34.1	41.7
September	6.8	5.6	37.7	50.0
October	4.0	4.2	39.9	51.39
November	3.9	4.3	43.1	48.6
December	2.9	4.4	45.7	47.0
Annual	9.1	7.5	40.7	42.7

Source: C-NLOPB 2014.

Table 3.12 Frequency of Occurrence of Visibility States for the Grand Banks.

Month	Frequency of Occurrence (%)			
	Very Poor (< 0.5 km)	Poor (0.5 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	6.0	5.9	45.3	42.9
February	7.7	7.3	45.6	39.3
March	9.2	8.4	43.5	38.9
April	16.6	9.3	39.2	34.9
May	21.5	10.9	34.6	33.1
June	29.3	11.6	31.8	27.3
July	40.3	11.5	25.4	22.9
August	21.5	7.9	32.7	37.9
September	10.1	5.0	33.5	51.3
October	7.3	4.6	36.8	51.4
November	8.3	5.6	38.6	47.5
December	6.5	5.5	42.6	45.4
Annual	15.8	7.9	37.2	39.1

Source: C-NLOPB 2014.

Table 3.13 Frequency of Occurrence of Visibility States for the Laurentian Basin.

Month	Frequency of Occurrence (%)			
	Very Poor (< 1 km)	Poor (1 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	6.5	3.3	19.3	70.9
February	9.5	3.9	21.1	65.4
March	11.1	3.2	15.6	70.1
April	21.2	4.1	14.7	60.0
May	28.5	3.8	11.3	56.3
June	30.6	3.6	12.1	53.7
July	33.0	3.1	13.2	50.8
August	16.6	2.4	13.6	67.3
September	7.3	1.6	11.7	79.4
October	5.4	1.5	11.3	81.7
November	7.9	2.0	14.0	76.0
December	5.6	2.2	16.1	76.0
Annual	15.6	2.9	14.3	67.2

Source: Oceans 2014.

Table 3.14 Frequency of Occurrence of Visibility States for the Tail of the Banks.

Month	Frequency of Occurrence (%)			
	Very Poor (< 0.5 km)	Poor (0.5 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	4.0	4.2	42.0	49.8
February	4.1	4.7	41.3	49.9
March	5.1	4.9	38.5	51.5
April	9.4	6.8	38.5	45.3
May	14.5	8.6	34.9	42.0
June	20.7	11.4	32.8	35.1
July	21.6	11.0	32.1	35.3
August	10.6	6.6	35.2	47.7
September	5.1	4.0	33.0	57.9
October	4.0	4.5	33.8	57.8
November	5.2	4.5	37.3	53.0
December	3.8	4.1	40.6	51.5
Annual	9.8	6.6	36.2	47.4

Source: C-NLOPB 2014.

Table 3.15 Frequency of Occurrence of Visibility States for the Newfoundland Basin.

Month	Frequency of Occurrence (%)			
	Very Poor (< 1 km)	Poor (1 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	2.9	2.0	16.9	78.2
February	4.5	1.8	17.5	76.2
March	4.3	1.8	15.5	78.4
April	8.6	1.8	14.3	75.4
May	12.8	2.6	13.0	71.7
June	16.9	2.6	13.8	66.7
July	22.1	2.7	14.1	61.1
August	11.1	1.7	12.1	75.0
September	5.1	1.4	10.6	82.9
October	3.4	1.5	10.9	84.3
November	4.3	1.6	12.7	81.5
December	3.2	1.7	15.5	79.6
Annual	8.5	1.9	13.9	75.7

Source: Oceans 2014.

The passage of high and low pressure circulation systems yield a climate within the Study Area that can be highly variable, with further variation between the Labrador and eastern Newfoundland/southern portions of the Study Area. Conversely, intense low pressure systems also frequently become 'captured' and slow down or stall off the coasts of Newfoundland and Labrador, resulting in an extended period with little change in conditions which, depending on system location, size and intensity, may range between minor to severe. Atmospheric circulation is predominantly from the northwest in the Labrador region, transporting cold Arctic air masses to the northerly portion of the Study Area (Prisenberg et al. 1996). Otherwise, 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 months (Meteorological convention defines seasons by quarters; e.g., winter = December–February) 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 tracks bring an average of eight low pressure systems per month to at least the eastern Newfoundland and southern portions of the Study Area, ranging 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 Labrador portion of the Study Area (Barney n.d.). These cold air temperatures also 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 Labrador portion of the Study Area when the air temperature is -10ºC, the westerly wind speed is 30 kn, 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 Labrador portion of the Study Area, this often results in grey skies, frequent drizzle or freezing drizzle and temperatures around 0ºC (Barney n.d.). In the summer months, the primary storm tracks shift further north than in the winter, and storms are overall less frequent and much weaker in the Study Area, with decreased significant wave heights and wind speeds, which relatively infrequently reach gale- or storm-force. 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 central and southern portions of the Study Area from the southwest to south. Southwesterlies are also common in the Labrador portion of the Study Area, with the northerly low pressure systems resulting in relatively frequent rainfall and coastal fog (Barney n.d.). On warm, sunny days, short and heavy afternoon showers are common in Labrador, creating clouds and localized areas of precipitation and occasionally developing into thunderstorms; coastal Labrador receives an average of two to five thunderstorms annually, which may include hail and, rarely, a remote tornado (Barney n.d.).

Problematic and quickly deepening storms are an issue south of Newfoundland, near the warm Gulf Stream waters, whereby rapidly deepening oceanic cyclones develop into a "weather bomb": a storm that undergoes central pressure drops > 24 mb in 24 h. Weather bombs typically include hurricane-force winds near the storm's center during the rapidly deepening stage and a clear area near the center during the storm's mature stage. Post-development, these systems travel either across Newfoundland or near the southeast coast, producing gale- to storm-force winds from the southwest to south. These systems do not typically reach the offshore Labrador portion of the Study Area.

Tropical cyclones also reach the eastern Newfoundland and southern portions of the Study Area, producing the strongest sustained surface winds observed on earth. The hurricane season in the North Atlantic Basin is generally from June through to November; however, tropical storms may occur outside of 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, travelling towards

Newfoundland and the Orphan Basin, 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. As with weather bombs, tropical storms do not typically extend into the Labrador portion of 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-latitudes 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 decreases 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.

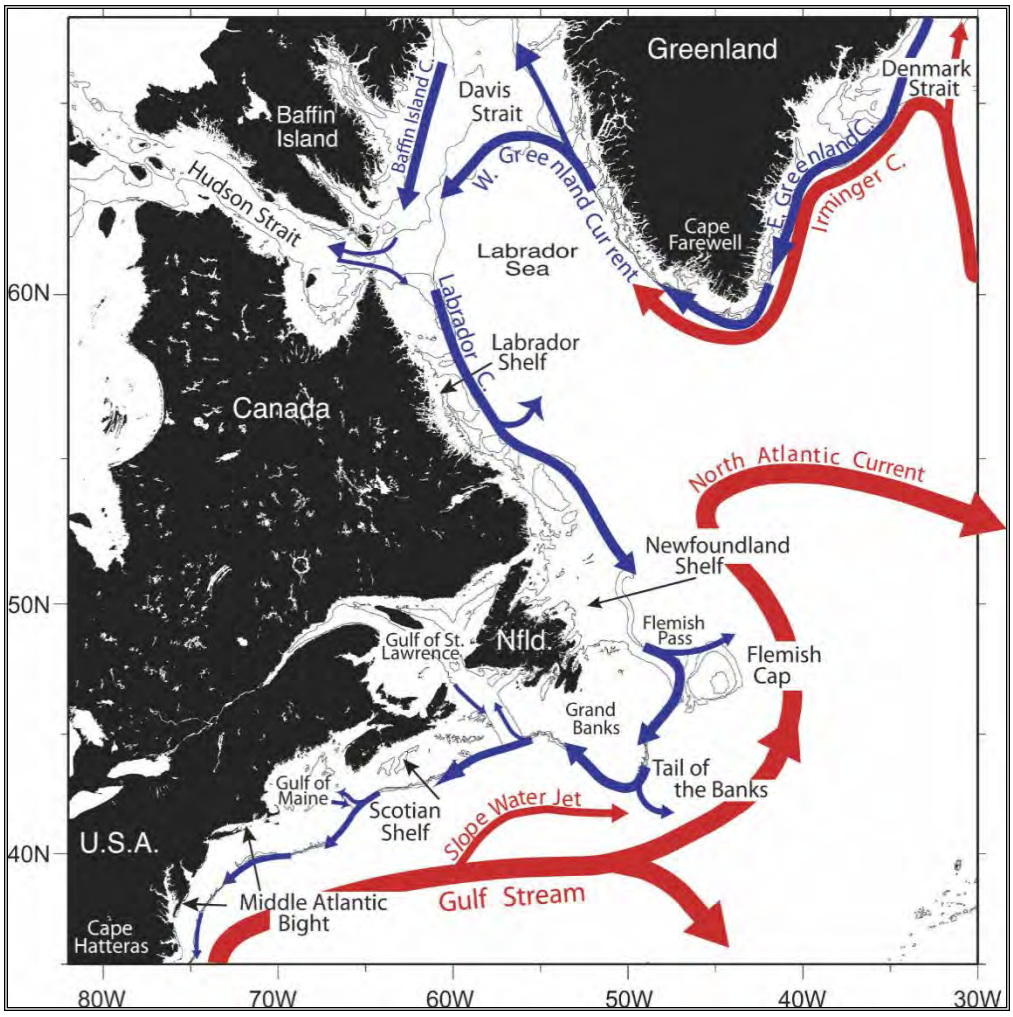
3.3 Physical Oceanography

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, Southern Newfoundland, and Eastern Newfoundland SEAs (C-NLOPB 2008, 2010, 2014). A summary of the major currents in the Study Area is provided below, with additional information from project-specific EAs (LGL2014, 2015a,b).

3.3.1 Major Currents in the Study Area

The large scale circulation off the coast of Newfoundland and Labrador is dominated by well-established currents that flow along the margins of the continental shelf. The major current systems in the area are the Labrador Current, the North Atlantic Current, and the Gulf Stream. The main current pattern is shown in Figure 3.2, with cold shelf break waters shown in blue and warm Gulf Stream waters shown in red.

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.



Source: Fratantoni and Pickart 2007.

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

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 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 outer branch of the Labrador Current exhibits a distinct seasonal variation in flow speeds, with mean flows at a maximum in October and a minimum in March and April. This annual cycle is reported to be the result of the large annual variation in the steric height over the continental shelf in relation to the much less variable internal density characteristic of the adjoining deep waters. The additional freshwater in spring and summer is largely confined to the waters over the shelf. In summer, the difference in sea level between the shelf and the open ocean is 0.09 m greater than in winter. This difference produces a greater horizontal surface pressure gradient and hence, stronger mean flows.

The Gulf Stream and its associated eddies play an important role in the southern region of the Study Area. This extensive western boundary current plays a significant part in the poleward transfer of heat and salt and serves to warm the European subcontinent. While the Gulf Stream is usually located south of 40°N, one of the inherent features of this current system is its meandering path. These meanders may be formed both in northward and southward directions. At certain stages of their development, northward forming meanders separate from the main stream and generate rings or eddies, which begin moving independently from the Gulf Stream flow. Once eddies are formed, they drift in different directions and can be sustained for a considerable period of time. Their size may be of 100 to 300 km in diameter and may reach considerable depths. The trajectory of these warm water rings, once they depart from the Gulf Steam jet, together with their interaction with the bathymetry of the Continental Slope and with other current flows, influence the dynamic regime in the vicinity of the shelf break of the Grand Banks and the Scotian Shelf.

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 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.

An additional influence on ocean circulation in the southern region of the Study Area is the water exchange with the Gulf of St. Lawrence through the Laurentian Channel. In Laurentian Channel, the currents flow into the Gulf of St. Lawrence along the east side of the channel and out of the Gulf along the west side. The flow into the Gulf of St. Lawrence on the eastern side of Cabot Strait is mainly barotropic with a speed of 20 cm/s. The flow out of the Gulf of St. Lawrence on the western side of the Cabot Strait flows mainly along the western side of Laurentian Channel. A smaller portion flows along the inner Scotian Shelf and onto the Mid-shelf.

The interaction among these circulations is known to correlate with the behaviour of the North Atlantic Oscillation (NAO) index. The NAO index is the difference in winter sea level atmospheric pressures between the Azores and Iceland, and 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.

At all locations within 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 impacts 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.

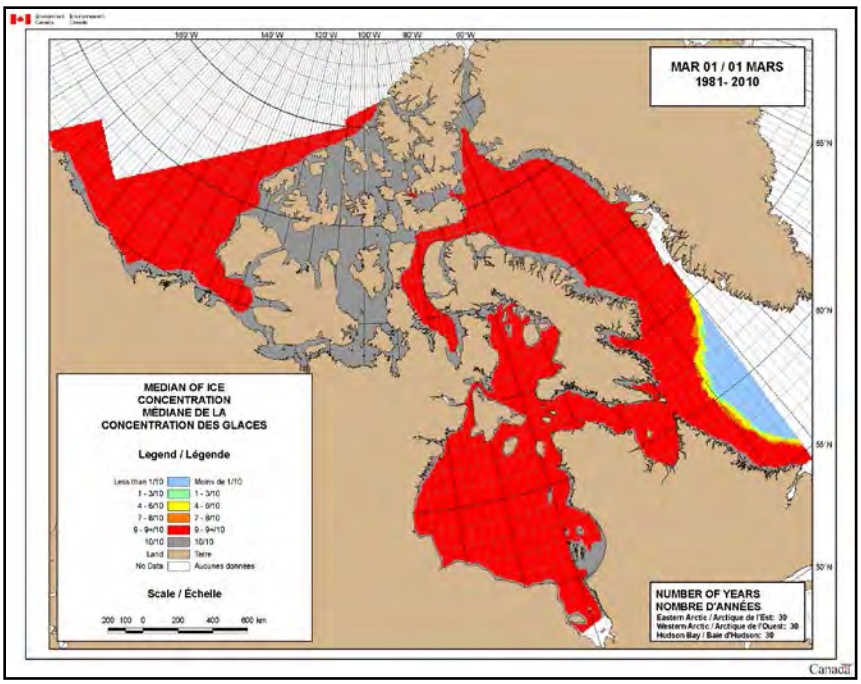
3.4 Ice Conditions

Ice conditions are an important component of the physical environment and often directly affect offshore activities along the coast of Newfoundland and Labrador. A review of ice conditions in the Study Area has been provided in the Labrador Shelf, Southern Newfoundland, and Eastern Newfoundland SEAs (C-NLOPB 2008, 2010, 2014). A summary of ice conditions is provided below, with updated information on sea ice extent and iceberg sightings for offshore Newfoundland and 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

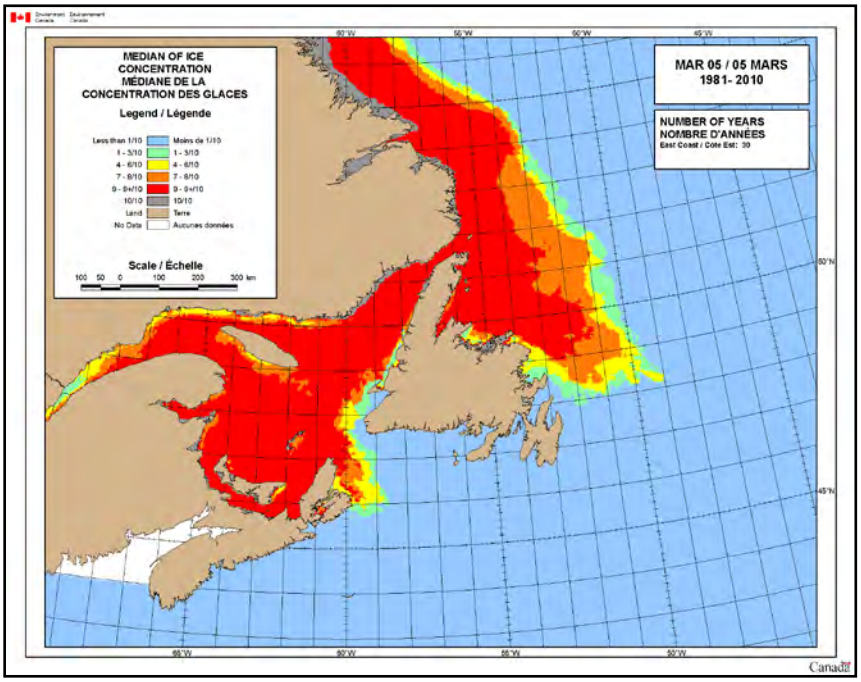
Sea ice generally begins to form in mid-November on the coast of northern Labrador and by mid-December on the coast of southern Labrador (LGL 2014), spreading south to Newfoundland waters by early-January. The 30-year median concentration of sea ice reaches its maximum in the northern Labrador portion of the Study Area (north of 55ºN) during the week of 1 March (Figure 3.3), and in the southern Labrador (south of 55ºN extending to Newfoundland) and eastern Newfoundland (extending towards the Flemish Cap) portions of the Study Area during the week of 5 March (Figure 3.4). No 30-year median concentration sea ice is present in the southern (including the southern Grand Banks) portion of the Study Area. The maximum median sea ice extent reaches beyond the northernmost portion of the Study Area and to 56-59ºW in the northern Labrador portion of the Study Area, to ~51ºW in the southern Labrador portion and to ~48ºN, 49ºW in the eastern Newfoundland portion of the Study Area. During median years, only the central and northern portions of the Study Area would have some ice cover (Figures 3.5 and 3.6). During extreme years, sea ice could occur throughout the northern and southern Labrador and eastern Newfoundland portions of the Study Area (Figures 3.5 and 3.6). Sea ice typically extends southwards to ~44ºN during extreme years in the southern portion of the Study Area (Figure 3.6); however, sea ice could occur as far south as ~43ºN (Figure 3.7). The majority or entirety of the northern and southern Labrador portions of the Study Area will be free of sea ice from mid-August until mid-November. The eastern Newfoundland portion of the Study Area will be virtually or entirely ice-free from mid-July to mid-December. The southern portion of the Study Area will generally be ice-free from early-May until early-February.

A weekly analysis of the Canadian Ice Service's 30-Year Frequency of Presence of Sea Ice indicates that the northern Labrador portion of the Study Area is first affected by sea ice beginning the week of 12 November, lasting until the week beginning 27 August. 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 Labrador portion of the Study Area. The southern Labrador 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 eastern Newfoundland portion of the Study Area is initially affected by sea ice beginning the week of 18 December, with ice present until the week beginning 23 July. The southern portion of the Study Area is first affected by sea ice during the week of 5 February, lasting until the week beginning 14 May. The frequency of presence of sea ice is greatest over the southern Labrador, eastern Newfoundland and southern portions of the study area during the week of 12 March (Figure 3.9).



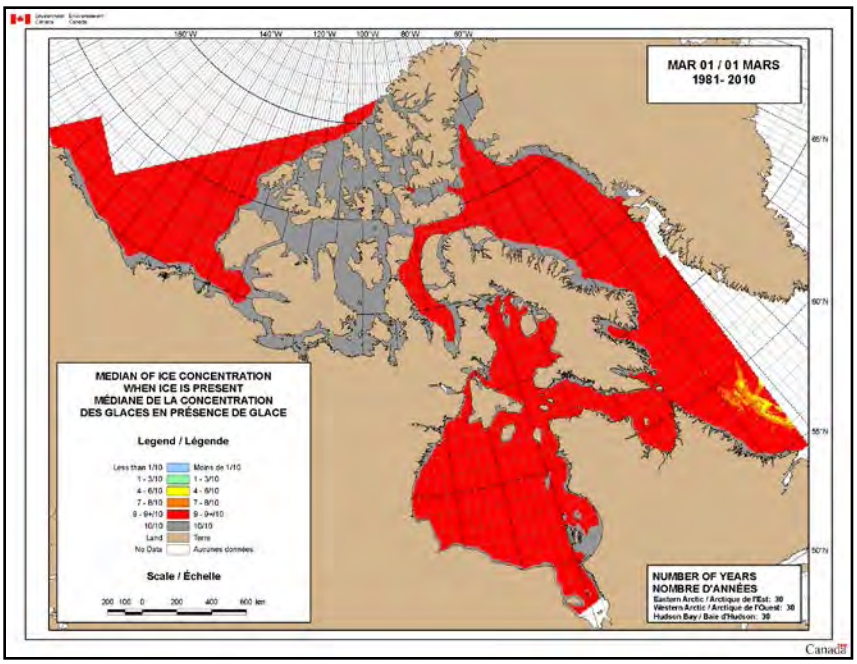
Source: Canadian Ice Service 30-Year Ice Atlas.
(http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en), accessed November 2015.

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



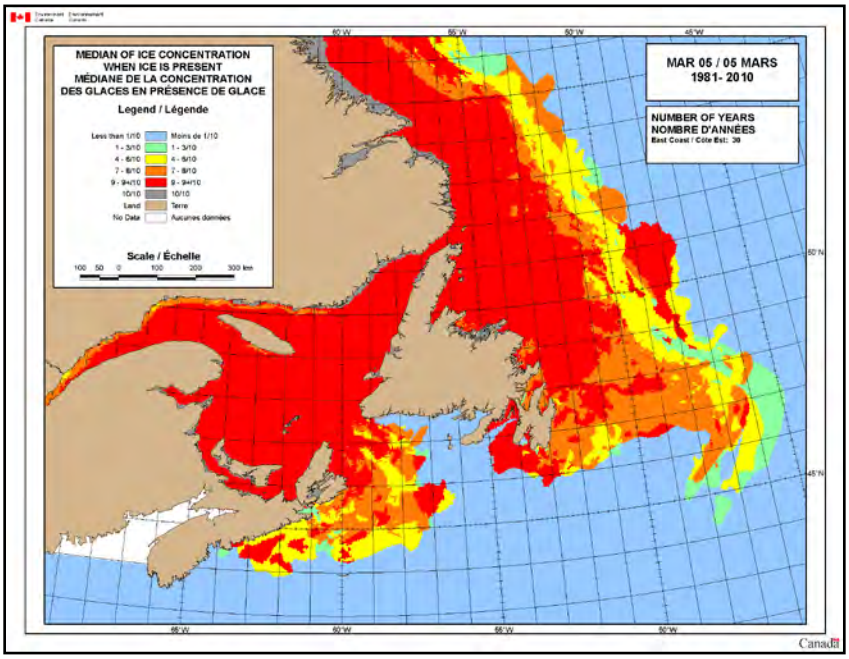
Source: Canadian Ice Service 30-Year Ice Atlas.
(http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en), accessed November 2015.

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



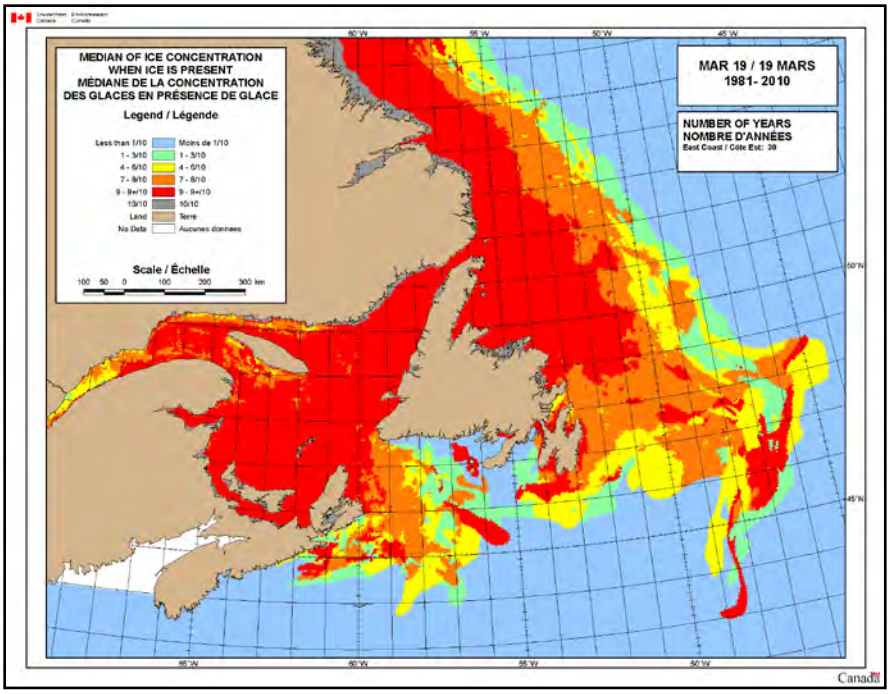
Source: Canadian Ice Service 30-Year Ice Atlas.
(http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en), accessed November 2015.

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



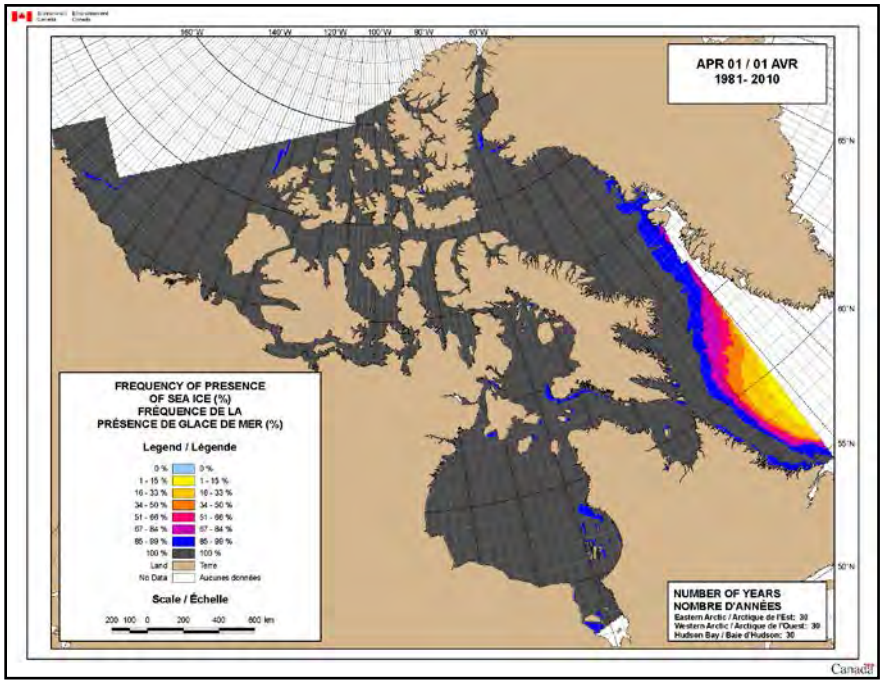
Source: Canadian Ice Service 30-Year Ice Atlas.
(http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en), accessed November 2015.

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



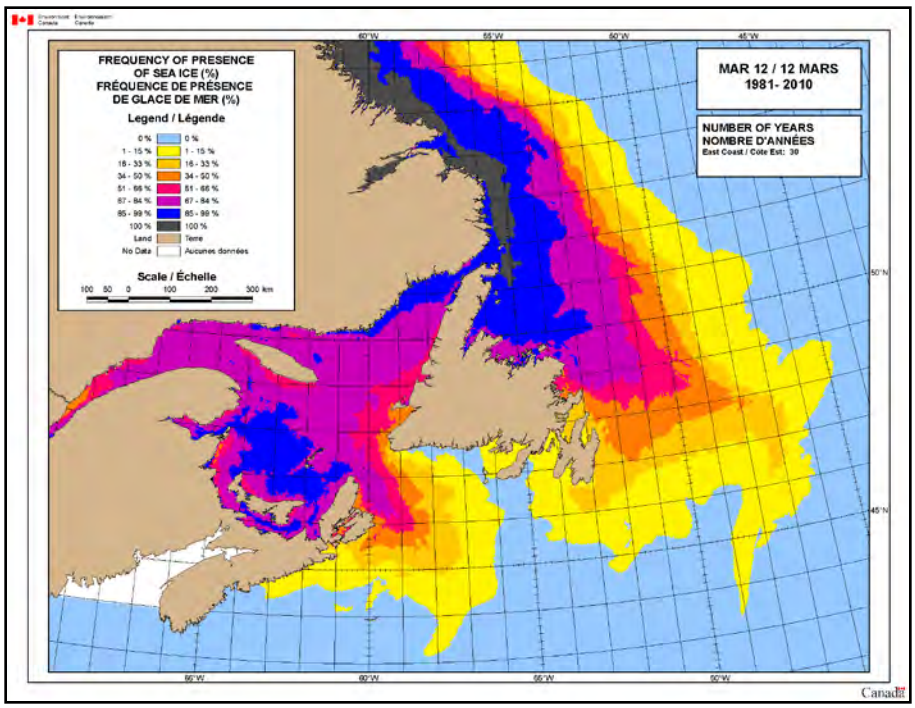
Source: Canadian Ice Service 30-Year Ice Atlas.
(http://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en), accessed November 2015.

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://iceweb1.cis.ec.gc.ca/30Atlas/page1.xhtml?grp=Guest&lang=en), accessed November 2015.

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 November 2015.

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

When sea ice is present, the predominant ice type within the northern Labrador 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.

New ice begins to form near the coast in the week of 19 November within the southern Labrador portion of 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.

New ice is present off the northeast coast of Newfoundland as of the week of 18 December, with grey ice extending southwards from the southern Labrador portion of the Study Area by the week of 25 December. Grey-white ice begins to form by the week of 1 January, with thin

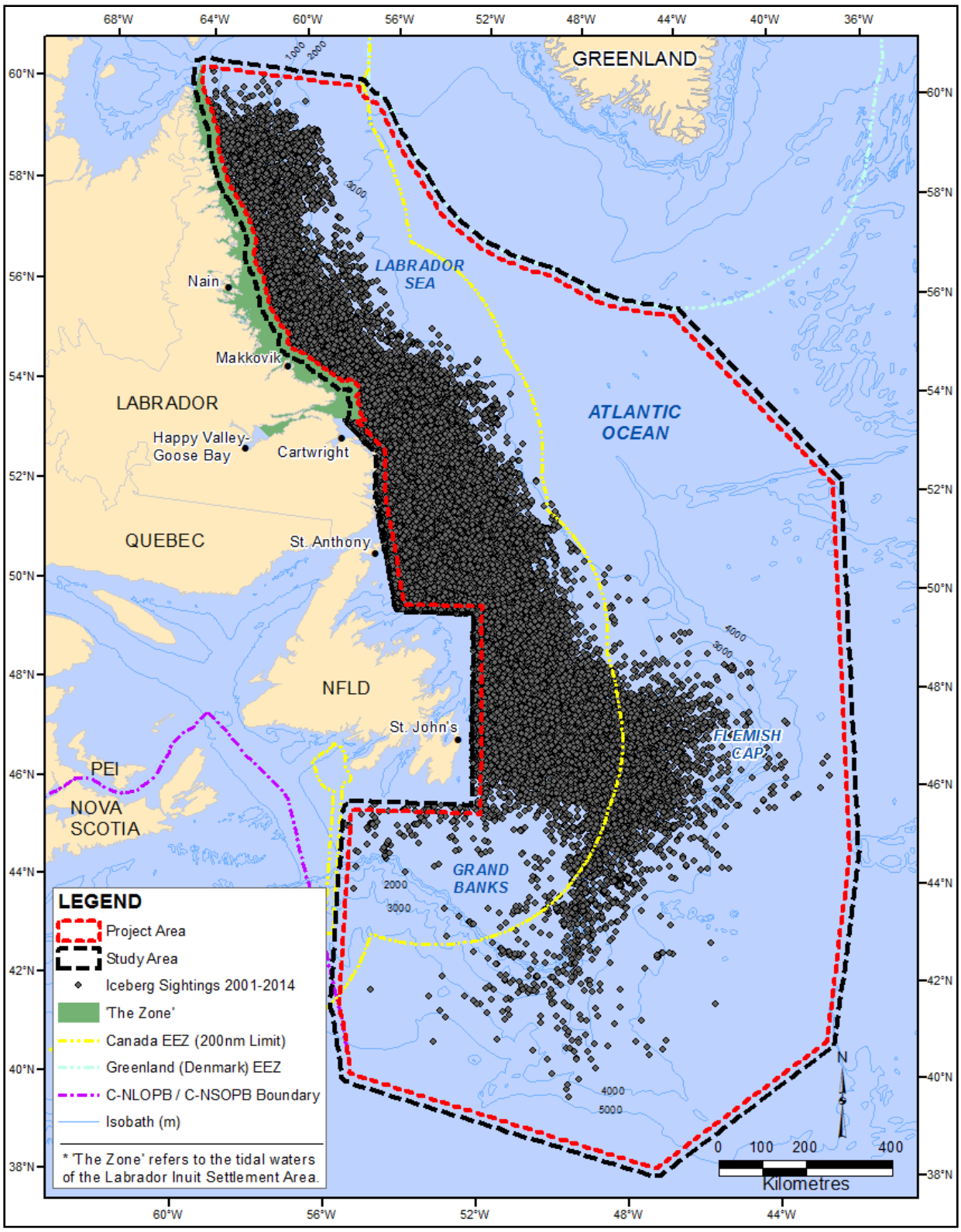
first-year ice not appearing until the week of 22 January. Thin first-year ice is the predominant ice type in the eastern Newfoundland portion of the Study Area until April. Medium first-year ice is first present by the week of 12 February, and consists of the majority of sea ice in early-April. Old ice is present by the week of 16 April.

Grey-white ice begins to enter the southern portion of the Study Area by the week of 15 January, followed by a mixture of grey and grey-white ice by the week of 22 January. New ice also extends into the southern Study Area by the week of 5 February, with thin first-year ice appearing by the week of 12 February. Medium first-year ice is present by the week of 5 March and old ice by the week of 26 March.

3.4.2 Icebergs

Icebergs often cause concern with regard to navigation and offshore activities along the coast of Newfoundland and Labrador. The major source, contributing ~90% of icebergs in Canadian waters, is 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 along the western border of the Study Area from offshore Labrador to Newfoundland, branching eastward towards the Flemish Cap and extending towards the south-central portion of the Study Area. No iceberg sightings were recorded in the easternmost portion of the Study Area, and sightings greatly decrease in the southwestern and southeastern portions of the Study Area (Figure 3.10).

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 3.16, during the period from 2001–2014, a total of 59,688 icebergs were observed in the Study Area. It should be noted that in Labrador waters north of ~52ºN in the Study Area, there were no iceberg sightings data available for 2001, 2002 and 2004, and there were only three and seven sightings for 2003 and 2005, respectively. Sightings may not include all icebergs passing through the Study Area, but indicate the relative abundance by month. Of the 59,688 icebergs sighted, 57.1% were observed during the period from May to November. Most were sighted in April, June and May (26.5, 23.0 and 21.3%, respectively), followed by March (13.0%) and July (10.7%). All remaining months contributed < 3% 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 to November of 2009, there were 4,381 icebergs observed in the Study Area. During the same time period of 2010, there were only 850 icebergs observed.



Source: NSIDC 1995, IIP Iceberg Sightings Database, accessed October 2015.

Figure 3.10 Iceberg Sightings in the Study Area, 2001–2014.

Table 3.16 Annual and Monthly Iceberg Sightings within the Study Area, 2001–2014.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2001	**-**	85	98	84	120	240	66	**-**	**-**	**-**	**-**	**-**	**693**
2002	-	72	828	1,370	831	661	104	-	-	-	-	-	**3,866**
2003	-	11	391	1,261	1,994	393	55	-	-	-	-	-	**4,105**
2004	-	1	78	1,060	1,438	201	42	7	-	-	-	-	**2,827**
2005	-	5	18	44	8	20	-	-	-	-	-	3	**98**
2006	6	133	134	649	549	2,369	-	-	-	-	3	6	**3,849**
2007	45	25	536	348	536	1,226	1,471	1	-	-	3	5	**4,196**
2008	37	146	648	2,753	624	649	322	21	15	-	-	2	**5,217**
2009	39	112	1,099	1,274	2,115	1,442	653	153	18	-	-	2	**6,907**
2010	2	40	131	1,023	207	449	148	40	5	-	1	-	**2,046**
2011	1	50	172	144	826	918	1,090	414	19	1	-	-	**3,635**
2012	12	130	403	1,045	1,206	599	364	72	51	20	15	2	**3,919**
2013	16	246	129	510	968	1,192	993	149	32	2	3	7	**4,247**
2014	119	682	3,081	4,227	1,277	3,396	1,081	213	7	-	-	-	**14,083**
Total	**277**	**1,738**	**7,746**	**15,792**	**12,699**	**13,755**	**6,389**	**1,070**	**147**	**23**	**25**	**27**	**59,688**
% of Total	0.5	2.9	13.0	26.5	21.3	23.0	10.7	1.8	0.2	0.0	0.0	0.0	-

Source: NSIDC 1995, IIP Iceberg Sightings Database, accessed October 2015.

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 2001–2014, 38.3% of the 59,688 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 recently described in the Labrador Shelf SEA (C-NLOPB 2008), the Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), and three project-specific EAs (LGL 2014, 2015a,b), as well as EAs for MKI's Labrador Sea Seismic Program (LGL 2014), WesternGeco Canada's Eastern Newfoundland Offshore Seismic Program (LGL 2015a), and WesternGeco Canada's Southeastern Newfoundland Offshore Seismic Program (LGL 2015b). 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 three SEAs (C-NLOPB 2008, 2010, 2014) have also been examined for any change in status.

4.1 Ecosystem

This EA focuses on components of the ecosystem such as selected species and stages of fish, marine-associated birds and marine mammals that are important ecologically, economically, and/or socially, with potential to interact with the Project. This is the VEC approach to environmental assessment which is detailed in § 5.0. The VECs and/or their respective groups are discussed in the following subsections.

4.2 Fish and Fish Habitat VEC

The Fish and Fish Habitat VEC of the Study Area has been recently described in the Labrador Shelf SEA (§ 4.4 to 4.8 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.1 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.1 and 3.2 of C-NLOPB 2010), and three project-specific EAs (§ 4.2 of LGL 2014, 2015a, b). An overview of the fish and fish habitat of the Study Area, based primarily on information from the three SEAs and three site-specific EAs, is provided below. Newly available information is also included in this section. Fish and fish habitat data gaps identified in the two SEAs are also discussed in terms of current status.

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 the 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. Members include bacteria, fungi, phytoplankton, and zooplankton (mostly invertebrates, but may also include eggs and larvae of fishes, known as ichthyoplankton). In simplest terms, phytoplankton (e.g., diatoms) 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 predacious zooplankton (e.g., chaetognaths, jellyfish, etc.), all of which may be grazed by higher predators such as fish, seabirds, and marine mammals. This food web also links to the benthic ecosystem through bacterial degradation processes, dissolved and particulate carbon, and direct predation. An understanding of plankton production is important because areas of enhanced production and (or) biomass are areas where fish, seabirds, and marine mammals congregate to feed.

Phytoplankton distribution, productivity, and growth regulation in high-latitude ecosystems constitute a complex system with light, nutrients, and herbivore grazing being the principal factors limiting phytoplankton regulations (Harrison and Li 2008). In the NW Atlantic, there is generally a spring plankton bloom (May/June) which is often followed by a smaller bloom in the fall (September/October). This general pattern likely applies to the Study Area. There may be areas 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 2014 and 2015 (DFO 2015a) indicate the highest chlorophyll ‘a’ concentrations in the southern portion of the Study Area occurred on the shelf and along the slope areas between April and June. A second peak, albeit less than the spring peak, occurred in October and November, primarily in slope areas. In the northern portion of the Study Area (i.e., off Labrador), the highest chlorophyll ‘a’ concentrations occurred on the shelf and along the slope areas between June and late August. A second peak, albeit less than the earlier 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 offshore. Sunlight has been considered the limiting factor for development of the spring bloom; however, factors such as nutrients, latitude and water column stratification are also important (Wu et al. 2008).

Zooplankton reproduction is tied to the phytoplankton bloom, which either coincides with or immediately follows the brief but intense phytoplankton blooms in the high latitudes (Huntley et al. 1983; Head et al. 2000; Head and Pepin 2008). Zooplankton 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 birds higher in the food chain. Zooplankton is a food source for a broad spectrum of species and they contribute

carbon via faecal matter and dead zooplankton to benthic food chains. Pepin et al. (2011) noted plankton distribution in the Study Area to be 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), the Eastern Newfoundland SEA (§ 4.2.1.3 of C-NLOPB 2014), and the Southern Newfoundland SEA (§ 3.1.3 of C-NLOPB 2010), and is summarized briefly in this subsection. Some of the key points concerning the various components of planktonic communities for the eastern and southern Grand Banks as well as 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, usually 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.
- Nitrate levels are limited in the Eastern NL SEA Study Area relative to other areas of the NW Atlantic and favour the growth of diatoms.
- The areas within the Southern NL SEA Study Area where primary production was highest at certain times during 2008 (based on chlorophyll-a concentration) included the coastal region of the southwest coast of Newfoundland, the western edge of St. Pierre Bank/Laurentian Channel, and both the slope and shelf of the southwest Grand Bank.
- 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 serve as a food source as well as degrade organic matter (Bunch 1979). Typically, microflora are most abundant in the upper layers, and their numbers decrease with depth (Li and Harrison 2001).
- The spring bloom of phytoplankton is the driving force of high-latitude marine ecosystem dynamics and its initiation in the Labrador Sea is strongly regionally dependent (Wu et al. 2008). The spring bloom in the southern Labrador Sea starts in March as a continuation of the bloom that commences on the Grand Banks and spreads northward. In the northern Labrador Sea, the spring bloom starts in early April with the bloom occurring earlier in both the north and south Labrador Sea areas as compared to the central Labrador Sea (Wu et al. 2008).

- The role of sea-ice dynamics on the phytoplankton dynamics in the Labrador Shelf area is significant in that the marginal ice zones release freshwater via melting thereby strengthening stratification and affecting salinity and temperature distributions of the upper mixed layer. Retreat of the sea ice also influences the timing and magnitude of the phytoplankton bloom as well as penetration of light into the water column (Wu et al. 2007).
- The Labrador Shelf area is highly productive because of upwelling along the slopes of the offshore banks and channels and the outflow of nutrient rich water from the Hudson Strait (Drinkwater and Harding 2001; Breeze et al. 2002).
- Arctic water masses that influence the Labrador Current are dominated by calanoid copepods (*Calanus finmarchicus*, *Calanus glacialis*, and *Calanus hyperboreus*) and the cyclopoid *Oithona similis* (Huntley et al. 1983).
- Sea ice biota are fauna and flora of all trophic levels that live in, on, or associated with sea ice during all or part of their life cycle. Some of these species become part of the plankton when the ice melts. Communities are found at the surface, interior, and bottom of the ice. There are different mechanisms for the formation of these communities depending on where the community is located within the ice (Horner et al. 1992).
- In general, larger microplankton are dominated by diatoms (e.g., *Chaetoceros* sp.), but dinoflagellates (*Ceratium* spp.) become more abundant in fall/winter (Harrison et al. 2013).
- Copepods make up a large 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.
- Euphausids such as krill are an important prey species 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 to increase survivorship.
- Ichthyoplankton assemblages (fish eggs and larvae) on the Northeast Newfoundland Shelf are primarily dominated by capelin (*Mallotus villosus*), sand lance (*Ammodytes* sp.), lanternfishes, and Arctic cod (*Boreogadus saida*).
- The vertical distributions of many zooplankton species exhibit diurnal variability, whereby concentrations in the surface waters are greater during the day.

The Atlantic Zone Monitoring program (AZMP) was implemented by DFO in 1998 in an attempt 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 2015a). The AZMP findings in relation to oceanographic conditions in the Study Area for 2014 are summarized below.

- Sea-surface temperatures were at record highs in August 2014 in 7 of 12 regions in the zone, and generally above normal during ice-free months, across the zone. Bottom temperatures were generally normal or above normal across the zone.
- Nitrate inventories in both surface and subsurface waters were below normal on the Newfoundland and Labrador Shelf and Grand Banks.
- Overall abundance of coepepods throughout much of the Atlantic Zone has increased relative to levels observed in 2013.
- Chlorophyll a inventories were near the long-term average throughout much of the Atlantic Zone.
- Timing indices of the spring bloom was substantially delayed on the northern Labrador and northeast Shelf in contrast to the Flemish Pass and Cap that occurred earlier (Pepin et al. 2015).
- The abundance of *Calanus glacialis* and *Calanus hyperboreus* has shown long-term declines in abundance on the Flemish Cap and southeast Grand Bank (Pepin et al. 2015).
- High abundance levels of non-copepod zooplankton (e.g., larval stages of benthic invertebrates and carnivores that feed on other zooplankton) were observed on the Newfoundland Shelf and Grand Banks in 2014.
- The abundance levels of zooplankton species *Pseudocalanus* spp. has increased throughout the Newfoundland Shelf while *Calanus finmarchicus* has demonstrated below to well below normal levels throughout much of the Atlantic Zone.

Planktonic organisms are so ubiquitous and abundant, and many have such rapid generation times that there will be essentially no or 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 here. 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: infaunal organisms, sessile organisms, and epibenthic species (Barrie et al. 1980). Infaunal organisms live on or are buried in soft substrates and include bivalves, polychaetes, amphipods, sipunculids, ophiuroids, and some gastropods. Sessile organisms live attached to hard substrates and would include barnacles, tunicates, bryzoans, holothurians, and some anemones. The epibenthic organisms are active swimmers that remain in close association to the seabed and include mysiids, amphipods, and decapods.

Benthic invertebrate communities can be spatially variable because of physical habitat characteristics such as water depth, substrate type, currents, and sedimentation. The primary

factors affecting the structure and function of such communities in high latitude communities are water mass differences, sediment characteristics, and ice scour (Carey 1991). The wide range of these characteristics within the 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 environment in the Study Area can be broken into two distributional zones (Carey 1991):

1. Continental shelf where the biomass is higher at the shelf edge; and
2. Upper slope areas where the biomass begins to decrease.

The benthic invertebrate communities of portions of the Study Area have been described in the Labrador Shelf SEA (§ 4.6 and 4.7 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.1.5 of C-NLOPB 2014), Southern Newfoundland SEA (§ 3.1.4 of C-NLOPB 2010), and three EAs (§ 4.2 of LGL 2014, 2015a,b). It is important to note that beyond the Canadian 200 nm limit, excluding the Nose and Tail of the Grand Banks, the Flemish Pass and the Flemish Cap, there is a substantial deficiency in data relating to the benthos. The information presented in this subsection pertains to studies completed on the continental shelf and slope of the Study Area.

- Some of the key deep subtidal invertebrate species in the Eastern Grand Banks area include snow crab (*Chionoecetes opilio*), Iceland scallops (*Chlamys islandica*), sea scallops (*Placopecten magellanicus*), northern shrimp (*Pandalus borealis*), striped pink shrimp (*Pandalus montagui*), Atlantic surf clams (*Spisula solidissima*), propeller clams (*Cyrtodaria silique*), pale sea urchin (*Strongylocentrotus pallidus*), hooded shrimp (Cumacea), and whelks (*Buccinum* sp.).
- Characteristic deep subtidal invertebrate species in the Southern Grand Banks area include lobster (*Homarus americanus*), snow crab, toad crab (*Hyas* sp.), rock crab (*Cancer* sp.), Iceland scallops, sea scallops, northern shrimp, Stimpson's surf clams (*Mactromeris polynyma*), propeller clams (*Cyrtodaria siliqua*), ocean quahogs (*Arctica islandica*) and sea urchins.
- There have been a limited number of benthic studies conducted in the waters off Labrador, particularly those deeper than 200 m, the depths most commonly found in the Study Area. The studies described in the Labrador Shelf SEA (Sikumiut 2008) largely concern benthic organisms and communities occurring in inshore waters shallower than 200 m.
- A number of research studies have characterized benthic communities on the Grand Banks (Schneider et al. 1987; Kenchington et al. 2001; Gale 2013; Gilkinson 2013) and associated slopes (Houston and Haedrich 1984).
- The Sydney Basin SEA and the Laurentian Sub-basin SEA both described benthic invertebrate communities reported by Hutcheson et al. (1981) and Nesis (1965) in deep subtidal areas of the Grand Banks. Reported invertebrate groups included

echinoderms, polychaetes, crustaceans, bivalve molluscs and benthic colonial organisms such as bryozoans, hydrozoans, sponges and corals.

- Schneider et al. (1987) reported observing epifaunal communities of the northeastern part of the Grand Banks that were dominated by bivalves and echinoderms such as brittlestars, urchins, and sand dollars.
- Trawling impact studies conducted by Prena et al. (1999) and Kenchington et al. (2001) using video grabs and benthic sled and trawl bycatch sampling characterized benthic communities on the northeast slope of the Grand Banks within the Study Area over a three year period. Kenchington et al. (2001) documented 246 benthic taxa which were primarily echinoderms, polychaetes, crustaceans, and molluscs.
- In contrast to other survey types, DFO RV trawl surveys were dominated by relatively large taxa such as sponges, anemones, shrimp, crab and urchins. Other taxa included echinoids such as sand dollars, sea stars, brittle stars and basket stars (LGL 2012, 2013).
- Infaunal invertebrates collected at Lewis Hill (southwestern Grand Banks) in recent years were dominated by polychaetes, followed by nemertean worms, amphipods and sea cucumbers. The invertebrate community found at Lewis Hill was very similar to those found in similar surficial sediment types elsewhere on the Grand Banks (Husky 2003a,b).
- Many benthic communities in the Eastern Newfoundland SEA Study Area are quite diverse compared to higher trophic levels and can be expected to vary over time and with changing environmental conditions.

Gilkinson (2013) provides summary data related to benthos caught during DFO research survey vessel trawling in North Atlantic Fisheries Organization (NAFO) Divisions 3LNO between 2006 and 2010. Figure 1 in Gilkinson (2013) indicates that the trawl-caught benthos biomass was dominated by sponges, sea anemones, snow crab and echinoderms. Catches of sponges and shrimp in 3L were larger than those in 3NO. Also, sponge catches tended to be higher in 2J compared to 3K while sea anemone catch biomass was greater in 3K. During the DFO NEREUS grab sampling program, 2008 to 2010, a total of 455 benthic macrofaunal taxa were identified from 22,000 specimens representing 12 phyla. The average sampling depth was 92 m (range 58-157 m). Overall, 51% of samples collected were composed of pure sand. The majority (77%) of samples were collected from the mid-depth zone (>50-100 m) of which 46% contained pure sand. This increased to 61% in the deep zone. The three phyla that dominated the grab samples included Annelida, Arthropoda, and Mollusca. These three phyla comprised 86% of all recorded taxa. Annelida was the most species rich phylum (39% of all species) with polychaetes accounting for 99% of all annelid taxa. Amphipods accounted for 60% of arthropod taxa, while gastropods and bivalves accounted for 51% and 43% of mollusc taxa, respectively. Dominance in species richness by these three phyla is typical of northwest Atlantic continental shelves that are composed primarily of sandy seabeds (Gilkinson et al. 2005, and Kenchington et al. 2001 *in* Gilkinson 2013). Some of the main species collected in grab samples included the annelids

Glycera capitata, Prionospio steenstrupi, Terebellides stroemi, Nothria conchylega, Nothria conchylega, and *Pectinaria granulate*, the arthropods *Hyas coarctatus, Unciola irrorata,* and *Unciola leucopis*, and the molluscs *Antalis entails, Crenella decussate, Arctica islandica, Liocyma fluctuosa*, and *Chlamys islandicus*.

Also, in a study conducted by Houston and Haedrich (1984), grab samples were taken in the vicinity of Carson Canyon (continental edge and slope) on the southeastern Grand Banks that revealed communities dominated by polychaetes, hooded shrimp, sipunculid worms, amphipods, echinoderms, isopods and bivalves. The relative dominance of these taxa depended on the substrate, although polychaetes were among the top four abundant taxa in each of sand, gravel and silt (Houston and Haedrich 1984).

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, in terms of standing crop and abundance, at the shallower site were *Tachyrhynchus erosus* and *Macoma loveni* for molluscs, *Rhodine gracilior*, *Maldane sarsi,* and *Chaetozone setosa* for polychaetes, *Ophiura robusta* for echinoderms, and *Unciola leucopis* for crustaceans. The deeper site was dominated by *Yoldiella lucida*, *Thyasira gouldi*, and *Dentalium occidentale* for molluscs, *Glycera capitata*, *Ophelina cylindrocaudatus*, *Lumbrineris impatiens*, and an unidentified species for polychaetes, and *Amphipholis squamata* and *Amphiura fragilis* for echinoderms. The dominant crustaceans at the deeper site included *Ischyrocerus megacheir*, *Ampelisca gibba*, *Ampelisca amblyops*, *Haploops tubicola*, and *Byblis crassicornis*. At the shallower site, the water mass was influenced by mixing between the Labrador Current water and deeper, warmer Atlantic Intermediate water. The deeper site occurred under the Irminger Atlantic water mass.

A recent study (Murillo et al. 2015) provides information on the epibenthic invertebrate assemblages that occur beyond the Canadian 200 nm limit on the Tail and southern Nose of the Grand Bank, and in the Flemish Cap area. Sampling was conducted with bottom trawls. Twelve spatially coherent epibenthic megafaunal assemblages were identified, nested within three major regional-scale faunal groups: (1) the continental shelf of the Tail of the Grand Bank, typified by the sea cucumber (*Cucumaria frondosa)* and the sand dollar (*Echinarachnius parma*); (2) the

upper slope of the Grand Bank and the top of the Flemish Cap, typified by the sponges *Radiella hemisphaerica* and *Iophon piceum*, and the sea star *Ceramaster granularis*; and (3) the lower slope of the Grand Bank and Flemish Cap, typified by the sea urchin *Phormosoma placenta*, and the sea pens *Anthoptilum grandiflorum* and *Funiculina quadrangularis*. Statistical analysis concluded that faunal group 1 is most closely associated with shallow depth (i.e., <200 m), coarse sediments, and cold fresh water associated with the Labrador Current, and faunal group 3 with greater depth (i.e., 500-600 m), muddy sediments, and warmer, more saline water. An extensive comprehensive list of epifauna collected during the bottom trawl surveys is presented in Table A.1 *in* Murillo et al. (2015). This study fills a knowledge gap in these areas.

There is a substantial deficiency in data related to the benthos that occurs in the portion of the Study Area beyond the Canadian 200 nm, excluding the Nose and Tail of the Grand Banks, the Flemish Pass and the Flemish Cap.

For more information on the life history and biology of some of the key benthic species in the Study Area see Table 4.58 of the Eastern Newfoundland SEA (C-NLOPB 2014).

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), such as large gorgonian corals (Breeze et al. 1997). Others, such as small gorgonians, cup corals, and sea pens, prefer sand or mud substrates (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, thirty species of corals were documented, including two antipatharians (black wire corals), 13 alcyonaceans (large gorgonians, small gorgonians, and soft corals), four scleractinians (solitary stony corals), and 11 pennatulaceans (sea pens). The authors noted that corals were more widely distributed on the continental edge and slope, most found deeper than 200 m.

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 relation to fishes (e.g., Gilkinson and Edinger 2009; Kenchington et al. 2010a,b; Baillon et al. 2012; Baker et al. 2012). Wareham (2009) updated deep-sea coral distribution data for the

Newfoundland and Labrador and Arctic Regions to partially fill information gaps previously identified by Wareham and Edinger (2007). Their study area encompassed the continental shelf, edge, and slope ranging from Baffin Bay to the Grand Banks, including the Labrador Shelf (NAFO Divisions 2GHJ). Distributional maps were compiled by Wareham (2009) using DFO Newfoundland and Labrador Region Multispecies Surveys (2000 to 2007), DFO Arctic Multispecies Surveys (2006 to 2007), Northern Shrimp Survey (2005), and from Fisheries Observers aboard commercial fishing vessels (2004 to 2007). The maps provided by Wareham (2009) show the distribution of several coral groups occurring along the continental edge and slope from Baffin Bay to the Grand Banks. The groups profiled include antipatharians, alcyonaceans, scleractinians, and pennatulaceans. Six previously undocumented coral species, composed of one alcyonacean, two scleractinians, and three pennatulaceans, were identified in the Newfoundland and Labrador and Arctic Regions (Wareham 2009).

According to distribution maps included in Wareham (2009), there are numerous species of corals occurring within or adjacent to the Study Area. The species identified include large gorgonians (*Keratoisis ornata*, *Paragorgia arborea*, *Primnoa resedaeformis*, and *Paramuricea* spp.), small gorgonians (*Acanthogorgia armata*, *Acanella arbuscula, Radicipes gracilis*, and *Anthothela grandiflora*), and soft corals (*Anthomastus grandiflorus*, *Duva florida*, *Gersemia rubiformis*, and *Nephtheid* spp.). Also noted were scleractinian species (*Flabellum alabastrum, Javania cailleti, Dasmosmilia lymani, Vaughanella margaritata* and *Flabellum macandrewi*) and several pennatulacean species (*Protoptilum carpenteri*, *Anthoptilum grandiflorum, Halipteris finmarchica, Pennatula grandis, Pennatula phosporea, Distichoptilum gracile*, *Funiculinia quandrangularis* and unspecified sea pen species). Antipatharian species were also observed within the Study Area along the Flemish Pass, NE Newfoundland shelf, and 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. Map 1 in Wareham (2009) indicates a continuous coral distribution within the Study Area primarily on the edges of the continental shelf and slope of the Grand Banks. In another deep-water coral distribution study within the eastern region of the Study Area, it was determined that the Flemish Cap supported the greatest species diversity of deep-water corals (Murillo et al. 2011). They observed 34 species on the Flemish Cap, followed by 22 species in the Flemish Pass and on the Nose of the Grand Banks.

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 dramatic 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, of roughhead grenadier (*Macrourus berglax*) with large gorgonians/antipatharians and soft corals, and of marlin-spike grenadier (*Nezumia bairdii*) with

small gorgonians. Baillon et al. (2012) determined that several types of coral, particularly sea pens (e.g., *Anthoptilum grandiflorum*) were hosts to eggs and/or larvae of two redfish species (*Sebastes fasciatus* and *S. mentella*), 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, 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 Northwest Atlantic contained a significantly higher biodiversity and abundance of associated megafauna compared to non-sponge habitat.

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

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

Since 2008, the North Atlantic Fisheries Organization (NAFO) Scientific Council has identified various areas of significant coral and sponge concentrations within the NAFO Regulatory Area. These areas that have been deemed closed to fishing with bottom gear are shown in § 4.7 on Sensitive Areas (NAFO 2015a).

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

Data collected during DFO RV surveys in the Study Area during May to November 2013, indicate that corals and sponges were caught primarily in the slope areas of the Grand Banks and off Labrador although some were also sampled on the shelf (see Figures 4.27 and 4.28 *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, 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., snow crab, northern shrimp and Greenland halibut *Reinhardtius hippoglossoides*) and other species caught incidentally (e.g., wolffishes [*Anarhichas* spp]).

Snow crab, northern shrimp 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

Snow Crab

Aspects of the snow crab life history, including information on distribution, are discussed in § 4.2.2.1 of LGL 2014, 2015a,b). Subsections 4.8.2 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.5 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on snow crab.

Snow crab landings in NAFO Div. 2HJ have increased by 25% to 1,740 t from 2013 to 2014 and recruitment has increased since 2011. Meanwhile, landings in NAFO Div. 3K (Offshore) have declined by half since 2009 to 6,100 t in 2014, their lowest level in two decades. Snow crab landings in NAFO Div. 3LNO (offshore) have remained near their highest level, at about

26,000 t, in the past three years (DFO 2015c). Long-term recruitment prospects in these NAFO Divisions are considered unfavourable due to a recent warming oceanic regime (DFO 2015c).

There are two fishery closure areas that occur in the Project Area: (1) Hawke Channel; and (2) Funk Island Deep (see Figure 4.49); both were created to offer protection to snow crab (DFO 2015c). More details on these closure areas are provided in § 4.7 on Sensitive Areas.

In the commercial fishery conducted within the Study Area during May to November, 2013-2014, snow crab harvesting was conducted along the southeastern, eastern and northeastern shelf and upper slope of the Grand Banks, on the shelf south of the Avalon and Burin Peninsulas, on the shelf immediately east of the Avalon Peninsula, and the area off NW Newfoundland and SE Labrador (see Figure 4.13 in § 4.3.3.2). Distributions of fishing effort for snow crab within the Study Area during recent years prior to 2013 are provided in Figures 4.16-4.18 in § 4.3.3.2 of LGL (2014), Figures 4.23 and 4.24 in § 4.3.3 of LGL (2015a), and Figures 4.17 and 4.18 in § 4.3.3 of LGL (2015b).

Northern Shrimp

Aspects of the northern shrimp life history, including information on distribution, are discussed in § 4.2.2.1 of LGL (2014, 2015a,b). Subsections 4.8.3 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.5 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.1.4.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on northern shrimp.

The northern shrimp fishery in NAFO Div. 3LNO within the Study Area has seen a reduction in shrimp catch and declining Total Allowable Catch (TAC) levels in recent years. TACs increased from 6,000 t in 2000 to 30,000 t in 2009 and 2010 but declined to 4,300 t in 2014 due to continued declines in survey and commercial fishery indices. Small and large Canadian fishing fleets have altered their fishing patterns in response to low catch rates by fishing along the border to 3K. The number of countries fishing for shrimp in 3L decreased, from as many as 16 in 2006 to only one country in 2013. The majority (over 92.7%) of total biomass in NAFO Div. 3LNO from either spring or fall surveys has come from 3L, while 3N accounted for only 0.2-8.1%, and 3O accounted for less than 1% (Orr and Sullivan 2014). Northern shrimp have also been declining in NAFO Div. 3M, with biomass and abundance decreasing by 20% and 21% respectively in 2013 from the previous year (Casas 2013). The fishable biomass in Shrimp Fishing Area (SFA) 4 (NAFO Div. 2G) and 5 (NAFO Div. 2HJ) has been relatively stable since 2010; they were 134,000 t and 116,000 t, respectively, in 2014 (DFO 2015d). This decline has been attributed to a lack of strong year classes and poor recruitment in recent years. Climate-driven changes (e.g., time of phytoplankton bloom) and increases in predation pressure suggest low recruitment to the fishable biomass in the medium term in SFA 6 (including a portion of NAFO Div. 3K) (DFO 2015d).

In the commercial fishery conducted within the Study Area, northern shrimp harvesting during May to November, 2013-2014 was prosecuted primarily along the northeastern slope of the Grand Banks, the area off NW Newfoundland and SE Labrador, and at various slope areas off Labrador (see Figure 4.10 in § 4.3.3.2). Fishing effort distribution for snow crab within the Study Area during recent years prior to 2013 are provided in Figures 4.11-4.13 in § 4.3.3.2 of LGL (2014), and Figures 4.15-4.17 in § 4.3.3.2 of LGL (2015a). Catch locations for northern shrimp in the Study Area during DFO RV surveys in May to November, 2013, reflected the pattern observed with the commercial fishery data (see Figure 4.24 in § 4.3.7).

Note that the portion of NAFO Div. 3L where water depth <200 m is closed to commercial shrimp fishing during 2016 due to the decline of the stock (NAFO 2016).

Cockles

Life history aspects of the cockle, including distribution information, are presented in § 4.2.2.1 of LGL (2015b).

Figures 4.27 and 4.28 in § 4.3.3 of LGL (2015b) show the locations of cockle harvesting in the Study Area during May to November between 2005 and 2011. Cockle harvesting is concentrated on the eastern shelf of the Grand Banks in the general vicinity of Lilly Canyon and Carson Canyon.

Stimpson's Surf Clam

Life history aspects of the Stimpson's surf clam, including distribution information, are presented in § 4.2.2.1 of LGL (2015b). Subsection 3.1.4.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provides life history information on Stimpson's surf clam.

The fishery for Stimpson's surf clam takes place on Banquereau Bank and the Grand Banks using factory freezer fishing vessels equipped with hydraulic clam dredges. The fishery was established in 1986 (Roddick et al. 2011). There are four licenses for offshore vessels in this fishery however only two vessels are currently active. The stock, which does not have a high exploitation rate, is thought to be relatively healthy. The fishery typically takes place in areas with water depths of 45 to 65 m (Roddick 2013).

Fishes

Greenland Halibut (Turbot)

Life history aspects of Greenland halibut, including distribution information, are presented in § 4.2.2.1 of LGL (2014, 2015a). Subsections 4.8.6 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.2 of

the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Greenland halibut.

In the commercial fishery conducted within the Study Area during May to November, 2014, Greenland halibut harvesting was prosecuted primarily along the northeastern slope of the Grand Banks, and secondarily along the slope region of the Southern Grand Banks (see Figure 4.16 in § 4.3.3.2). Distributions of fishing effort for Greenland halibut within the Study Area during recent years prior to 2014 are provided in Figures 4.11-4.13 in § 4.3.3 of LGL (2014), Figures 4.29 and 4.30 in § 4.3.3 of LGL (2015a), and Figure 3.51 in § 3.3.1 of C-NLOPB (2010). Catch locations for Greenland halibut in the Study Area during DFO RV surveys in May to November, 2009-2013, were distributed along the outer shelf and upper slope of the Northern and Southern Grand Banks (see Figure 4.25 in § 4.3.7).

Atlantic Halibut

Life history aspects of Atlantic halibut (*Hippoglossus hippoglossus)*, including distribution information, are presented in § 4.2.2.1 of LGL (2015a). Subsections 4.8.22 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.2 and 4.2.1.5 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Atlantic halibut.

In the commercial fishery conducted within the Study Area during May to November, 2014, Atlantic halibut harvesting was conducted along the northeastern slope of the Grand Banks, the slope region of the Southern Grand Banks and on the Southeast Shoal (see Figure 4.18 in § 4.3.3.2). Distributions of fishing effort for Atlantic halibut within the Study Area during recent years prior to 2014 are provided in Figures 4.48-4.51 in § 3.3.1.2 of LGL (2015b).

Atlantic Cod

Life history aspects of Atlantic cod (*Gadus morhua*), including distribution information, are presented in § 4.2.2 of LGL (2014), and § 4.2.2.1 of LGL (2015a,b). Subsections 4.8 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Atlantic cod.

A recent study by Rose and Rowe (2015) discusses 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). While the Bonavista Corridor occurs within the Project Study Area, the Notre Dame Channel, southern Hamilton Bank and Hawke Channel are located north of the Project Study Area.

In the commercial fishery conducted within the Study Area during May to November, 2014, Atlantic cod were harvested along the northeastern slope of the Grand Banks, the slope region of the Southern Grand Banks and on the Southeast Shoal (see Figure 4.17 in § 4.3.3.2). Distributions of fishing effort for Atlantic cod within the Study Area during recent years prior to 2014 are provided in Figures 4.42-4.45 in § 4.3.3.2 of LGL (2015b). DFO RV data collected in the Study Area during May to November 2013 indicated Atlantic cod catches in the shelf and slope areas of the Northern and Southern Grand Banks (see Figure 4.24 in § 4.3.7).

American Plaice

Life history aspects of American plaice (*Hippoglossoides platessoides*), including distribution information, are presented in § 4.2.2.1 of LGL (2015a,b). Subsections 4.8.5 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014), and 3.7.1 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on American plaice.

In the commercial fishery conducted within the Study Area during May to November, 2014, American plaice were harvested primarily on the shelf of the Southern Grand Banks (see Figure 4.18 in § 4.3.3.2). DFO RV data collected in the Study Area during May to November 2013 indicated American plaice catches throughout the shelf and slope areas of the Northern and Southern Grand Banks (see Figure 4.24 in § 4.3.7).

Yellowtail Flounder

Life history aspects of yellowtail flounder (*Pleuronectes ferruginea)*, including distribution information, are presented in § 4.2.2.1 of LGL (2015a,b). Subsections 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on yellowtail flounder.

In the commercial fishery conducted within the Study Area during May to November, 2014, yellowtail flounder harvesting was prosecuted primarily in the Southeast Shoal area of the Southern Grand Bank (see Figure 4.16 in § 4.3.3.2). Fishing effort distribution for yellowtail flounder within the Study Area during recent years prior to 2014 are provided in Figure 4.23 in § 4.3.3.2 of LGL (2015b). Catch locations for yellowtail flounder in the Study Area during DFO RV surveys in May to November, 2009-2013, were distributed across the shelf of the Northern and Southern Grand Banks (see Figure 4.26 in § 4.3.7).

White Hake

Life history aspects of white hake (*Urophycis tenuis*), including distribution information, are presented in § 4.2.2.1 of LGL (2015b). Subsections 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on white hake.

Redfishes

Life history aspects of redfishes, including distribution information, are presented in § 4.2.2.1 of LGL (2015a,b). Subsections 4.8.4 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on redfishes.

In the commercial fishery conducted within the Study Area during May–November, 2014, redfish harvesting was conducted primarily along the slope area of the northeastern Grand Bank and the Southern Grand Bank (see Figure 4.17 in § 4.3.3.2). Fishing effort distribution for redfishes within the Study Area during recent years prior to 2014 are provided in Figures 4.37-4.39 in § 4.3.3.2 of LGL (2015b). Catch locations for deepwater redfish in the Study Area during DFO RV surveys in May –November, 2013, were distributed along the slope of the Northern and Southern Grand Banks (see Figure 4.24 in § 4.3.7).

4.2.2.2 Other Fishes of Note

Capelin

Life history aspects of capelin, including distribution information, are presented in § 4.2.2.2 of LGL (2015a). Subsections 4.8.10 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.2.2.3 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on capelin.

Wolffishes

Three species of wolffish (i.e., northern *Anarhichas denticulatus*, spotted *A. minor*, and Atlantic *A. lupus)* have statuses under Schedule 1 of *SARA*. The northern and spotted wolffishes have *threatened* statuses 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 on 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 § 4.2.2.2 of LGL (2015a) and 4.2.2.1 of LGL (2015b). Subsections 4.2.3 of the Labrador Shelf SEA (C-NLOPB 2008), 4.2.1.6 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.7.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provide life history information on Atlantic wolffish.

DFO RV data collected in the Study Area during May to November, 2013 indicated that Atlantic wolffish were caught in the shelf and slope areas of the Northern and Southern Grand Banks (see Figure 4.26 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 (2015a) and 4.8.12 of the Labrador Shelf SEA (C-NLOPB 2008).

Swordfish

Life history aspects of swordfish (*Xiphias gladius*), including distribution information, are presented in § 4.2.2.1 of LGL (2015b). Subsection 3.2.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010) also provides life history information on swordfish.

Anadromous Fishes

The two predominant anadromous fish species that occur 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) and also provide life history information on Atlantic salmon and Arctic char. Subsection 3.2.2.8 of the Southern Newfoundland SEA (C-NLOPB 2010) discusses the Atlantic salmon populations that occur in the southern portion of the Study Area.

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 to 10 months and larvae hatch in the spring	12 to 16 weeks
Snow Crab	On banks and possibly along some upper slope regions over the extent of its distribution	Mating in early spring Fertilized eggs carried by female for 2 years and larvae hatch in late spring/early summer	12 to 15 weeks
Greenland Cockle	Eastern Grand Banks	Uncertain	Uncertain
Stimpson's Surf Clam	Eastern Grand Banks	Fall	4 to 8 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
Yellowtail Flounder	Shallower sandy areas – typically <100 m water depth – at bottom	May to September, typically peaking in June/July Both eggs and larvae are planktonic.	Pelagic larvae are brief residents in the plankton
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
Atlantic Halibut	Uncertain	Likely spawns between January and May Both eggs and larvae are planktonic	6 to 8 weeks
American Plaice	Spawning generally occurs throughout the range the population inhabits.	April to May	12 to 16 weeks
Redfish	Primarily along edge of shelf and banks, in slope waters, and in deep channels	Mating in late winter and release of young between April and July (peak in April)	No planktonic stage
Atlantic Cod	Spawn along outer slopes of the shelf in depths from tens to hundreds of metres	March to June	10 to 12 weeks
Atlantic Salmon	Spawn in freshwater	October to November	Several weeks in freshwater
Wolffishes	Along bottom in deeper water, typically along continental slope	Summer to early winter (species-dependent)	Uncertain
Swordfish	NW Atlantic population believed to spawn in the Caribbean Sea, Gulf of Mexico, and off Florida	Year-round	Uncertain
Porbeagle Shark	Very little known about the location of the pupping grounds; likely southern Grand Banks	Mating in late-summer/fall and pupping between early-April and early-June	Uncertain
Arctic Char	Spawn in freshwater	October to November	Several weeks in freshwater
Cusk	Uncertain	May to August	Presumed to be 4 to 16 weeks
Sandlance	On sand in shallow water of the Grand Banks	November to January	Several weeks

4.2.3 Fish and Fish Habitat Data Gaps Identified in Relevant SEAs

The following data gaps 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 following data gap associated with the Fish and Fish Habitat VEC was identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- Data regarding fish and fish habitat in deep water beyond the continental slope, particularly for species that are not commercially important at this time.

The following data gaps associated with the Fish and Fish Habitat VEC were identified in the Southern Newfoundland SEA (§ 3.1.6 and 3.2.6 of C-NLOPB 2010).

- Data regarding the spatial and temporal distributions of macroinvertebrate eggs and larvae, and ichthyoplankton are deficient. Some spawning areas have been identified but little work has been done on the passive movements of the eggs and larvae of macroinvertebrates and fishes. More knowledge of drift routes would also provide more perspective on nursery areas.
- Data regarding benthos are quite dated and are primarily related to specific coastal areas and/or restricted time periods.
- Data regarding benthic community composition are limited; most are resultant of species-specific studies.
- Data regarding the life histories of many macroinvertebrates and fishes are deficient.
- Current data regarding the population size and structure of several macroinvertebrate and fish species are deficient.
- Data regarding many pelagic fishes are deficient.

All of the data gaps indicated above still exist. Any new information that has been made available since the two SEAs were completed is noted throughout § 4.2.

4.3 Fisheries

The Fisheries VEC of the Study Area has been described in the Labrador Shelf SEA (§ 4.10 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.3.4 of C-NLOPB 2014), the Southern

Newfoundland SEA (§ 3.3 of C-NLOPB 2010), and three project-specific EAs (§ 4.3 of LGL 2014, 2015a, b). An overview of the fisheries of the Study Area, based on these documents as well as new information available since their publication is provided below.

This subsection describes the commercial fishery in the Study Area between 2009–2014. The Study Area overlaps portions of NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, 3K, 3L, 3M, 3N, 3O, 3Ps, 4Vs and 6H (Figure 4.1).

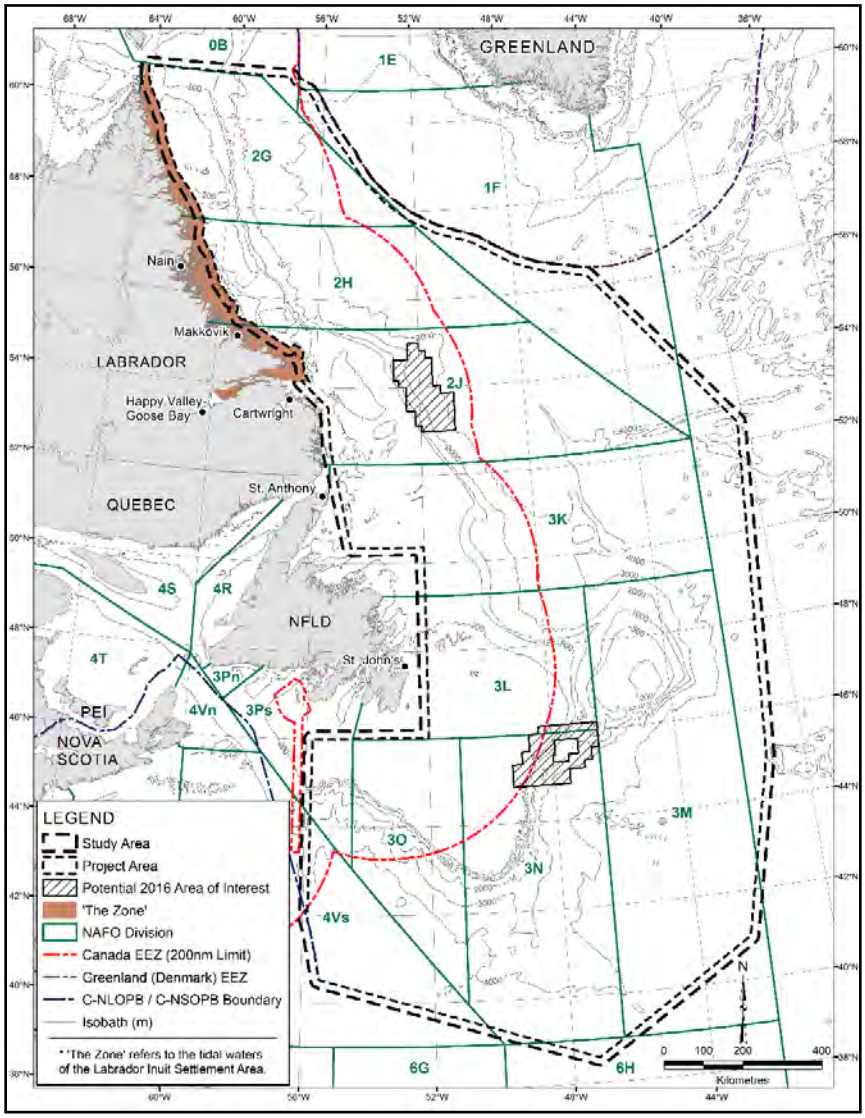


Figure 4.1 Study Area and Project Area in Relation to Regional Fisheries Management Areas (NAFO Divisions and Unit Areas).

This subsection also briefly describes recreational fisheries, traditional fisheries, aquaculture activity, and fisheries research surveys in the Study Area. The biology and status of the principal macro-invertebrate and fish species included in this section were discussed in § 4.2, Fish and Fish Habitat.

4.3.1 Information Sources

NAFO catch weight data are used to describe both domestic and foreign fisheries prosecuted beyond the 200 nm EEZ. Over half of the Study Area is located outside of the 200 nm limit (see Figure 4.1). The NAFO data are derived from the STATLANT 21 data set for 2009–2014. The STATLANT reporting system of questionnaires data are described in § 4.3.1 of LGL (2015a). The data analyses in this EA quantifies harvesting for NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, 3K, 3L, 3M, 3N, 3O, 3Ps, 4Vs and 6H (see Figure 4.1).

The primary fisheries data analyses use all DFO Atlantic Regions georeferenced landings data for the 2009–2010 time period, as well as gridded cell landings data for 2011–2014. The DFO datasets, analyses and georeferencing/grid methodology of pre- and post-2010 DFO data are described in § 4.3.1 of LGL (2015a). Figures based on the 2009–2014 commercial fishery landings data are included in the EA, including harvest location maps for 2013 and 2014. Figure references from the Labrador Shelf SEA (C-NLOPB 2008), Eastern and Southeastern Offshore Newfoundland SEAs (C-NLOPB 2010, 2014) and project-specific EAs (LGL 2014, 2015a,b) are provided for commercial harvest locations prior to 2014.

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 (2015a). During the 2009–2014 period, commercial harvesting within the Study Area beyond the 200 nm EEZ, in terms of catch weight, was dominated by northern shrimp (28% of total catch weight; primarily in NAFO Divisions 3K and 2J), snow crab (17%; primarily in 3L), surf clam (7%; almost exclusively in 4Vs), Greenland halibut (7%; primarily in 3L and 0B), Atlantic redfishes (7%; primarily in 3M and 3O), Atlantic cod (7%; primarily in 3M and 3Ps) and capelin (6%; primarily in 3L and 3K). The highest catch weights during the six year period were reported in NAFO Divisions 3L (21%), and 3K (19%), followed by 4Vs (11%), 2J (9%), 3M and 3Ps (7% each) and 3N (6%); all remaining Divisions within the Study Area accounted for ≥4% each. Canadian vessels accounted for 79% of the commercial catch weight reported for this area during 2009-2013. Only in Divisions 1E, 1F and 3M did the foreign vessels dominate catches (>99% of total catch weight in these Divisions). Catches in 1E were dominated by northern shrimp and Atlantic cod; catches in 1F were dominated by Atlantic cod and beaked deep-water redfish; and catches in 3M were dominated by Atlantic cod and Atlantic redfishes. Canadian and foreign

vessels accounted for ~40% and 60%, respectively, of the total catches in Divisions 3N and 3O, where the primary species captured included yellowtail flounder, skate sp. and snow crab in 3N and Atlantic redfishes, snow crab and yellowtail flounder in 3O.

4.3.3 Domestic Fisheries

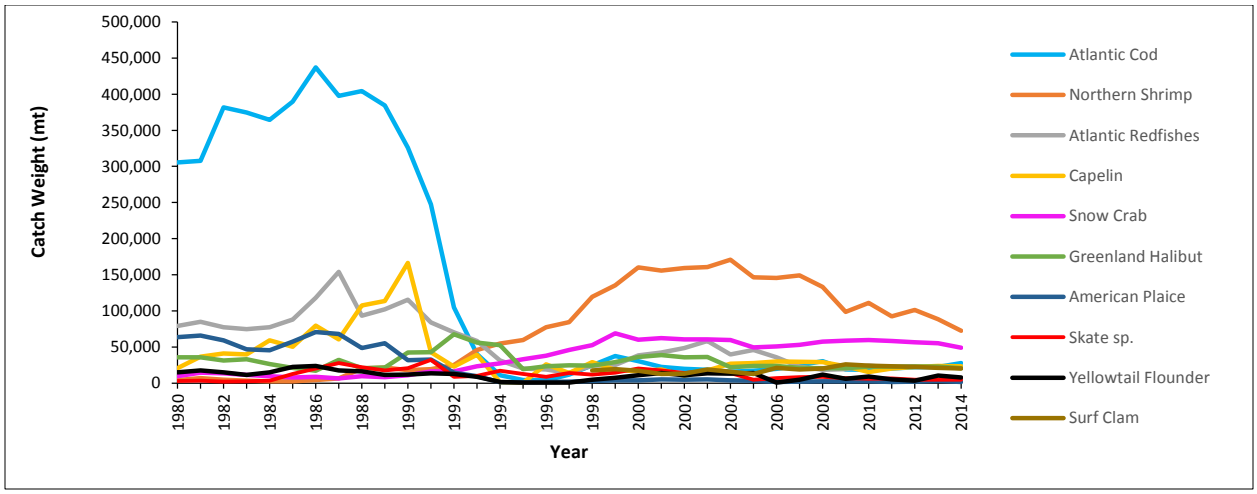
This subsection provides an overview of the commercial fisheries within and/or adjacent to the Study Area. The first part of this subsection provides the historical context. The second part is related to the georeferenced (lat/long) data recorded specifically within the Study Area for 2009-2010, and annual gridded cell (6' x 6') data for 2011–2014. Statistical summaries of the commercial catch data are provided for the Study and Project areas.

4.3.3.1 Historical Fisheries

A historical overview of fisheries was given in § 4.3.4.2 of the Eastern Newfoundland SEA (C-NLOPB 2014) and 3.3.3.1 of LGL (2015a). As per recent EAs in the region (e.g., LGL 2014, 2015a,b), the Study Area fisheries trended away from groundfish and towards crustacean harvesting in the late 1990s and early 2000s. In the late 1980s, the fisheries in NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, 3K, 3L, 3M, 3N, 3O, 3Ps, 4Vs and 6H largely targeted Atlantic cod, Atlantic redfishes, capelin and American plaice (Figure 4.2). However, the fishery was considerably reduced in the early 1990s at the time of the moratorium (Figure 4.2). Since then, much lower quotas have been allocated, based on scientific advice and other considerations. Priority groundfish species and their Integrated Fisheries Management Plans (IFMPs) are described in § 4.3.3.1 of LGL (2015a).

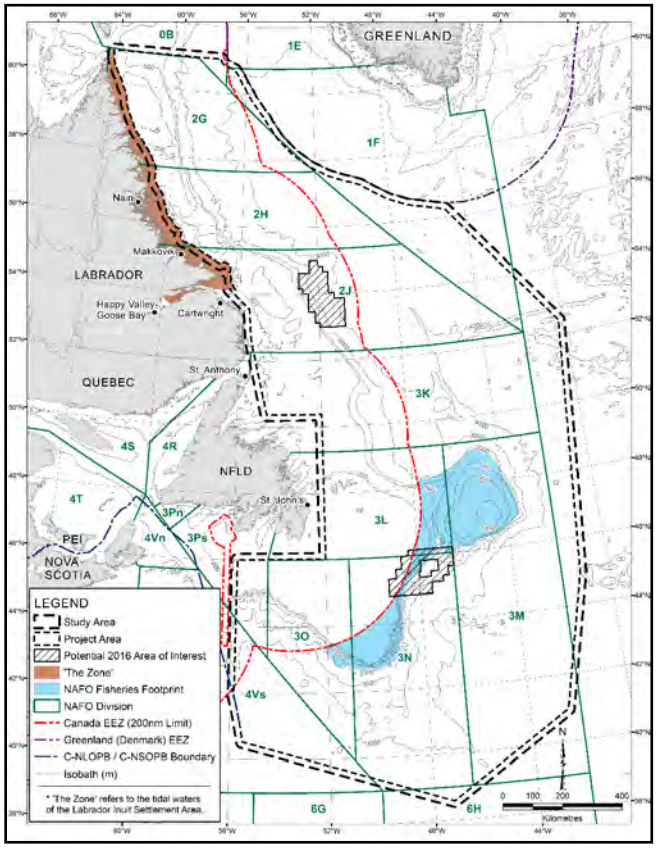
Invertebrate catches, most notably northern shrimp and snow crab, have become increasingly important within the Study Area, particularly since the mid-1990s. However, as detailed in § 4.3.3.1 of LGL (2015a), northern shrimp stocks have recently begun to decline, resulting in no shrimp fishery being permitted in Division 3L in either 2015 or 2016 (NAFO 2015b,c). With relatively high recruitment levels since the mid 2000's, the cod and redfish stocks on the Flemish Cap in NAFO Division 3M are currently in a healthy state, and are projected to be able to support an increase in catches in 2016 and 2017 (NAFO 2015b,d). Despite this recent healthy projection in Division 3M, fishing bans remain in place for 2016 for several groundfish species in NAFO Divisions 3LNO, including Atlantic cod, American plaice (also banned in 3M), witch flounder (in 3L) and capelin (in 3NO) (NAFO 2015b).

NAFO's bottom fishing footprint was described in § 4.3.3.1 of LGL (2015a). The entirety of the footprint is within the Study and Project Areas, including a portion within the western region of the southernmost potential 2016 Area of Interest (Figure 4.3).



Source: NAFO STATLANT 21A Data Extraction Tool.

Figure 4.2 Historical Catch Weights for Predominant Species in the Commercial Fisheries in NAFO Divisions 0B, 1E, 1F, 2G, 2H, 2J, 3K, 3L, 3M, 3N, 3O, 3Ps, 4Vs and 6H, All Countries, 1980–2014.



Source: NAFO 2015e.

Figure 4.3 Location of the NAFO Fisheries Footprint, 1987–2007, in relation to the Study and Project Areas.

4.3.3.2 Study Area Catch Analysis, 2009–2014

The May–November, 2009–2010, domestic harvests reported within the Study Area and Project Area are shown in Table 4.2. Domestic harvests from within the Study Area, May-November, 2011–2014, are shown in Tables 4.3–4.6. As indicated, the principal fisheries (by catch weight and value; in order of descending importance) are for northern shrimp, snow crab and Greenland halibut, which combined accounted for ~89% of the average annual catch weight in these areas during May–November, 2009–2010. Other notable species in commercial fisheries in the Study Area include yellowtail flounder, whelk, Atlantic cod, striped shrimp, Atlantic halibut and redfish. The total annual commercial fisheries catch weights of all species in the Study Area during May–November 2009–2010 remained relatively constant, between ~110,500–123,200 mt per year; the sum of quartile catch ranges in the Study Area decreased during May–November 2011–2014, from ~32,000 in 2011 down to ~19,000 in 2014 (Figure 4.4).

Commercial Harvest Locations in the Study Area

Georeferenced harvest locations for all species, May–November, 2005–2010 for the Labrador Shelf and eastern and southeastern offshore Newfoundland are shown in Figure 4.3 of LGL (2014) and Figures 4.5 of LGL (2015a,b), respectively. Harvest locations in 6' x 6' cells during May–November, 2011–2013 for the Labrador Shelf and eastern and southeastern offshore Newfoundland are shown in Figures 4.4–4.5 of LGL (2014) and Figures 4.6–4.8 of LGL (2015a,b). Year-round harvest locations are indicated in Figure 4.32 of the Labrador Shelf SEA (C-NLOPB 2008), Figures 4.123–4.124 of the Eastern Newfoundland SEA (C-NLOPB 2014) and Figure 3.18 of the Southern Newfoundland SEA (C-NLOPB 2010). Figure 4.5 shows harvest locations in 6' x 6' cells in relation to the Study and Project Areas for all species, May-November, 2013 and 2014. As these figures indicate, virtually no fish harvesting occurs in the eastern portion of the Study and Project Areas. The majority of harvesting occurs on the Grand Banks shelf and slope, out to the 1,000 m isobath. These locations are generally consistent from year to year.

Table 4.2 Study Area and Project Area Average Annual Catch Weight and Value by Species, May–November, 2009–2010.

Species	Study Area				Project Area			
	Quantity		Value		Quantity		Value	
	mt	% of Total	$	% of Total	mt	% of Total	$	% of Total
Northern Shrimp	68,549	58.7	95,587,657	46.0	66,264	60.0	92,654,387	46.9
Snow Crab	30,065	25.7	89,743,586	43.2	28,238	25.6	84,287,982	42.7
Greenland Halibut	5,201	4.4	10,835,471	5.2	5,188	4.7	10,811,409	5.5
Yellowtail Flounder	4,222	3.6	1,327,368	0.6	4,221	3.8	1,326,574	0.7
Whelk	2,620	2.2	2,309,681	1.1	922	0.8	813,302	0.4
Atlantic Cod	1,268	1.1	1,308,584	0.6	886	0.8	889,422	0.5
Striped Shrimp	944	0.8	1,774,202	0.9	892	0.8	1,679,955	0.9
American Plaice	837	0.7	345,883	0.2	828	0.7	337,939	0.2
Cockle	576	0.5	766,479	0.4	576	0.5	766,479	0.4
White Hake	505	0.4	250,347	0.1	494	0.4	245,238	0.1
Redfish	489	0.4	283,453	0.1	434	0.4	262,433	0.1
Skate sp.	290	0.2	71,338	<0.1	274	0.2	67,224	<0.1
Pollock	221	0.2	150,921	0.1	220	0.2	150,241	0.1
Monkfish	220	0.2	233,926	0.1	220	0.2	233,686	0.1
Atlantic Halibut	216	0.2	1,704,928	0.8	206	0.2	1,623,043	0.8
Atlantic Haddock	111	0.1	86,669	<0.1	110	0.1	85,888	<0.1
Witch Flounder	105	0.1	41,257	<0.1	105	0.1	41,247	<0.1
Swordfish	84	0.1	494,912	0.2	84	0.1	494,912	0.3
Hagfish	81	0.1	62,569	<0.1	81	0.1	62,569	<0.1
Stimpson's Surf Clam	81	0.1	141,484	0.1	81	0.1	141,484	0.1
Atlantic Herring	69	0.1	14,872	<0.1	69	0.1	14,872	<0.1
Mackerel	30	<0.1	11,307	<0.1	30	<0.1	11,307	<0.1
Bluefin Tuna	29	<0.1	316,619	0.2	29	<0.1	309,719	0.2
Roughhead Grenadier	24	<0.1	15,811	<0.1	24	<0.1	15,811	<0.1
Capelin	22	<0.1	3,002	<0.1	22	<0.1	3,002	<0.1
Cusk	5	<0.1	3,216	<0.1	5	<0.1	3,094	<0.1
Porbeagle Shark	4	<0.1	5,216	<0.1	4	<0.1	5,216	<0.1
Mako Shark	3	<0.1	8,548	<0.1	3	<0.1	8,548	<0.1
Bigeye Tuna	1	<0.1	15,519	<0.1	1	<0.1	15,519	<0.1
Sea Scallop	1	<0.1	1,366	<0.1	1	<0.1	1,047	<0.1
Mahi Mahi (dolphinfish)	1	<0.1	2,324	<0.1	1	<0.1	2,324	<0.1
Roundnose Grenadier	1	<0.1	472	<0.1	1	<0.1	472	<0.1
Albacore Tuna	0.4	<0.1	801	<0.1	0.4	<0.1	801	<0.1
Iceland Scallop	0.2	<0.1	299	<0.1	0.2	<0.1	274	<0.1
Shark sp.	0.2	<0.1	90	<0.1	0.2	<0.1	89	<0.1
Lobster	0.1	<0.1	956	<0.1	<0.1	<0.1	0	<0.1
Atlantic (striped) Wolffish	0.1	<0.1	58	<0.1	0.1	<0.1	57	<0.1
Skipjack Tuna	0.1	<0.1	514	<0.1	0.1	<0.1	514	<0.1
Flounder sp.	<0.1	<0.1	25	<0.1	<0.1	<0.1	20	<0.1
Totals	**116,876**	**100.0**	**207,921,729**	**100.0**	**110,515**	**100.0**	**197,368,099**	**100.0**

Source: DFO commercial landings database, 2009–2010.

Table 4.3 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) attributed to each species).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Northern Shrimp	724	1,110	1,479	1,583	991	1,273	1,466	1,166	4,896
Snow Crab	795	1,296	1,590	323	559	1,127	1,539	779	4,004
Greenland Halibut	177	353	253	54	127	366	271	73	837
Redfish sp.	49	107	153	55	83	113	120	48	364
Atlantic Halibut	104	116	84	32	92	180	59	5	336
Atlantic Cod	79	73	84	57	108	109	60	16	293
American Plaice	38	79	104	56	109	94	57	17	277
Witch Flounder	30	73	108	52	70	79	72	42	263
Roughhead Grenadier	29	56	62	17	21	54	65	24	164
Yellowtail Flounder	20	56	58	29	75	61	22	5	163
Skate sp.	17	72	58	5	31	79	32	10	152
Atlantic Haddock	25	40	41	33	56	50	29	4	139
White Hake	37	47	38	11	40	64	28	1	133
Monkfish	19	56	44	13	37	64	27	4	132
Whelk	7	23	36	52	20	27	44	27	118
Striped Shrimp	4	17	30	51	5	19	29	49	102
Bluefin Tuna	42	10	3	7	23	28	7	4	62
Pollock	7	18	13	17	20	18	15	2	55
Swordfish	36	15	1	0	20	28	4	0	52
Cusk	23	12	2	0	6	28	3	0	37
Mako Shark	13	8	1	0	7	12	3	0	22
Hagfish	1	2	9	2	3	9	2	0	14
Cockle	1	5	1	3	3	4	0	3	10
Bigeye Tuna	5	2	0	0	4	3	0	0	7
Roundnose Grenadier	4	3	0	0	0	7	0	0	7
Stimpson's Surf Clam	0	2	0	3	0	2	0	3	5
Atlantic (striped) Wolffish	3	0	0	0	2	1	0	0	3
Porbeagle Shark	3	0	0	0	2	1	0	0	3
Albacore Tuna	2	0	1	0	1	1	1	0	3
Yellowfin Tuna	3	0	0	0	2	1	0	0	3
Capelin	0	1	2	0	2	0	1	0	3
Atlantic Rock Crab	2	0	0	0	2	0	0	0	2
Winter Flounder	2	0	0	0	2	0	0	0	2
Mahi Mahi (dolphinfish)	2	0	0	0	2	0	0	0	2
Sea Scallop	2	0	0	0	2	0	0	0	2
Shark sp.	1	0	0	1	1	0	1	0	2
Mackerel	0	1	1	0	0	2	0	0	2
Groundfish	1	0	0	0	1	0	0	0	1
White Marlin	1	0	0	0	1	0	0	0	1
Total	**2,308**	**3,653**	**4,256**	**2,456**	**2,530**	**3,904**	**3,957**	**2,282**	**12,673**

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

[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 = ≥ 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 = ≥ $126,295.

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

Table 4.4 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) attributed to each species).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts[b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Northern Shrimp	586	1,050	1,247	1,441	878	1,055	1,208	1,183	4,324
Snow Crab	735	1,298	1,228	295	580	1,087	1,316	573	3,556
Greenland Halibut	172	294	238	39	150	286	255	52	743
Redfish sp.	58	106	138	28	72	91	135	32	330
Atlantic Halibut	118	119	80	12	112	146	66	5	329
Atlantic Cod	67	64	76	36	98	83	56	6	243
American Plaice	44	45	68	28	84	45	39	17	185
White Hake	39	66	48	4	48	73	34	2	157
Striped Shrimp	10	24	47	70	9	23	46	73	151
Witch Flounder	21	29	71	20	33	29	60	19	141
Skate sp.	23	62	49	5	33	57	47	2	139
Monkfish	23	64	42	9	40	65	32	1	138
Yellowtail Flounder	39	33	37	15	75	34	13	2	124
Roughhead Grenadier	23	32	49	19	21	39	44	19	123
Whelk	8	20	36	42	15	24	51	16	106
Atlantic Haddock	18	27	29	9	32	35	16	0	83
Bluefin Tuna	44	6	11	2	34	15	14	0	63
Swordfish	22	34	4	0	9	35	16	0	60
Pollock	4	23	24	0	20	19	12	0	51
Cusk	23	11	10	0	10	23	10	1	44
Mako Shark	11	22	2	0	5	17	13	0	35
Porbeagle Shark	19	4	0	0	7	13	3	0	23
Hagfish	1	5	9	0	4	6	5	0	15
Roundnose Grenadier	11	3	0	0	6	6	2	0	14
Bigeye Tuna	7	4	0	0	5	4	2	0	11
Albacore Tuna	7	4	0	0	4	6	1	0	11
Mahi Mahi (dolphinfish)	4	5	0	0	3	3	3	0	9
Capelin	0	0	5	1	5	0	1	0	6
White Marlin	0	5	0	0	0	2	3	0	5
Yellowfin Tuna	3	0	0	0	2	1	0	0	3
Flounder sp.	0	1	2	0	0	1	2	0	3
Iceland Scallop	1	1	0	0	1	1	0	0	2
Shark sp.	0	1	0	1	0	1	1	0	2
Atlantic (striped) Wolffish	0	1	0	0	0	0	1	0	1
Sea Scallop	1	0	0	0	1	0	0	0	1
Atlantic Rock Crab	1	0	0	0	1	0	0	0	1
Mackerel	0	1	0	0	1	0	0	0	1
Total	**2,143**	**3,464**	**3,550**	**2,076**	**2,398**	**3,325**	**3,507**	**2,003**	**11,233**

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

[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] 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, 2013 (values indicate the frequency of catch weight and value quartile codes (i.e., 1–4) attributed to each species).

Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Northern Shrimp	605	919	1,185	1,354	976	906	1,140	1,041	4,063
Snow Crab	478	1,099	1,211	328	401	884	1,130	701	3,116
Greenland Halibut	149	326	230	36	176	296	224	45	741
Atlantic Halibut	157	161	139	48	149	179	147	30	505
Atlantic Cod	84	160	171	56	124	177	149	21	471
American Plaice	51	152	125	54	133	118	99	32	382
Witch Flounder	56	105	120	42	97	89	105	32	323
Yellowtail Flounder	46	127	99	42	117	104	78	15	314
Redfish sp.	67	100	112	28	89	87	105	26	307
Atlantic Haddock	24	56	41	16	52	52	29	4	137
Whelk	12	24	68	25	23	43	55	8	129
White Hake	49	57	20	1	61	56	9	1	127
Striped Shrimp	11	28	39	38	10	24	38	44	116
Roughhead Grenadier	33	33	33	5	36	31	27	10	104
Skate sp.	22	29	26	5	39	21	18	4	82
Monkfish	11	19	15	5	24	19	7	0	50
Pollock	8	25	9	1	28	14	1	0	43
Cusk	28	11	0	0	18	20	1	0	39
Bluefin Tuna	2	1	12	0	1	5	9	0	15
Hagfish	0	6	7	0	2	10	1	0	13
Swordfish	7	4	0	0	3	6	2	0	11
Mako Shark	5	3	0	0	1	6	1	0	8
Mahi Mahi (dolphinfish)	3	3	0	0	0	4	2	0	6
Roundnose Grenadier	2	3	0	0	2	0	2	1	5
Dogfish sp.	2	3	0	0	2	0	2	1	5
Sculpin sp.	3	1	0	0	3	1	0	0	4
Flounder sp.	0	0	2	2	0	2	2	0	4
Capelin	0	1	2	1	3	1	0	0	4
Stimpson's Surf Clam	0	0	1	0	0	1	0	0	1
Mackerel	0	0	1	0	0	1	0	0	1
Albacore Tuna	0	1	0	0	0	0	1	0	1
Sea Scallop	1	0	0	0	1	0	0	0	1
Atlantic (striped) Wolffish	0	1	0	0	0	1	0	0	1
Atlantic Herring	1	0	0	0	1	0	0	0	1
Cockle	0	0	1	0	0	1	0	0	1
Total	**1,917**	**3,458**	**3,669**	**2,087**	**2,572**	**3,159**	**3,384**	**2,016**	**11,131**

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

[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] 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, 2014 (values indicate the frequency of catch weight and value quartile codes (i.e., 1–4) attributed to each species).

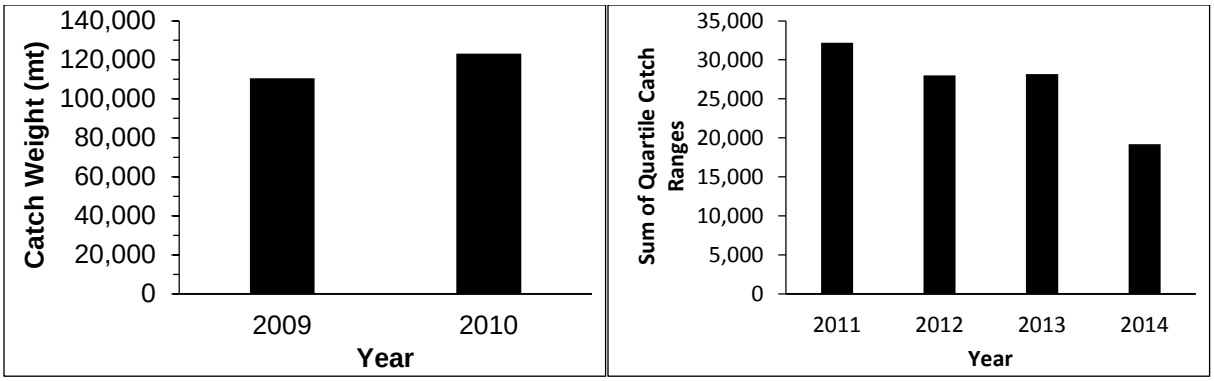
Species	Catch Weight Quartile Code Counts [a]				Catch Value Quartile Code Counts [b]				Total Counts [c]
	1	2	3	4	1	2	3	4	
Snow Crab	462	865	980	307	342	760	979	533	2,614
Northern Shrimp	351	493	538	670	479	458	520	595	2,052
Greenland Halibut	76	211	195	56	88	223	166	61	538
Atlantic Halibut	159	132	106	48	144	163	105	33	445
Atlantic Cod	90	135	111	58	123	158	98	15	394
American Plaice	44	72	75	35	83	79	54	10	226
Yellowtail Flounder	39	71	66	32	79	73	52	4	208
White Hake	77	55	42	9	88	76	18	1	183
Redfish sp.	44	48	38	30	57	49	33	21	160
Atlantic Haddock	24	41	47	20	44	50	34	4	132
Striped Shrimp	7	19	41	58	10	18	34	63	125
Skate sp.	45	23	20	8	53	29	10	4	96
Witch Flounder	15	21	24	25	21	19	21	24	85
Whelk	17	16	35	11	24	32	20	3	79
Pollock	6	22	25	4	29	23	5	0	57
Swordfish	29	19	7	0	18	19	16	2	55
Atlantic (striped) Wolffish	2	16	23	12	9	24	18	2	53
Mako Shark	18	16	7	0	11	15	13	2	41
Cusk	22	12	3	0	16	18	3	0	37
Roughhead Grenadier	2	13	11	9	2	16	12	5	35
Monkfish	5	11	8	8	13	11	8	0	32
Bluefin Tuna	10	7	7	6	7	12	8	3	30
Argentine	2	10	4	4	3	12	4	1	20
Porbeagle Shark	14	2	0	0	6	10	0	0	16
Mahi Mahi (dolphinfish)	7	6	2	0	4	5	5	1	15
White Marlin	3	4	1	0	2	1	4	1	8
Albacore Tuna	2	3	1	0	1	1	3	1	6
Groundfish sp.	0	4	0	0	0	1	3	0	4
Bigeye Tuna	2	1	0	0	1	1	1	0	3
Iceland Scallop	3	0	0	0	3	0	0	0	3
Sea Scallop	1	0	1	0	1	1	0	0	2
Capelin	0	0	2	0	2	0	0	0	2
Mackerel	0	0	1	0	0	1	0	0	1
Total	**1,578**	**2,348**	**2,421**	**1,410**	**1,763**	**2,358**	**2,247**	**1,389**	**7,757**

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

[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.

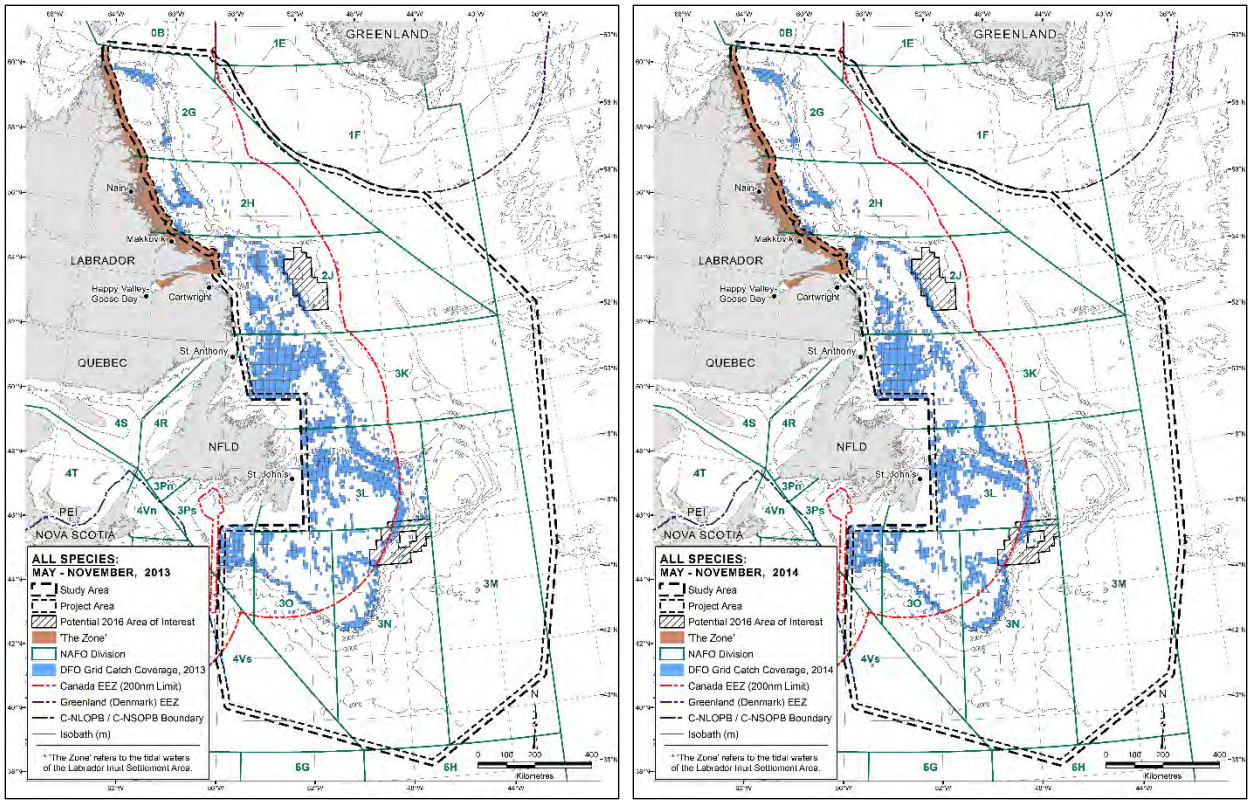
[b] Quartile ranges provided by DFO (quartile ranges calculated annually by DFO based on total catch values in a given year, all species combined). 2014 quartile ranges: 1 = $0 – $8,851, 2 = $8,852 – $38,076, 3 = $38,077 – $140,695, 4 = ≥ $140,696.

[c] 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, 2009–2014.
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 4.4 Annual Total Catch Weight, May–November, 2009–2010 (left), and Annual Total Catch Weight Quartile Codes, May–November, 2011–2014 (right) (all species within the Study Area).



Source: DFO commercial landings database, 2013, 2014.

Figure 4.5 Distribution of Harvest Locations, All Species Combined, May–November, 2013 (left) and 2014 (right).

Fishing Gear Used in the Study Area

Various types of fishing gear were used in the Study Area during May–November, 2009–2014; trawls (northern and striped shrimp, Greenland halibut, yellowtail flounder, Atlantic cod, Atlantic halibut, redfish), pots (snow crab, whelks), gillnets (Greenland halibut, yellowtail flounder, Atlantic cod, Atlantic halibut, redfish), and longlines (Greenland halibut Atlantic cod, Atlantic halibut, redfish) (Tables 4.7 and 4.8). Atlantic cod were also harvested using pots and hand lines (baited). Shrimp trawls (mobile gear) accounted for about 59% of the average total catch weight of all species in the Study Area between May–November, 2009–2010. Pots (fixed gear) accounted for about 26% of the average total catch weight during this period. Overall, mobile and fixed gears each accounted for about 67% and 33%, respectively (Table 4.7).

Fishing gears and harvest locations by gear type typically used in the Study Area are provided in § 4.10.2.3 of C-NLOPB (2008), Table 4.119 and Figure 4.137 in C-NLOPB (2014), and Table 3.5 and Figures 3.19 and 3.20 in C-NLOPB (2010). In general, the fixed gears have greater potential for interacting with Project activities than mobile gears, because they use submerged lines attached to buoys at the ocean surface, which can be easily snagged by towed seismic gear, causing damage to both the fishing gear and to the seismic streamer. They are often placed in one location for several days, are difficult to detect and may be set out over long distances in the water. Mobile and fixed gear harvest locations for the Labrador Shelf during 2005–2010 are shown in Figures 4.6–4.7 of LGL (2014); for eastern offshore Newfoundland during May–November 2005–2013, and 2008–2012 in Figures 4.9–4.12 and Figures 4.138–4.139 of LGL (2015a) and C-NLOPB (2014), respectively; and for southeastern/southern offshore Newfoundland during May–November 2005–2013 and 2006/2007 in Figures 4.9–4.12 and Figures 3.19–3.20 of LGL (2015b) and C-NLOPB (2010), respectively. Figures 4.6–4.7 show fixed and mobile gear catch locations relative to the Study and Project Areas, May-November, 2013 and 2014, respectively.

Harvest Timing in the Study Area

Average monthly catch weights of all species within the Study Area during May–November, 2009–2010, and total sum of monthly catch weight quartile codes for May–November, 2011–2014, are indicated in Figure 4.8. Monthly catch weight was highest during the May–August period and lowest during 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 4.7 Average Annual Study Area Catch Weight by Gear Type, May–November, 2009–2010.

Species	Fixed Gear		Mobile Gear	
	mt	% of Total	mt	% of Total
Northern Shrimp	0	0.0	68,549	58.7
Snow Crab	30,065	25.7	0	0.0
Greenland Halibut	3,151	2.7	2,050	1.8
Yellowtail Flounder	1	0.0	4,221	3.6
Whelk	2,620	2.2	0	0.0
Atlantic Cod	1,006	0.9	262	0.2
Striped Shrimp	0	0.0	944	0.8
American Plaice	20	0.0	817	0.7
Cockle	0	0.0	576	0.5
White Hake	502	0.4	3	0.0
Redfish	35	0.0	454	0.4
Skate sp.	288	0.2	2	0.0
Pollock	215	0.2	6	0.0
Monkfish	220	0.2	0	0.0
Atlantic Halibut	211	0.2	5	0.0
Atlantic Haddock	86	0.1	25	0.0
Witch Flounder	4	0.0	101	0.1
Swordfish	84	0.1	0	0.0
Hagfish	81	0.1	0	0.0
Stimpson's Surf Clam	0	0.0	81	0.1
Atlantic Herring	3	0.0	67	0.1
Mackerel	0	0.0	30	0.0
Bluefin Tuna	8	0.0	22	0.0
Roughhead Grenadier	24	0.0	0	0.0
Capelin	0	0.0	22	0.0
Cusk	5	0.0	0	0.0
Porbeagle Shark	4	0.0	1	0.0
Mako Shark	3	0.0	0	0.0
Bigeye Tuna	1	0.0	0	0.0
Sea Scallop	0	0.0	1	0.0
Mahi Mahi (dolphinfish)	1	0.0	0	0.0
Roundnose Grenadier	1	0.0	0	0.0
Albacore Tuna	0	0.0	0	0.0
Iceland Scallop	0	0.0	0	0.0
Shark sp.	0	0.0	0	0.0
Lobster	0	0.0	0	0.0
Atlantic (striped) Wolffish	0	0.0	0	0.0
Skipjack Tuna	0	0.0	0	0.0
Flounder sp.	0	0.0	0	0.0
Subtotal	**38,637**	**33.1**	**78,239**	**66.9**
Grand Total (mt)	**116,876**			

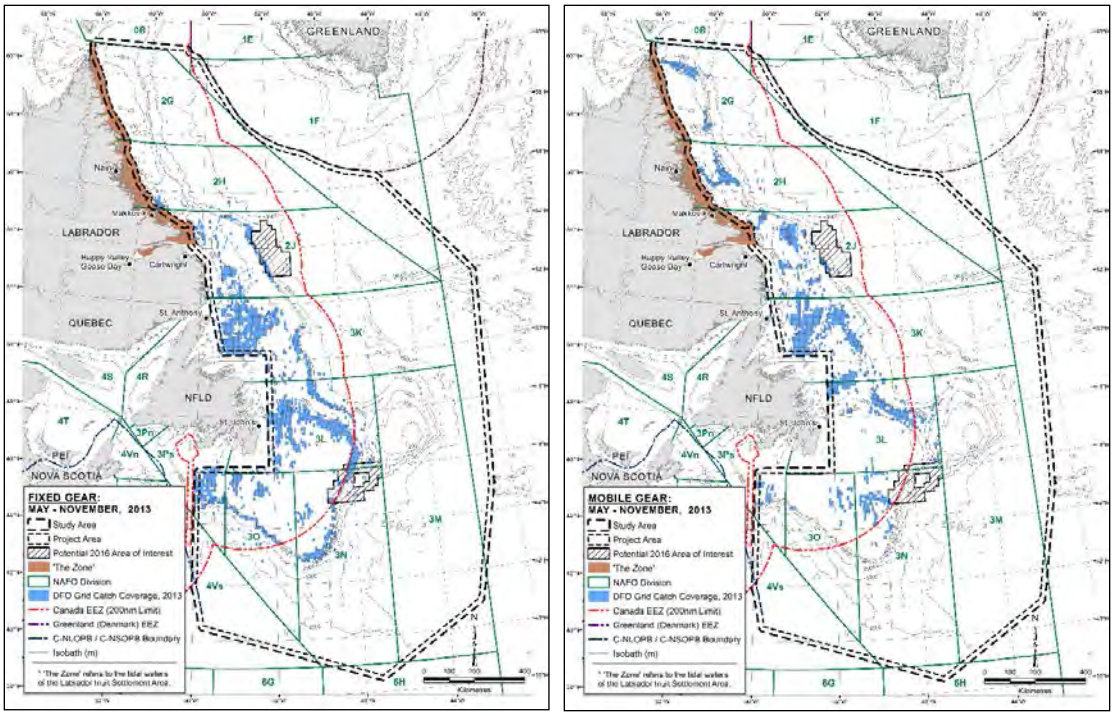
Source: DFO commercial landings database, 2009–2010.

Table 4.8 Summary of Gear Type Used and Timing of the Commercial Fishery in the Study Area, May–November, 2009–2014.

Species	Month Caught					Gear Type	
	2009–2010	2011	2012	2013	2014	Fixed	Mobile
Northern Shrimp	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	-	Trawl
Snow Crab	May–Nov	May–Aug	May–Aug	May–Aug	May–Aug	Pot	Trawl
Greenland Halibut	May–Nov	May–Nov	May–Nov	May–Nov	May–Sep	Gillnet; Longline; Pot	Trawl
Redfish	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
American Plaice	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline; Pot	Trawl
Skate sp.	May–Nov	Jun–Sep; Nov	Jun–Nov	Jun–Aug; Oct–Nov	May–Aug; Nov	Gillnet; Longline; Pot	Trawl
Atlantic Cod	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline; Pot	Trawl; Hand Line (baited)
Yellowtail Flounder	May–Nov	May–Jul; Oct–Nov	May–Jun; Oct–Nov	May–Jul; Sep–Nov	May–Aug; Oct–Nov	Gillnet; Longline	Trawl
Atlantic Halibut	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
Whelk	May–Aug	May–Aug	May–Aug	May–Oct	May–Oct	Pot	-
Roughhead Grenadier	May–Nov	Jun–Aug; Oct–Nov	May–Oct	May–Nov	May–Aug; Oct–Nov	Gillnet; Longline	Trawl
Witch Flounder	May–Nov	May–Sep; Nov	May–Aug; Oct–Nov	May–Nov	May–Nov	Gillnet	Trawl
White Hake	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
Atlantic Haddock	May–Nov	May–Nov	Jun–Nov	May–Nov	May-Nov	Gillnet; Longline; Pot	Trawl
Capelin	May–Nov	Jul	Jul	Jul	Jul	Trap Net	Trawl; Seine
Pollock	May–Nov	Jun–Nov	Jun–Nov	May; Jul–Aug; Oct–Nov	May–Nov	Gillnet; Longline	Trawl
Monkfish	May–Nov	Jun–Nov	Jun–Nov	May–Aug; Oct–Sep	May–Aug; Oct–Nov	Gillnet; Longline	Trawl
Striped Shrimp	May; Jul–Nov	Sep–Nov	May; Jul–Nov	May; Jul–Nov	May; Aug–Nov	-	Trawl
Swordfish	Jul–Nov	Jul–Nov	Jul–Nov	Jul–Aug; Oct	Aug–Oct	Gillnet; Longline	-
Bluefin Tuna	Jul–Nov	Jul–Nov	Jul–Nov	Jul; Sep	Aug–Nov	Longline	Troller Lines; Rod and Reel; Electric Harpoon
Cusk	Jun–Nov	May–Sep; Nov	May–Jul; Sep–Nov	May; Jul–Nov	May–Jul; Nov	Gillnet; Longline	Trawl
Cockle	Jul; Oct–Nov	Oct	-	Nov	-	-	Dredge
Stimpson's Surf Clam	Jul; Oct–Nov	Oct	-	Nov	-	-	Dredge
Mako Shark	Jun–Oct	Jul–Oct	Jul–Nov	Jul–Aug	Jun; Aug–Oct	Gillnet; Longline	Trawl
Atlantic (striped) Wolffish	May–Jul	Jun–Jul	Jun	Jul	May–Jul	Gillnet Longline	Trawl

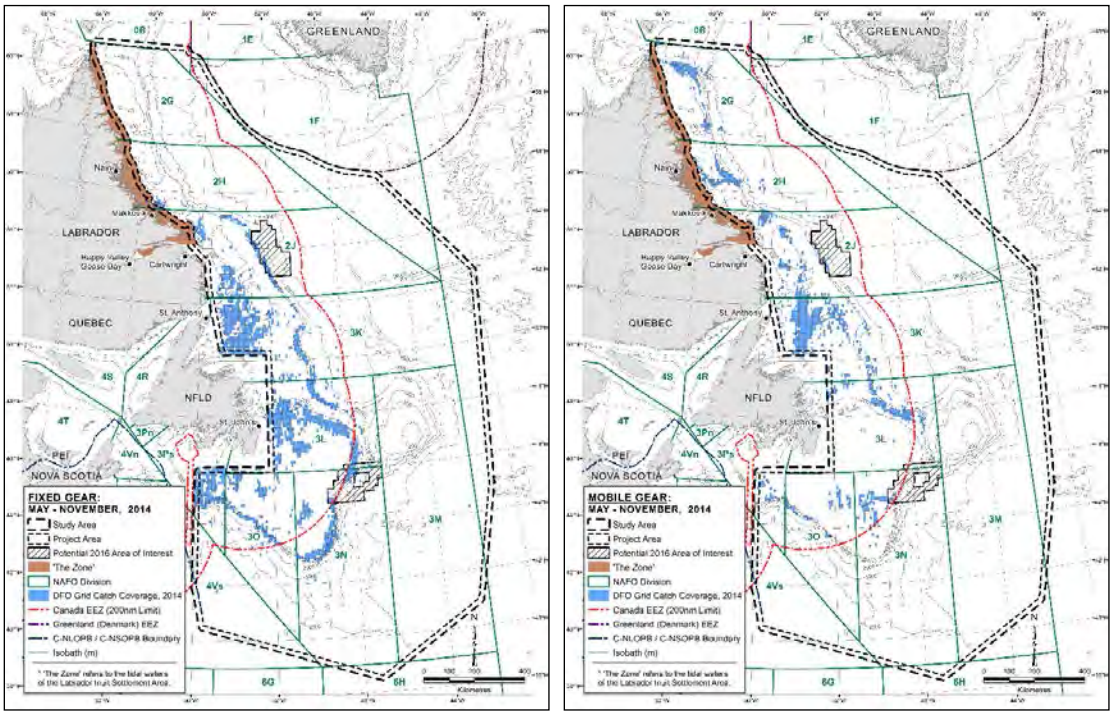
Species	Month Caught					Gear Type	
	2009–2010	2011	2012	2013	2014	Fixed	Mobile
Mahi Mahi (dolphinfish)	Jul–Oct	Jul–Aug	Jul–Aug; Oct	Jul–Aug	Aug–Sep	Gillnet; Longline	Trawl
Shark sp.	May–Nov	Oct	Nov	-	-	Gillnet	Trawl
Hagfish	Sep–Nov	Sep–Oct	Sep–Nov	Jun; Aug–Oct	-	Hagfish Barrel; Trap Net	-
Porbeagle Shark	May–Jun; Aug; Oct–Nov	Jul–Aug; Nov	May–Jun; Nov	-	May–Jul	Gillnet; Longline	Trawl
Bigeye Tuna	Jul–Oct	Jul–Sep; Nov	Jul–Sep; Nov	-	Sep	Longline	-
Roundnose Grenadier	Jun–Sep	Jul	Jun	Nov	-	Longline	-
Atlantic Herring	Jun–Jul; Sep; Nov	-	-	May	-	Gillnet	Trawl; Seine
Albacore Tuna	Jul–Sep	Jul–Sep	Jul–Sep; Nov	Jul	Aug–Sep	Longline	Troller Lines
Sea Scallop	Aug–Sep; Nov	May	Nov	May	Aug–Sep	-	Dredge
Flounder sp.	Nov	-	Sep	Nov	-	Gillnet	Trawl
Mackerel	Sep–Oct	Sep–Oct	Sep	Oct	Oct	-	Seine
Skipjack Tuna	Jul–Aug; Oct	-	-	-	-	Longline	-
Iceland Scallop	Jul; Sep	-	Aug	-	Jul–Aug; Oct	-	Dredge
Lobster	Jun	-	-	-	-	Pot	-
Yellowfin Tuna	-	Jul–Aug; Oct	Aug–Sep	-	-	Longline	-
Atlantic Rock Crab	-	Sep–Oct	Aug	-	-	Pot	-
Winter Flounder	-	Sep	May–Aug; Oct–Nov	-	-	Gillnet	-
Groundfish sp.	-	Jul	-	-	Nov	Longline	-
White Marlin	-	Jul	Aug	-	Aug	Longline	-
Dogfish sp.	-	-	-	Nov	-	Longline	-
Sculpin sp.	-	-	-	Oct	-	-	Trawl
Argentine	-	-	-	-	Aug	-	Trawl

Source: DFO commercial landings database, 2009–2014.



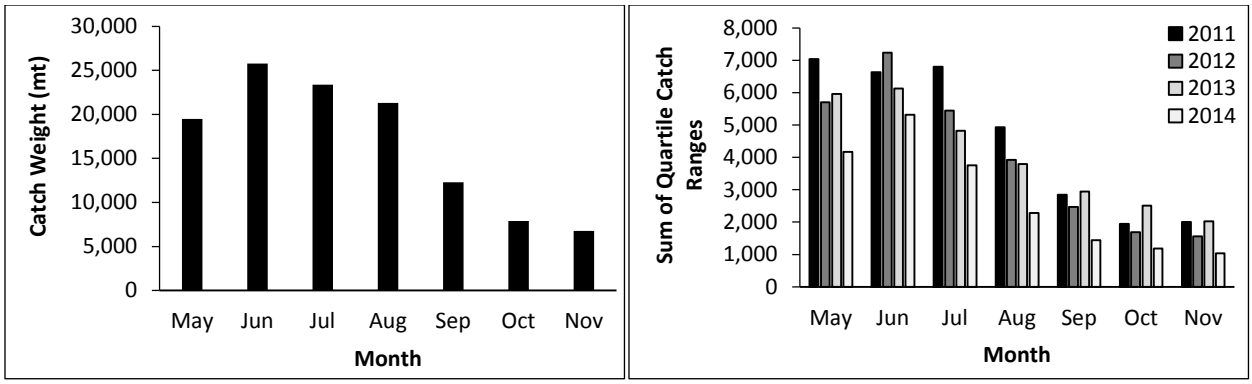
Source: DFO commercial landings database, 2013.

Figure 4.6 Fixed (left) and Mobile (right) Gear Harvest Locations, May–November, 2013.



Source: DFO commercial landings database, 2014.

Figure 4.7 Fixed (left) and Mobile (right) Gear Harvest Locations, May–November, 2014.



Source: DFO commercial landings database, 2009–2014.

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.

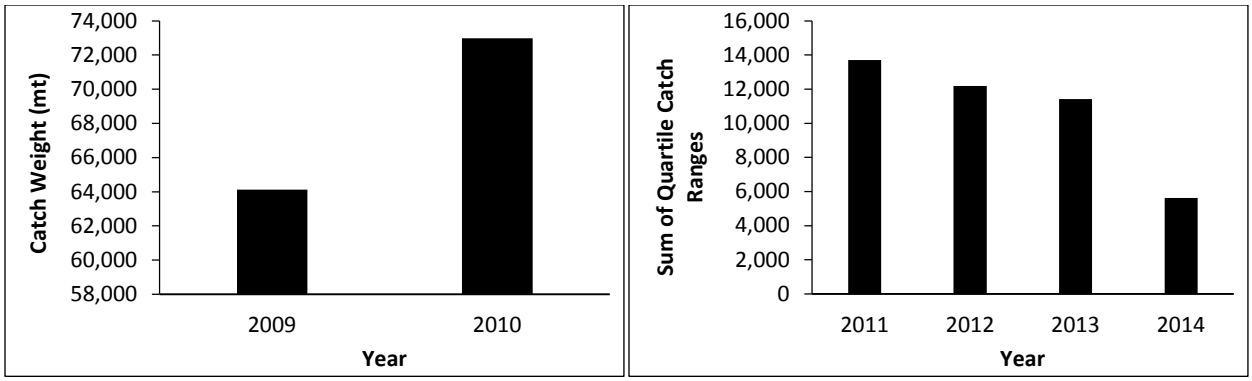
Figure 4.8 Average Monthly Catch Weight during May–November, 2009–2010 (left), and Total Monthly Sum of Catch Weight Quartile Codes, May–November, 2011–2014 (right), All Species in the Study Area.

Principal Species in the Study Area

The following section provides information on the principal species caught during fisheries being prosecuted in the Study Area.

Northern Shrimp

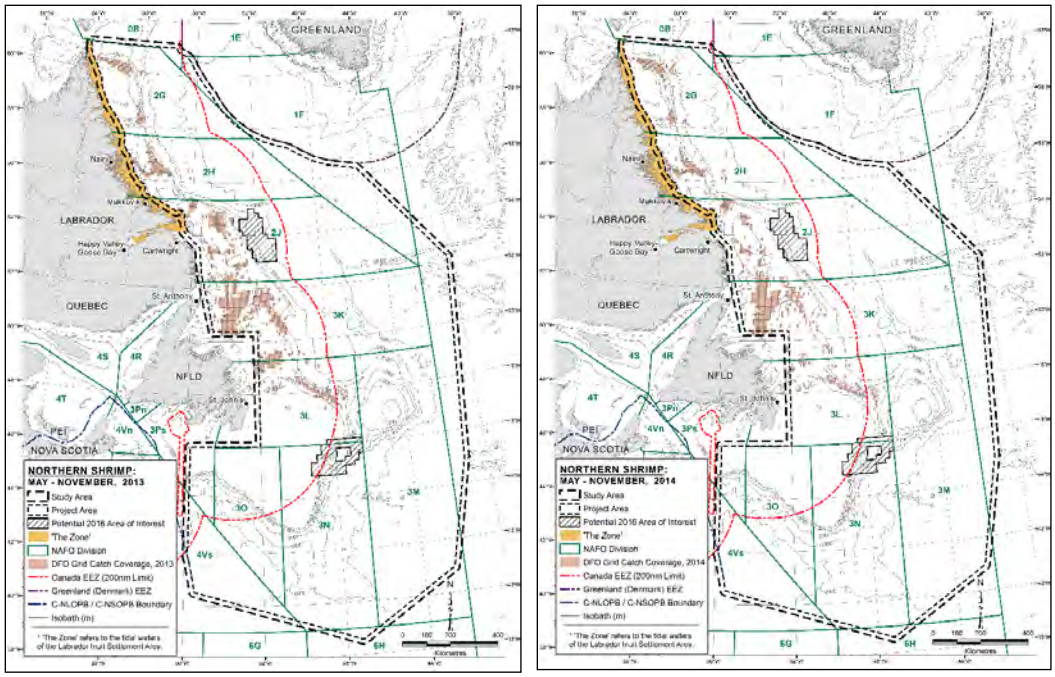
Overall, based on both quantity and value, northern shrimp was the most important commercial species in the Study Area during May-November, 2009–2013, and second most important in 2014. The total annual catch weights (2009–2010) and total annual catch weight quartile codes (2011–2014) for northern shrimp in the Study Area between May–November are provided in Figure 4.9. Fishing locations for northern shrimp during May–November are shown in Figures 4.11–4.13 of LGL (2014) for offshore Labrador, and Figures 4.15–4.18 of LGL (2015a) for eastern offshore Newfoundland. Annual catch locations during 2004–2006 and 2012 for offshore Labrador and eastern offshore Newfoundland are shown in Figures 4.59 and 4.141 of the Labrador Shelf SEA and Eastern Newfoundland SEA (C-NLOPB 2008, 2014), respectively. Figure 4.10 shows northern shrimp harvest locations during 2013 and 2014. Most of the northern shrimp were harvested in the central-western and northwestern portions of the Study and Project Areas, between the 200 and 500 m isobaths. Three catch location cells were within the northernmost 2016 Area of Interest in 2013, and one catch location cell was within this area in 2014; there were no northern shrimp catch locations within the southernmost 2016 Area of Interest in 2013 or 2014. The average and total monthly northern shrimp harvests in the Study Area during the May–November, 2009–2010 and 2011–2014 periods, respectively, are shown in Figure 4.11. Most of the northern shrimp was caught in July and August.



Source: DFO commercial landings database, 2009–2014.

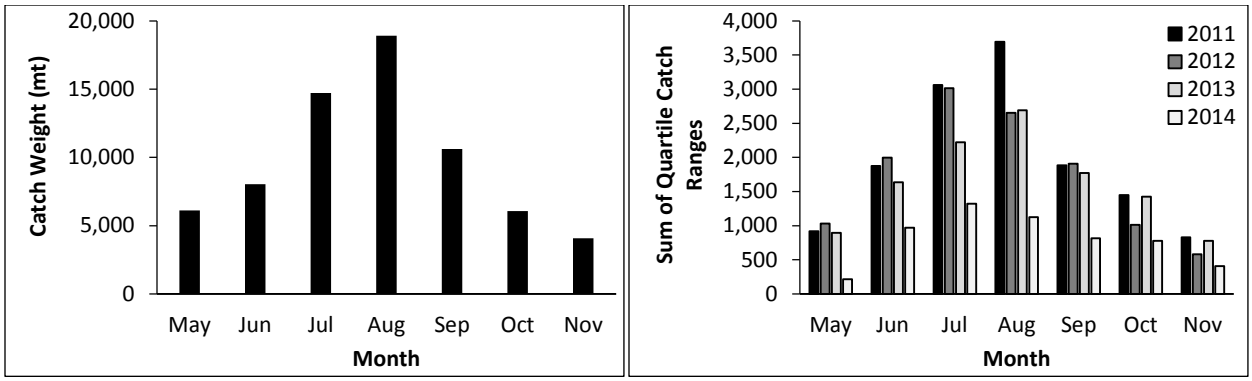
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.9 Total Annual Catch Weights, May–November, 2009–2010 (left), and Total Annual Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Northern Shrimp in the Study Area.



Source: DFO commercial landings database, 2013, 2014.

Figure 4.10 Distribution of Harvest Locations for Northern Shrimp, May–November, 2013 (left) and 2014 (right).



Source: DFO commercial landings database, 2009–2014.

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.

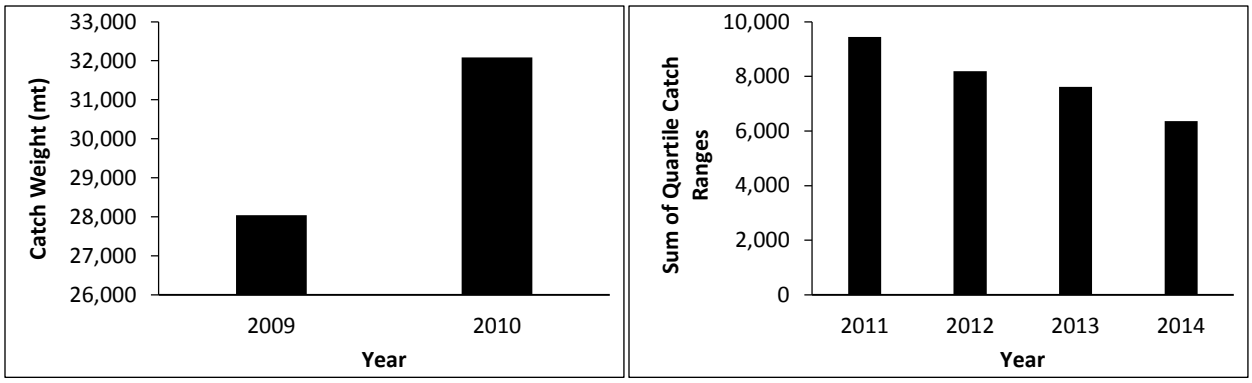
Figure 4.11 Average Monthly Catch Weights, May–November, 2009–2010 (left), and Total Monthly Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Northern Shrimp in the Study Area.

Snow Crab

In terms of catch weight, snow crab was the second most important commercial species in the Study Area during 2009–2013, and the most important in 2014. Total annual catch weights (2009–2010) and the total sum of catch weight quartile codes (2011–2014) for snow crab in the Study Area between May and November are indicated in Figure 4.12. Snow crab catch locations during May–November for offshore Labrador and eastern and southeastern offshore Newfoundland are shown in Figures 4.16–4.18 (2005–2012) of LGL (2014), Figures 4.21–4.24 (2005–2013) of LGL (2015a) and Figures 4.15–4.18 (2005–2013) of LGL (2015b), respectively. Annual harvest locations for snow crab in 2004–2006 are shown in Figure 4.56 of the Labrador Shelf SEA (C-NLOPB 2008), in 2012 in Figure 4.140 of the Eastern Offshore Newfoundland SEA (C-NLOPB 2014), and in 2006 and 2007 in Figure 3.57 of the Southern Newfoundland SEA (C-NLOPB 2010). Figure 4.13 shows the snow crab harvesting locations relative to the Study and Project Areas for May–November, 2013 and 2014. The majority of snow crab were captured in the western portion of the Study and Project Areas, in water depths <200 m. Multiple catch locations were within the southernmost 2016 area of interest during 2013 and 2014; no catch locations were within the northernmost 2016 area of interest during 2013 or 2014, although several locations were adjacent to the western portion of this Area in 2013. The average and total monthly snow crab harvests in the Study Area during the May–November 2009–2010 and 2011–2014 periods, respectively, are shown in Figure 4.14. Snow crab were caught between May–August in the Study Area, with the majority of catch taken in May–June.

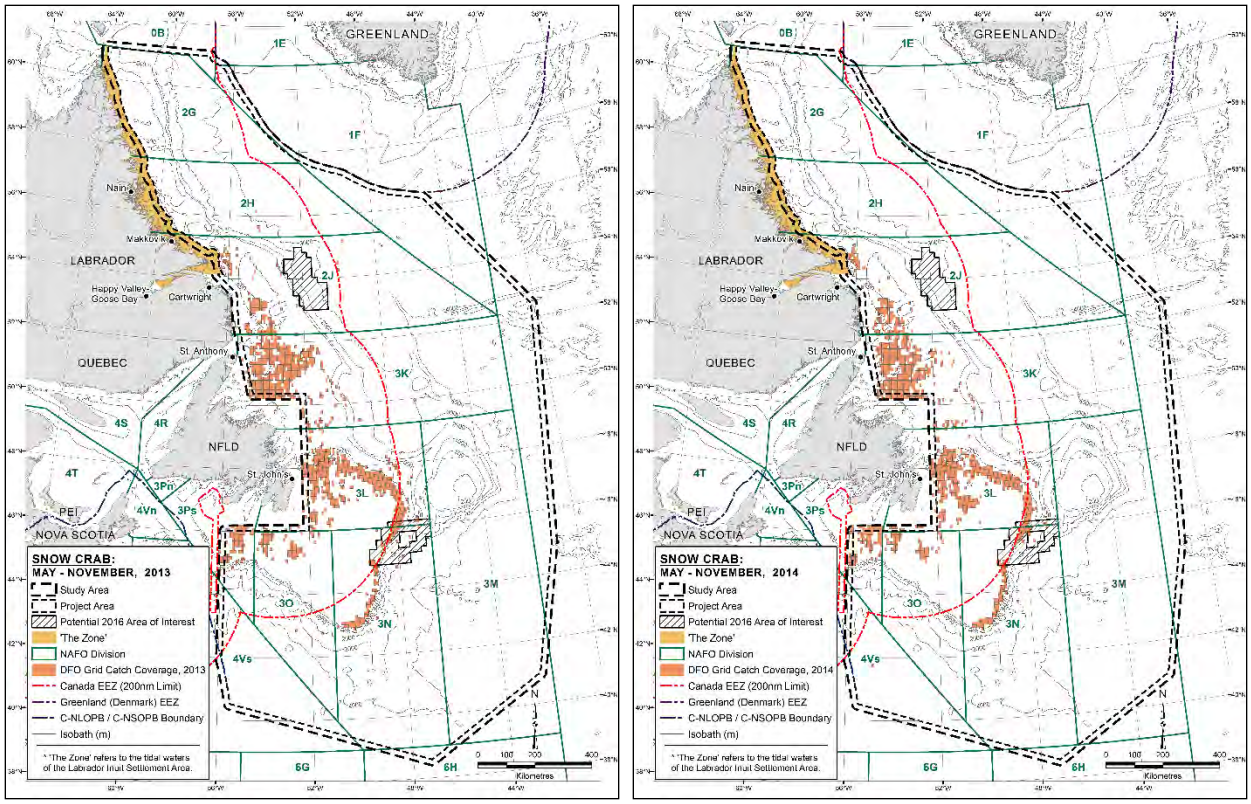
Greenland Halibut

Greenland halibut accounted for the largest portion of groundfish catches and was the third most important commercial species in the Study Area during 2009–2013. Total annual catch weights (2009–2010) and the total sum of catch weight quartile codes (2011–2014) for Greenland halibut in the Study Area between May and November are indicated in Figure 4.15. Greenland halibut catch locations during May–Nov for offshore Labrador during 2005–2012 and eastern offshore Newfoundland during 2005–2013 are shown in Figures 4.21–4.23 of LGL (2014) and Figures 4.27–4.30 of LGL (2015a), respectively. Annual harvest locations in 2004–2006 are shown in Figure 4.72 of the Labrador Shelf SEA (C-NLOPB 2008), in 2012 in Figure 4.142 of the Eastern Newfoundland SEA (C-NLOPB 2014), and in 2006 and 2007 in Figure 3.51 of the Southern Newfoundland SEA (C-NLOPB 2010). Figure 4.16 shows Greenland halibut harvest locations relative to the Study and Project Areas for 2013 and 2014. The majority of Greenland halibut were caught in the central and north-central portions of the Study and Project Areas, almost exclusively between the 500 and 1,000 m isobaths. Multiple catch locations were within the northernmost 2016 Area of Interest in 2013 and 2014; two catch location cells were within the southernmost 2016 Area of interest in 2013, and there were no catch locations within this area in 2014. The average monthly Greenland halibut harvests in the Study Area during the May–November, 2009–2010 and 2011–2014 periods are shown in Figure 4.17. Greenland halibut were primarily harvested during the June–August period in the Study Area.



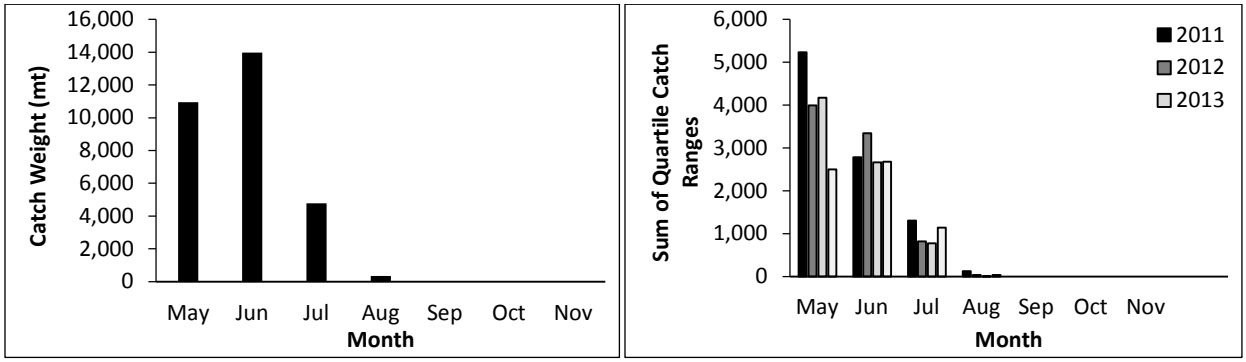
Source: DFO commercial landings database, 2009–2014.
Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.12 Total Annual Catch Weights, May–November, 2009–2010 (left), and Total Annual Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Snow Crab in the Study Area.



Source: DFO commercial landings database, 2013, 2014.

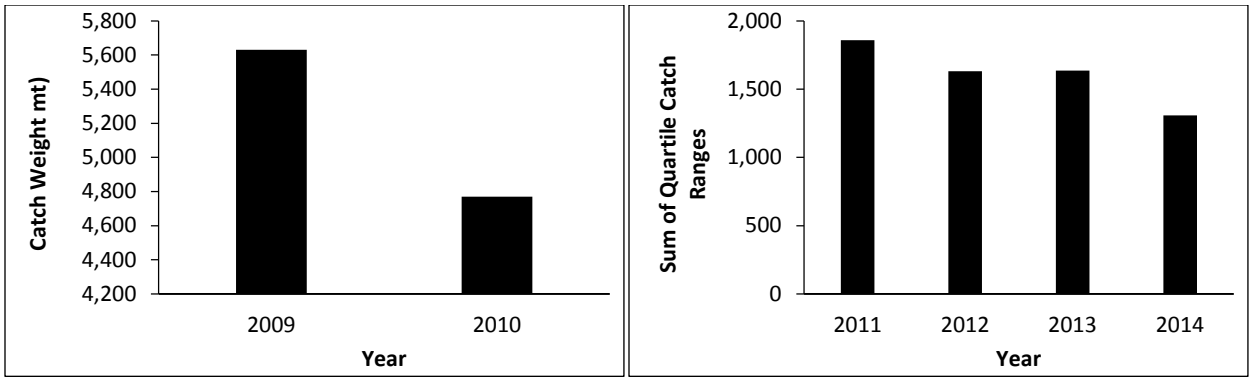
Figure 4.13 Distribution of Harvest Locations for Snow Crab, May–November, 2013 (left) and 2014 (right).



Source: DFO commercial landings database, 2009–2014.

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.

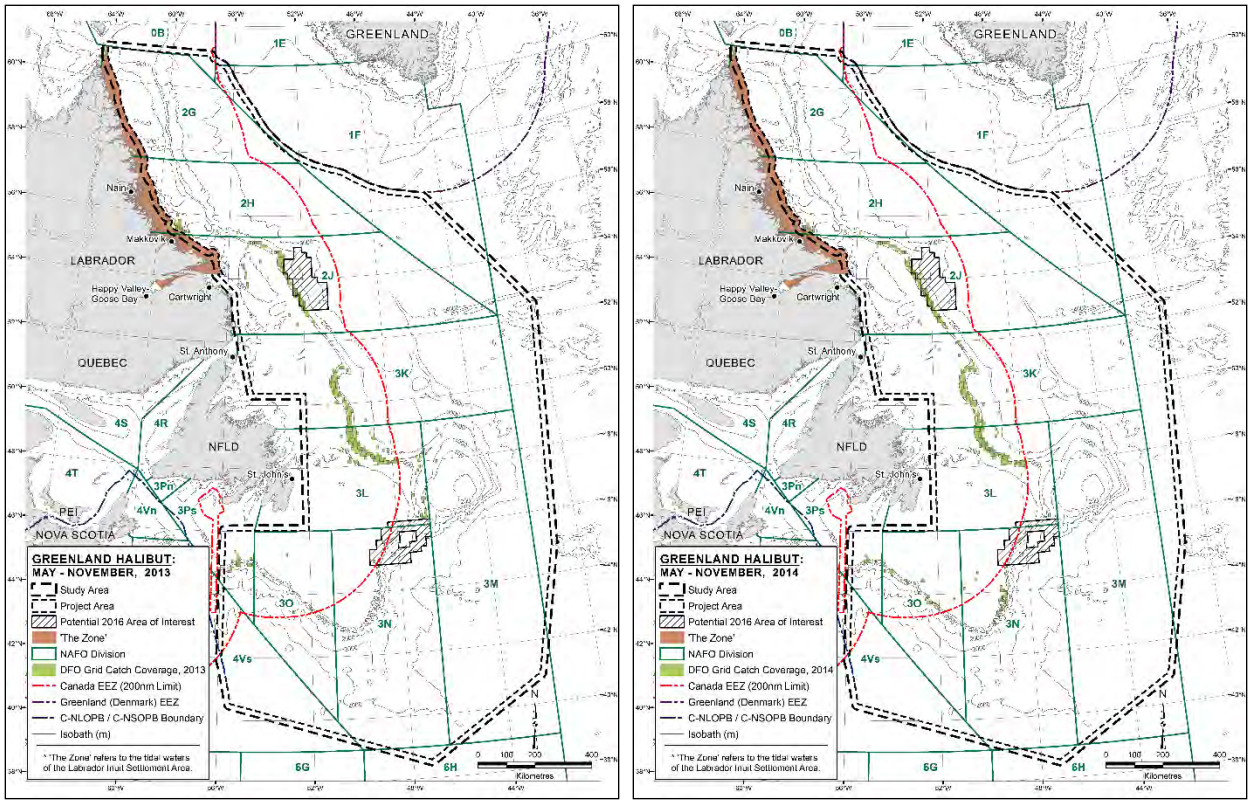
Figure 4.14 Average Monthly Catch Weights, May–November, 2009–2010 (left), and Total Monthly Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Snow Crab in the Study Area.



Source: DFO commercial landings database, 2009–2014.

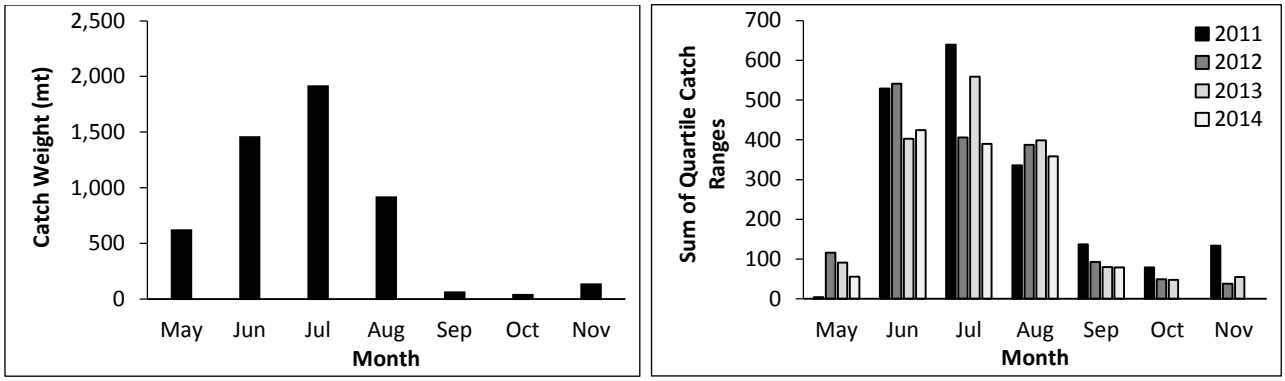
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.15 Total Annual Catch Weights, May–November, 2009–2010 (left), and Total Annual Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Greenland Halibut in the Study Area.



Source: DFO commercial landings database, 2013, 2014.

Figure 4.16 Distribution of Harvest Locations for Greenland Halibut, May–November, 2013 (left) and 2014 (right).



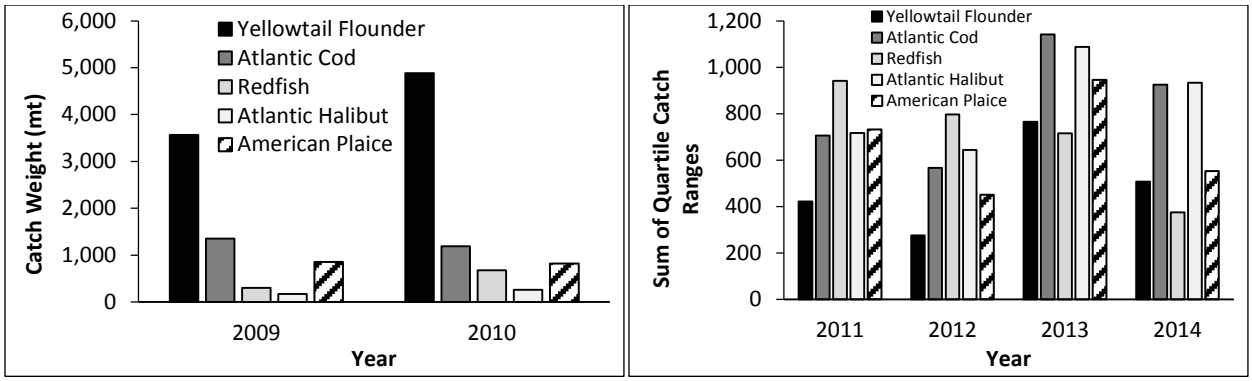
Source: DFO commercial landings database, 2009–2014.

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 4.17 Average Monthly Catch Weights, May–November, 2009–2010 (left), and Total Monthly Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Greenland Halibut in the Study Area.

Other Notable Species: Yellowtail Flounder, Atlantic Cod, Redfish, Atlantic Halibut and American Plaice

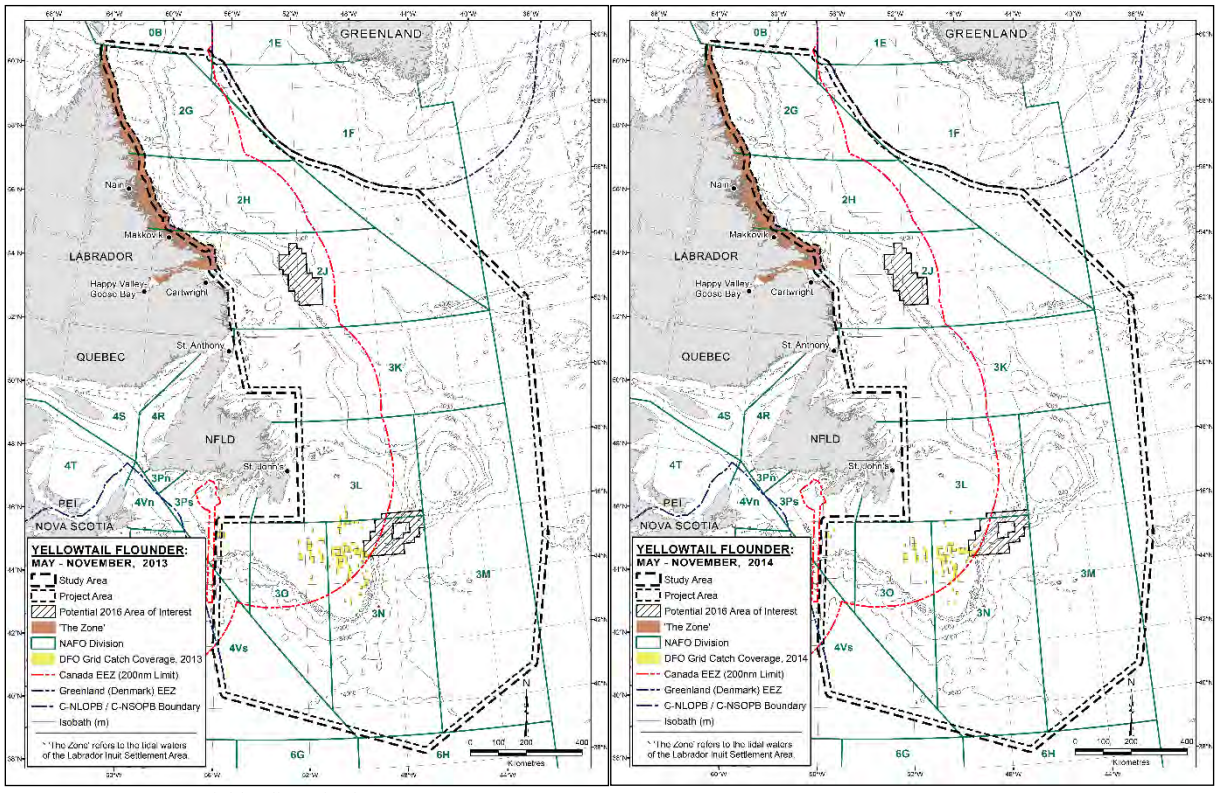
In addition to the three species above, yellowtail flounder, Atlantic cod, redfish, Atlantic halibut and American plaice have also been identified as important commercial species within the Study Area (§ 4.3.3.1 and Tables 4.2–4.6). Total annual catch weights (2009–2010) and the total sum of catch weight quartile codes (2011–2014) for these species in the Study Area between May and November are indicated in Figure 4.18. Harvest locations during May–November, 2005–2013, for yellowtail flounder, redfish, Atlantic cod and Atlantic halibut for southeast Newfoundland are shown in Figures 4.21–4.24, 4.37–4.39, 4.42–4.45 and 4.48 4.51, respectively, of LGL (2015b). Annual harvest locations for redfish and American plaice in 2004–2006 are shown in Figures 4.48 and 4.86, respectively, of the Labrador Shelf SEA (C-NLOPB 2008), in 2012 for yellowtail flounder, American plaice and redfish in Figures 4.143–4.145, respectively, of the Eastern Newfoundland SEA (C-NLOPB 2014), and in 2006 and 2007 for Atlantic cod, redfish, yellowtail flounder, Atlantic halibut and American plaice in Figures 3.24, 3.27, 3.30, 3.36 and 3.45, respectively, of the Southern Newfoundland SEA (C-NLOPB 2010). Figures 4.19–4.21 show harvest locations relative to the Study and Project areas for 2013 and 2014. The majority of these species were caught in the central portion of the Study and Project Areas, in areas with water depths <1,000 m. In 2013 and 2014, there were several catch locations within the northernmost (redfish, American plaice, Atlantic halibut [only in 2013]) and southernmost (Atlantic cod, Atlantic halibut, American plaice, yellowtail flounder) 2016 Areas of Interest; harvesting occurred in the shallower, western portion of these Areas.



Source: DFO commercial landings database, 2009–2014.

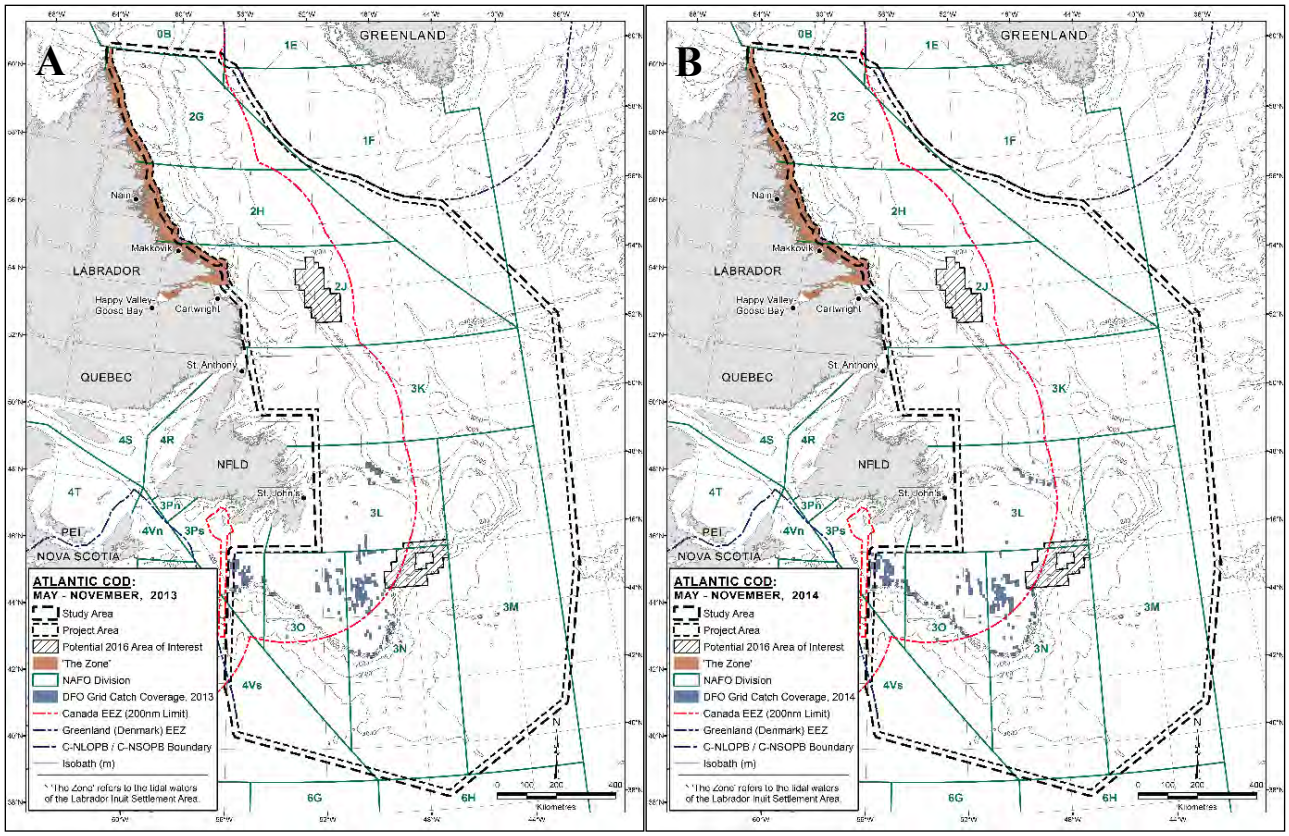
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.18 Total Annual Catch Weights, May–November, 2009–2010 (left), and Total Annual Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Yellowtail Flounder, Atlantic Cod, Redfish, Atlantic Halibut and American Plaice in the Study Area.



Source: DFO commercial landings database, 2013, 2014.

Figure 4.19 Distribution of Harvest Locations for Yellowtail Flounder, May–November, 2013 and 2014.



Source: DFO commercial landings database, 2013, 2014.

Figure 4.20 Distribution of Harvest Locations for Atlantic cod (A, B) and Redfish (C, D), May–November, 2013 and 2014.

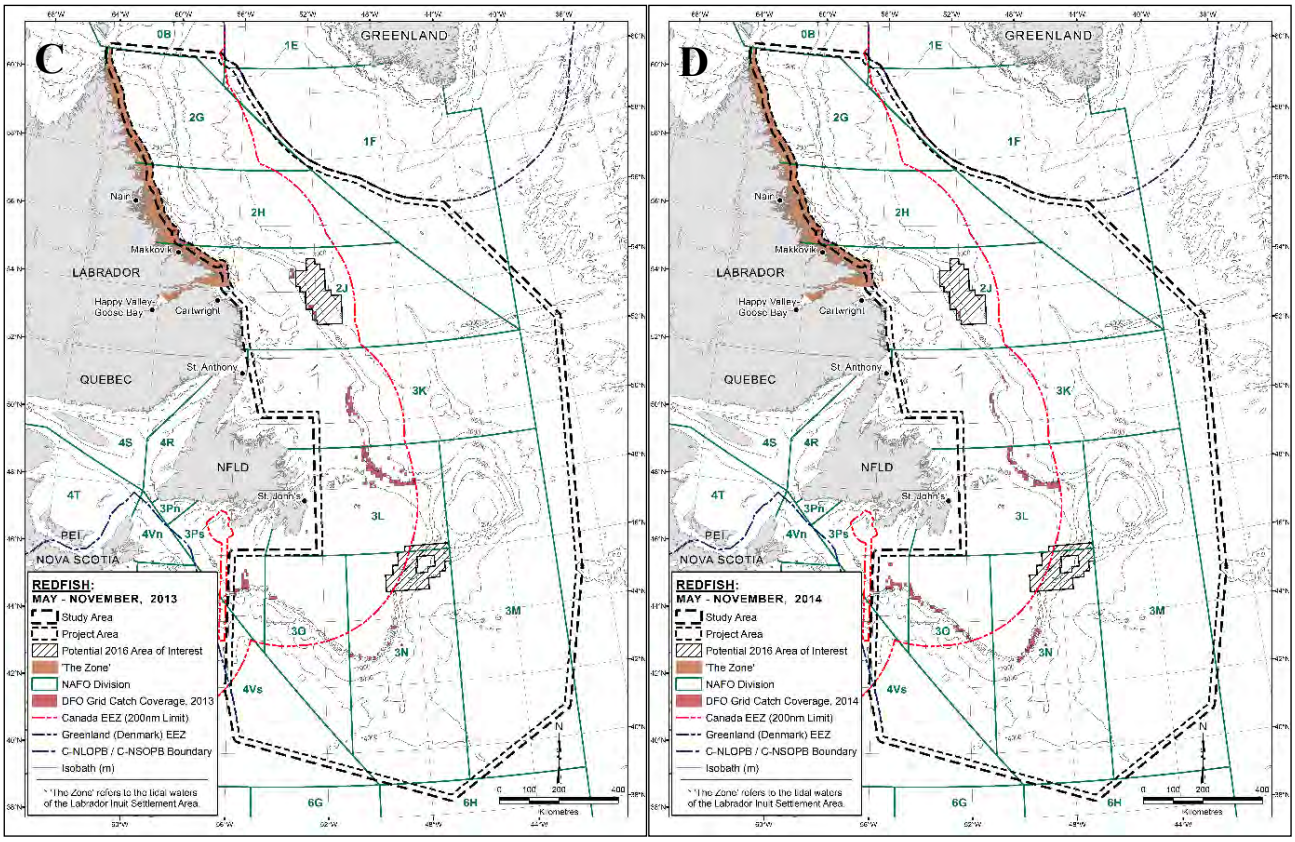
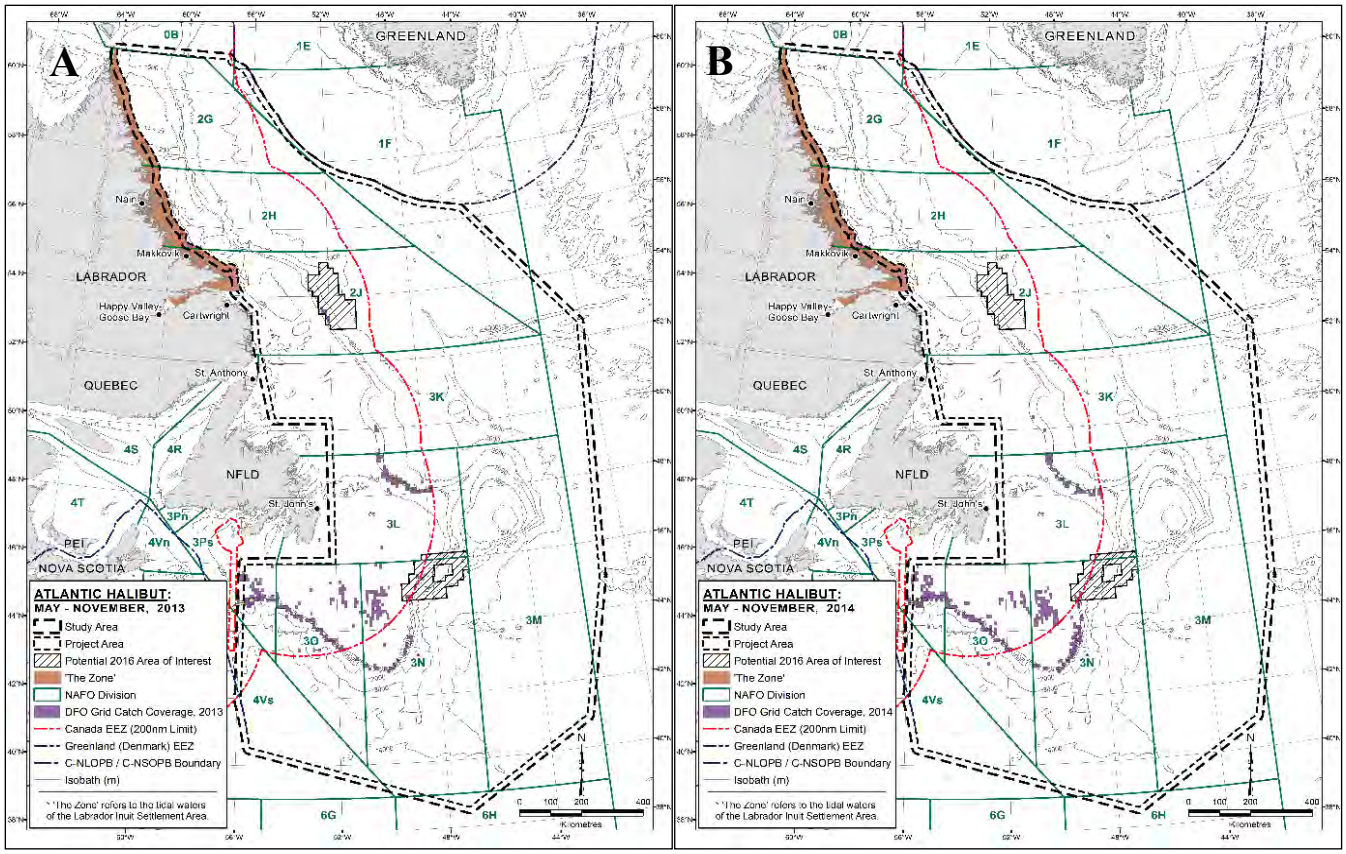


Figure 4.20 (Continued) **Distribution of Harvest Locations for Atlantic cod (A, B) and Redfish (C, D), May–November, 2013 and 2014.**



Source: DFO commercial landings database, 2013, 2014.

Figure 4.21 Distribution of Harvest Locations for Atlantic Halibut (A, B) and American Plaice (C, D), May–November, 2013 and 2014.

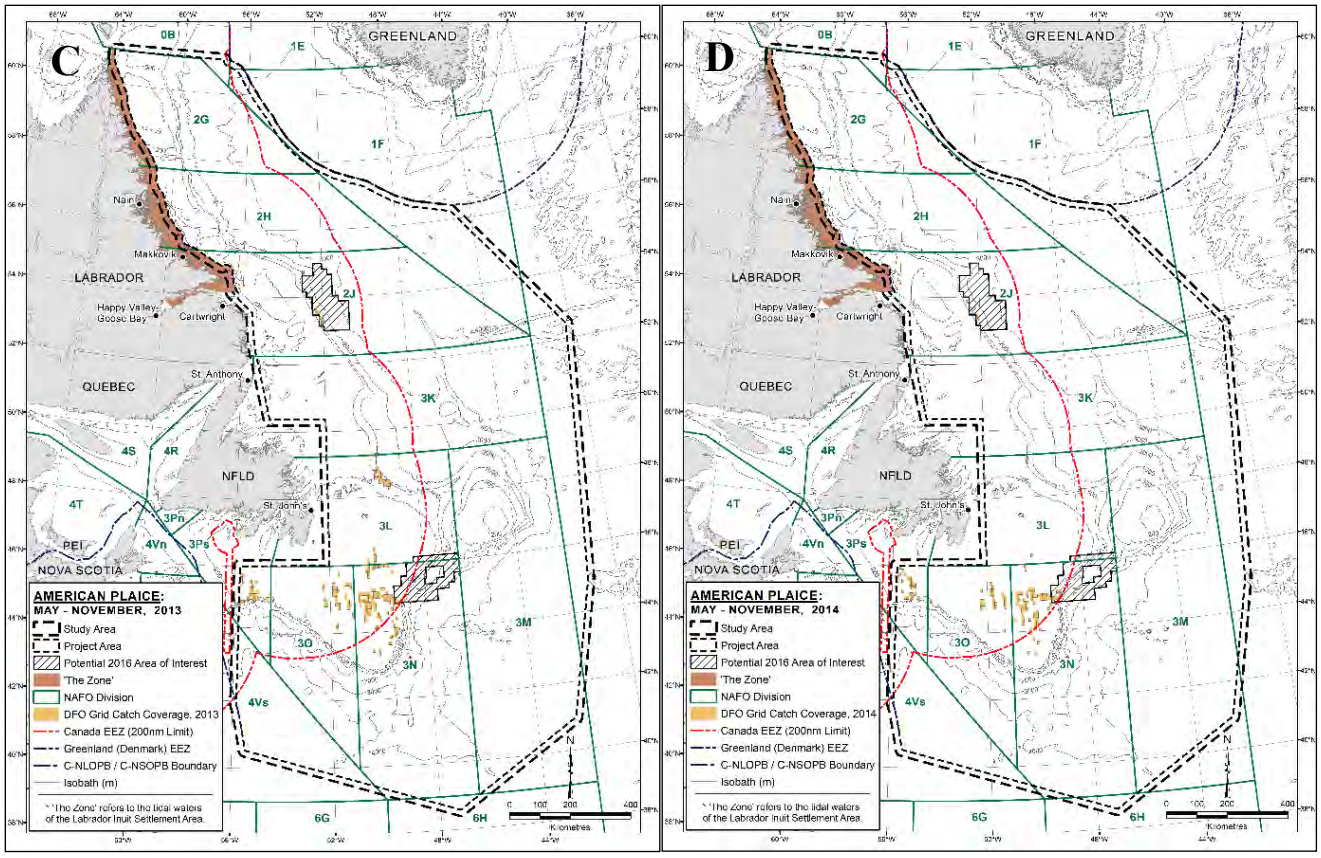
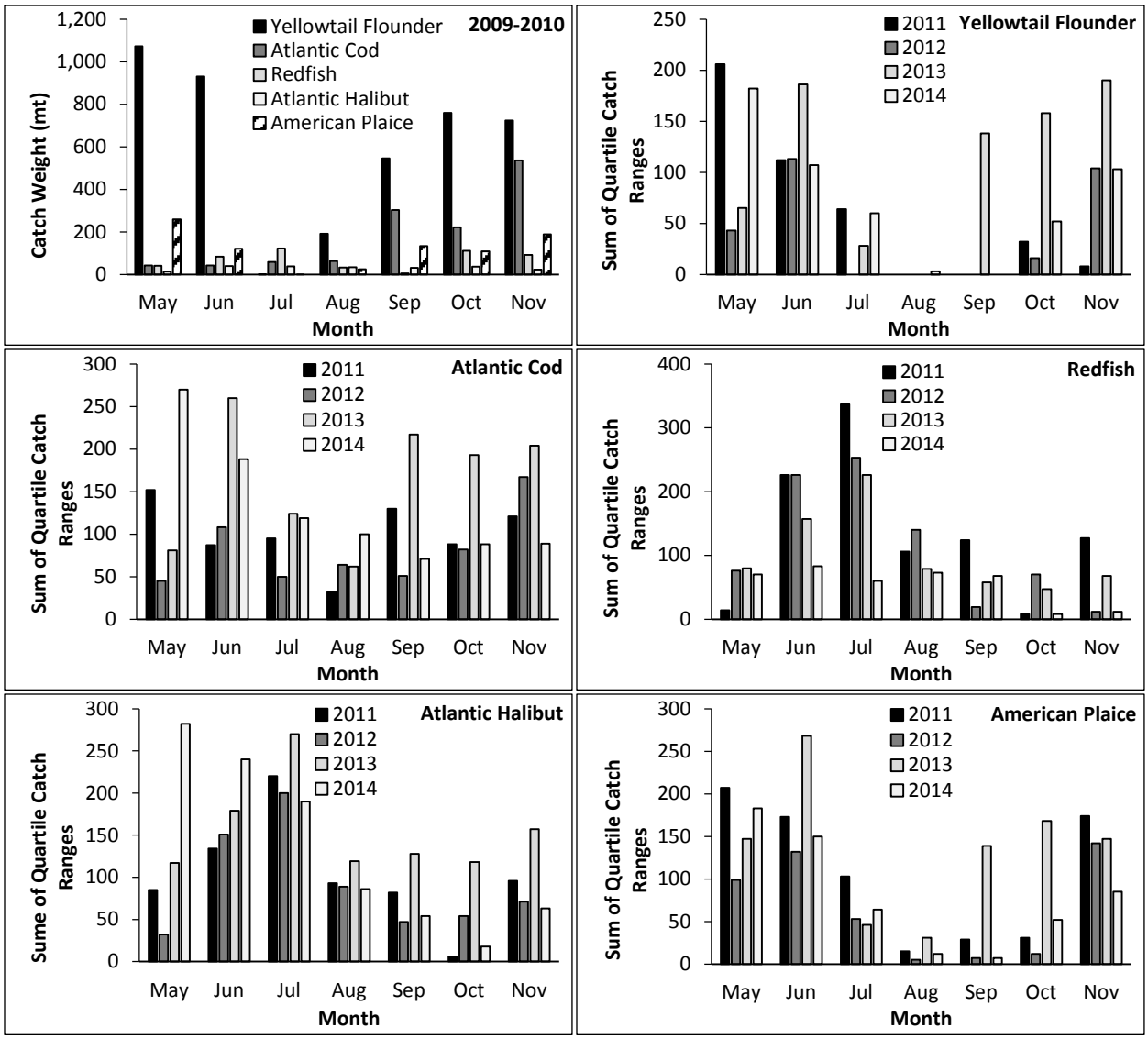


Figure 4.21(Continued) Distribution of Harvest Locations for Atlantic Halibut (A, B) and American Plaice (C, D), May–November, 2013 and 2014.

The average monthly harvests for these species in the Study Area during the May–November, 2009–2010 and 2011–2014 periods are shown in Figure 4.22. The majority of harvests were captured during late-spring and fall in the Study Area for these species, with the exception of redfish and Atlantic halibut which were primarily taken during June–July.



Source: DFO commercial landings database, 2009–2014.

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 Average Monthly Catch Weights, May–November, 2009–2010 (top left), and Total Monthly Catch Weight Quartile Codes, May–November, 2011–2014 for Yellowtail Flounder, Atlantic Cod, Redfish, Atlantic Halibut and American Plaice in the Study Area.

4.3.4 Traditional and Aboriginal Fisheries

Several communal commercial fisheries licences (CCFL) are held by Aboriginal groups for NAFO Divisions within the Study Area. The Qalipu First Nation Band holds CCFLs for snow crab and groundfish with allocations within Division 3K, and for shrimp in SFA 6 (i.e., 3K and a portion of 2J). The Innu Nation of Labrador holds a CCFL for fixed gear groundfish fishing activity within NAFO Divisions 3Ps and 3LMNO; this licence also permits access to shrimp in SFA 6 and SFA 7 (i.e., 3L) (D. Ball and D. Tobin, DFO, Resource Management and Aboriginal Affairs, pers. comm. December 2015). The latest available Canadian Atlantic Quota Report for Atlantic cod, published in 2012, listed the total allowable catch allocated by DFO to the Aboriginal fishery in 3Ps as 27 mt for April 2012–March 2013 (DFO 2013). The potential exists for the Mi'kmaq Alsumk Mowimsikik Koqoey Association (MAMKA) to expand from the inshore into 3KL, depending on future management measures for northern cod (D. Ball and D. Tobin, DFO Resource Management and Aboriginal Affairs, pers. comm. December 2015).

According to the Southern Newfoundland SEA (C-NLOPB 2010), waters well north of the southwestern portion of the Study Area (within NAFO Division 3Ps; exclusively including coastal, inshore and near shore waters in the vicinity of Conne River, Bay d'Espoir and Hermitage Bay, Newfoundland (D. Ball and D. Tobin, DFO, Resource Management and Aboriginal Affairs, pers. comm. December 2015) are used by the Conne River Band Council (Miawpukek First Nation Government) for Food, Social and Ceremonial fisheries, along with Communal/Commercial fishing activities. A detailed description of these activities was presented in § 3.3.4 of the Southern Newfoundland SEA (C-NLOPB 2010).

Otherwise, according to the Southern and Eastern Newfoundland SEAs (C-NLOPB 2010, 2014), there are no other known Aboriginal fisheries that occur within the eastern or southern portions of the Study Area.

Traditional resource use by Aboriginal people within the Labrador offshore portion of the Study Area is briefly described in § 5.8.3 of the Labrador Offshore SEA (C-NLOPB 2008), including fishing for crab, rock cod, cod, Arctic char, sculpin, mussel, clam, wrinkles and sea urchins. The Nunatsiavut Government holds a Communal Snow Crab licence and allocation within NAFO Divisions 2GHJ, north of 54º40' N, which includes the northern portion of the Study Area (DFO 2010b). The Innu Nation of Labrador communal fixed gear groundfish licence also permits activity within 2GHJ and shrimp allocations within SFA 4 (i.e., 2G and a portion of 2H), within the northern portion of the Study Area, (D. Ball and D. Tobin, DFO, Resource Management and Aboriginal Affairs, pers. comm. December 2015). The Innu Nation have a primary interest harvesting Greenland halibut in NAFO Division 0B (D. Ball and D. Tobin, DFO, Resource Management and Aboriginal Affairs, pers. comm. December 2015), which may occur within the northernmost portion of the Study Area.

4.3.5 Recreational Fisheries

Recreational fisheries in Newfoundland and Labrador are described in § 4.3.4.4 of the Eastern Newfoundland SEA (C-NLOPB 2014) and § 5.8.4 of the Labrador Shelf SEA (C-NLOPB 2008). In 2015, the recreational groundfish fishery will occur in all NAFO areas around Newfoundland and Labrador, including NAFO Divisions 2GH, 2J3KL, 3Ps, 3Pn and 4R, with the exception of the Eastport (northeast Newfoundland) and Gilbert Bay (southeast Labrador) Marine Protected Areas (MPAs) (DFO 2014a, 2015e). Of these NAFO areas, 2GH, 2J3KL and a portion of 3Ps are within the Study Area. This fishery is described in further detail in § 4.3.5 of LGL (2015a,b).

It is possible that recreational fisheries will be conducted within the shallower portions of the Project's Study Area.

4.3.6 Aquaculture

Aquaculture operations in Newfoundland and Labrador are described in § 4.3.4.3 of the Eastern Newfoundland SEA (C-NLOPB 2014). Currently, all aquaculture sites in Newfoundland and Labrador are coastally-based, and there are no approved aquaculture sites within the Study Area (C-NLOPB 2008, 2014; DFA 2015).

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

DFO RV data collected during annual multi-species trawl surveys provide distributional information for invertebrate and fish species not discussed in § 4.3.3 as well as additional distributional information for some of the commercial species discussed in § 4.3.3.

The total catch weight during 2008–2013 spring (May–August) and fall (September–November) DFO RV surveys in the Study Area was 1,217 mt. It should be noted that there were no RV tows conducted north of the Nain Bank (57.7ºN) between 2010–2013. Data collected during these surveys were analyzed, and catch weights, numbers and mean catch depths of species/groups contributing ≥0.1% of the total catch weight and species at risk (§ 4.6) are presented in Table 4.9.

Table 4.9 Catch Weights and Numbers, and Mean Catch Depths of Macroinvertebrates and Fishes Collected during DFO RV Surveys within the Study Area, 2008–2013[a].

Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Deepwater Redfish	519	3,705,734	358	324
Northern Shrimp	100	22,278,256	291	318
Yellowtail Flounder	97	334,798	75	75
American Plaice	74	458,090	220	179
Atlantic cod	61	93,620	209	163
Thorny Skate	49	33,776	267	230
Greenland Halibut	45	189,515	356	414
Capelin	37	2,480,441	141	156
Sponges	21	n/d	304	325
Shrimp (Natantia)	17	n/d	321	305
Sand Lance (offshore)	16	1,375,156	92	87
Roughhead Grenadier	12	27,745	469	549
Sea Cucumber (*Cucumaria frondosa*)	11	35,996	113	124
Striped Shrimp	10	2,569,192	167	142
Snow Crab	8	48,583	166	191
Witch Flounder	8	23,856	410	287
Silver Hake	7	54,921	247	280
Atlantic (striped) Wolffish	6	9,753	234	189
Sea Anemone (Actinaria)	6	43,361	312	308
Jellyfishes (Scyphozoa)	5	428	424	496
Basket Star (*Gorgonocephalus arcticus*)	5	205	177	189
Longfin Hake	5	51,010	476	412
White Hake	4	4,743	373	251
Basket Star (Gorgonocephalidae)	4	493	158	233
Blue Hake	4	32,041	564	785
Atlantic Haddock	4	3,836	105	126
Comb Jelly (Ctenophora)	4	654	73	73
Northern Wolffish	4	1,002	499	443
Polar Sea Star	3	26,505	88	95
Shrimp (*Argis dentata*)	3	609,701	157	126
Arctic cod	3	160,546	201	238
Spotted Wolffish	3	1,200	318	294
Marlin Spike	3	44,748	476	537
Sea Cucumber (Holothuroidea)	2	13,074	121	169
Sea Urchin (Echinoidea)	2	84,311	172	201
Longnose Eel	2	43,062	497	653
Roundnose Grenadier	2	18,754	589	798
Atlantic Halibut	2	158	269	347
Green Sea Urchin	2	108,063	110	119

Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Invertebrate sp.	2	202	222	362
Black Dogfish Shark	2	2,662	596	813
Monkfish	2	404	140	320
Arctic Eelpout	1	7,510	218	145
Spinytail Skate	1	193	502	686
Sea Urchin (*Strongylocentrotus* sp.)	1	60,244	113	141
Corals	n/d	13,764	298	416
Longhorn Sculpin	1	5,277	106	102
Toad Crab (*Hyas* sp.)	1	100,931	145	113
Shorthorn Sculpin	1	2,563	134	92
Brittle Star (Ophiuroidea)	1	29,453	146	262
Vahl's Eelpout	1	12,912	346	383
Sand Dollar (Echinarachnius parma)	1	41,927	132	170
Sessile Tunicate (*Boltenia* sp.)	1	11,433	120	131
Lanternfishes	1	139,065	454	569
Eelpout (*Lycodes* sp.)	1	18,107	322	245
Mailed Sculpin	1	93,581	163	217
Atlantic Argentine	1	4,885	333	316
Greenland Shark	1	2	-	601
Moustache Sculpin	1	82,766	106	134
Sea Raven	1	582	71	70
Icelandic Scallop	1	11,251	115	134
Pollock	1	188	186	234
Cusk	0.02	13	542	440
Wolffishes	0.001	2.00	635	-
Total	**1,196**	**35,607,244**	**243**	**258**

[a] There were no RV tows conducted north of the northern shelf of the Nain Bank (57.7ºN) between 2010–2013.
Source: DFO RV Survey Data, 2008–2013.
Note: n/d denotes data unavailable.

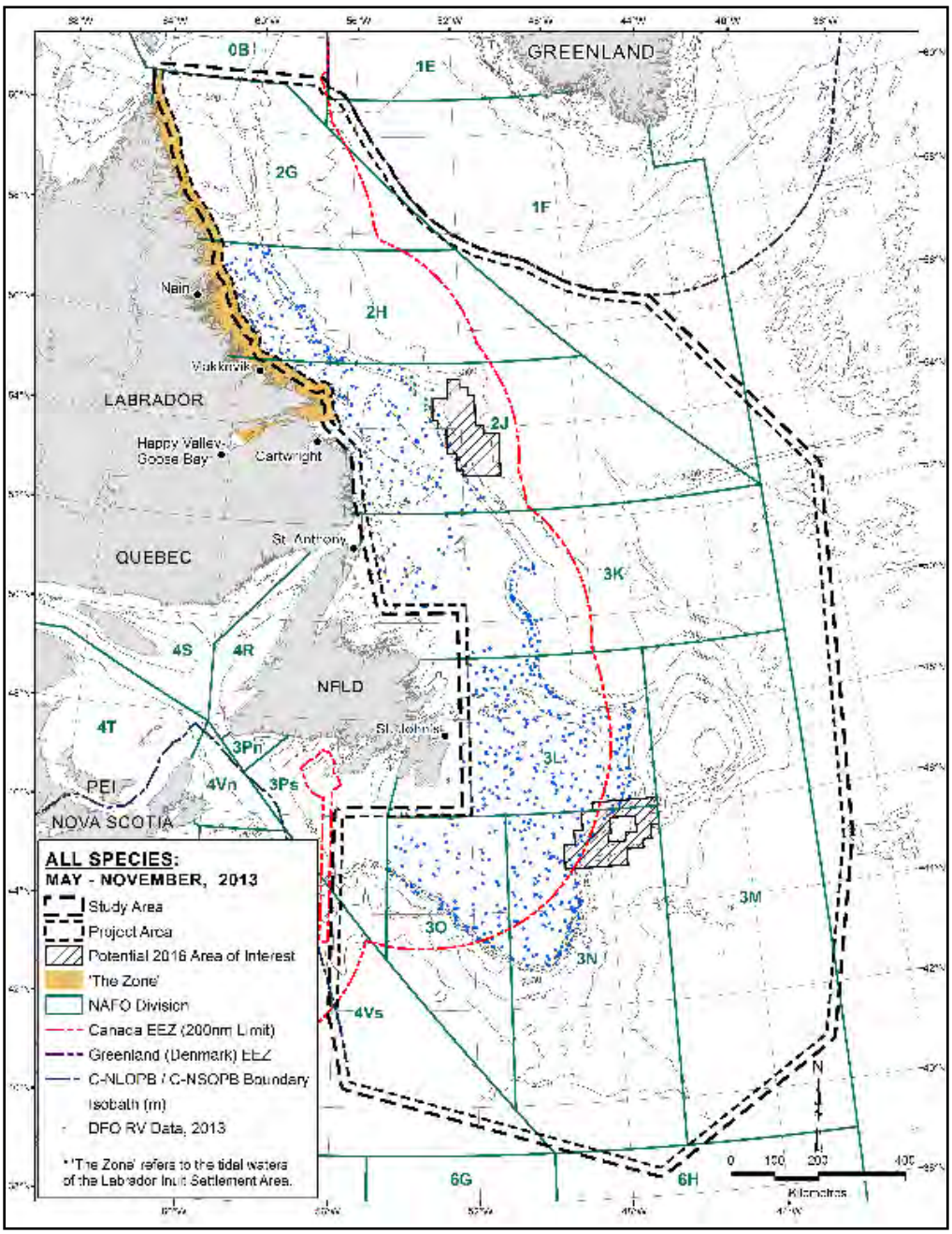
Deepwater redfish accounted for 43% of the total 2008–2013 catch weight, followed by northern shrimp (8%), yellowtail flounder (8%), American plaice (6%), Atlantic cod (5%), thorny skate (4%), Greenland halibut (4%), capelin (3%), sponges (2%), and shrimp (Natantia), sand lance (offshore), roughhead grenadier, sea cucumber (*Cucumaria frondosa*), striped shrimp, snow crab, witch flounder, silver hake and Atlantic (striped) wolffish (1% each). All other species/groups accounted for less than 1% of the total 2008–2013 catch weight in the Study Area. Principal species captured during the 2008–2013 DFO RV surveys were generally representative of predominant species targeted using similar mobile gear (bottom trawls) in the commercial fishery in recent years. Recent EAs for the Labrador Shelf (during 2007–2011) and eastern and southeastern offshore Newfoundland (during 2008–2012) regions include maps indicating the DFO RV survey catch locations for all species (see Figure 4.30 *in* LGL 2014, Figure 4.32 *in* LGL 2015a, and Figure 4.53 *in* LGL 2015b). The distribution of georeferenced catch locations reported during the 2013 DFO RV surveys within the Study Area is shown

in Figure 4.23. Species were caught in the western portions of the Study Area during the 2008–2013 DFO RV surveys, in water depths <2,000 m. Across all species caught during the 2008–2013 DFO RV surveys in the Study Area, total catch weight ranged from 165–227 mt per year.

Spring and fall RV surveys accounted for 41% and 59% of the total catch weight, respectively. The average mean depths of catch during spring and fall surveys from 2008–2013 were 243 m (min: 12 m; max: 1,084 m) and 258 m (min: 38 m; max: 1,526 m), respectively.

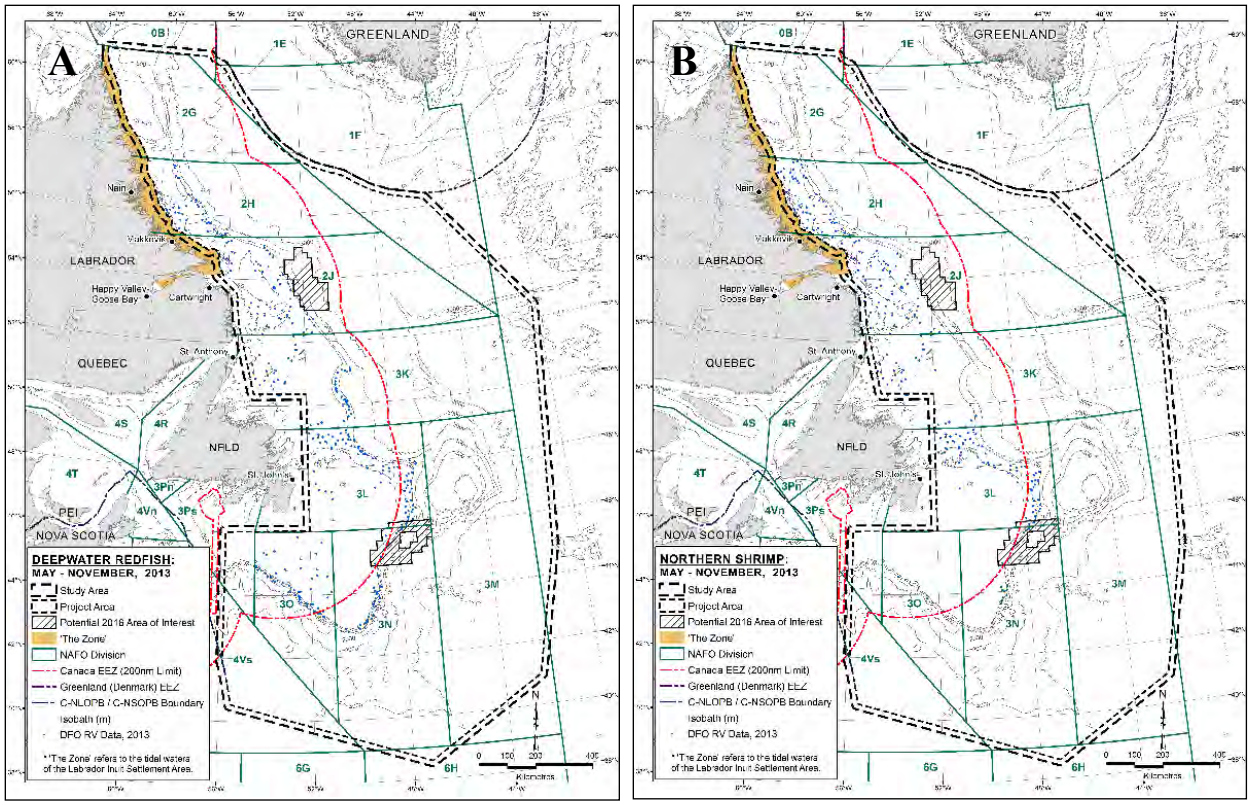
In descending order, the top five species/groups in terms of catch weight during the 2008–2013 spring surveys were deepwater redfish, yellowtail flounder, northern shrimp, American plaice and capelin. In descending order, the top five species/groups in terms of catch weight during the 2008–2013 fall surveys were deepwater redfish, northern shrimp, American plaice, Greenland halibut and yellowtail flounder. Species/groups that were caught predominantly during the spring RV surveys included wolffishes, pollock, sand dollar (*Echinarachnius parma*), Atlantic argentine, invertebrate sp., capelin, sea raven, shorthorn sculpin, mailed sculpin, Atlantic haddock, basket star (*Gorgonocephalus arcticus*), longhorn sculpin and silver hake. Species/groups that were caught in essentially equal amounts during both surveys included sea urchins (*Strongylocentrotus* sp., Atlantic (striped) wolffish, Atlantic cod, monkfish, comb jelly (Ctenopora) and green sea urchin. Species/groups that were caught predominantly during the fall RV surveys included Greenland shark, shrimp (Natantia), eelpout (*Lycodes* sp.), roundnose grenadier, polar sea star, Greenland halibut, lanternfishes, Icelandic scallop, black dogfish shark, moustache sculpin, blue hake, northern wolffish, jellyfishes, sea anemone (Actinaria), roughhead grenadier, sponges, longnose eel, snow crab, sessile tunicate (*Boltenia* sp.), spotted wolffish, spinytail skate, cusk and sea urchin (Echinoidea). The survey depth differences between spring and fall surveys likely account for some of the seasonal differences.

Figures 4.31–4.39 of LGL 2014, Figures 4.33–4.41 of LGL (2015a) and 4.54–4.61 of LGL (2015b) indicate 2007–2011 and 2008–2012 DFO RV survey catch locations on the Labrador Shelf and eastern and southeastern Newfoundland, respectively; specifically, maps were presented for deepwater redfish, sponges, corals and wolffishes in LGL (2014, 2015a,b); northern shrimp and Greenland halibut in LGL (2014, 2015a); American plaice and Atlantic cod in LGL (2015a,b); and thorny skate in LGL (2015b). Figures 4.24–4.26 show 2013 DFO RV survey catch locations in relation to the Study and Project Areas for these species and yellowtail flounder.



Source: DFO Research Vessel Survey Database, 2013.

Figure 4.23 Distribution of DFO RV Survey Catch Locations within the Study Area, 2013.



Source: DFO Research Vessel Survey Database, 2013.

Figure 4.24 Distribution of DFO RV Survey A) Deepwater Redfish, B) Northern Shrimp, C) American Plaice and D) Atlantic cod Catch Locations in the Study Area, 2013.

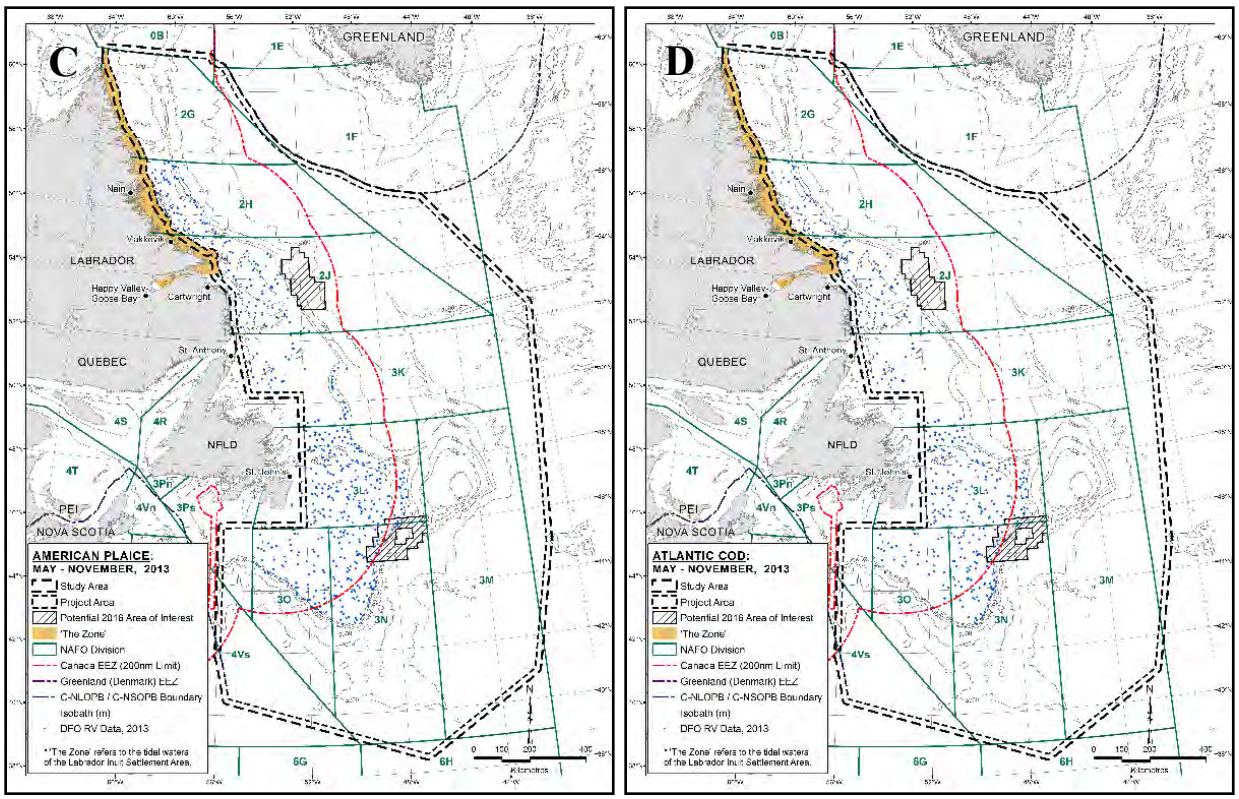
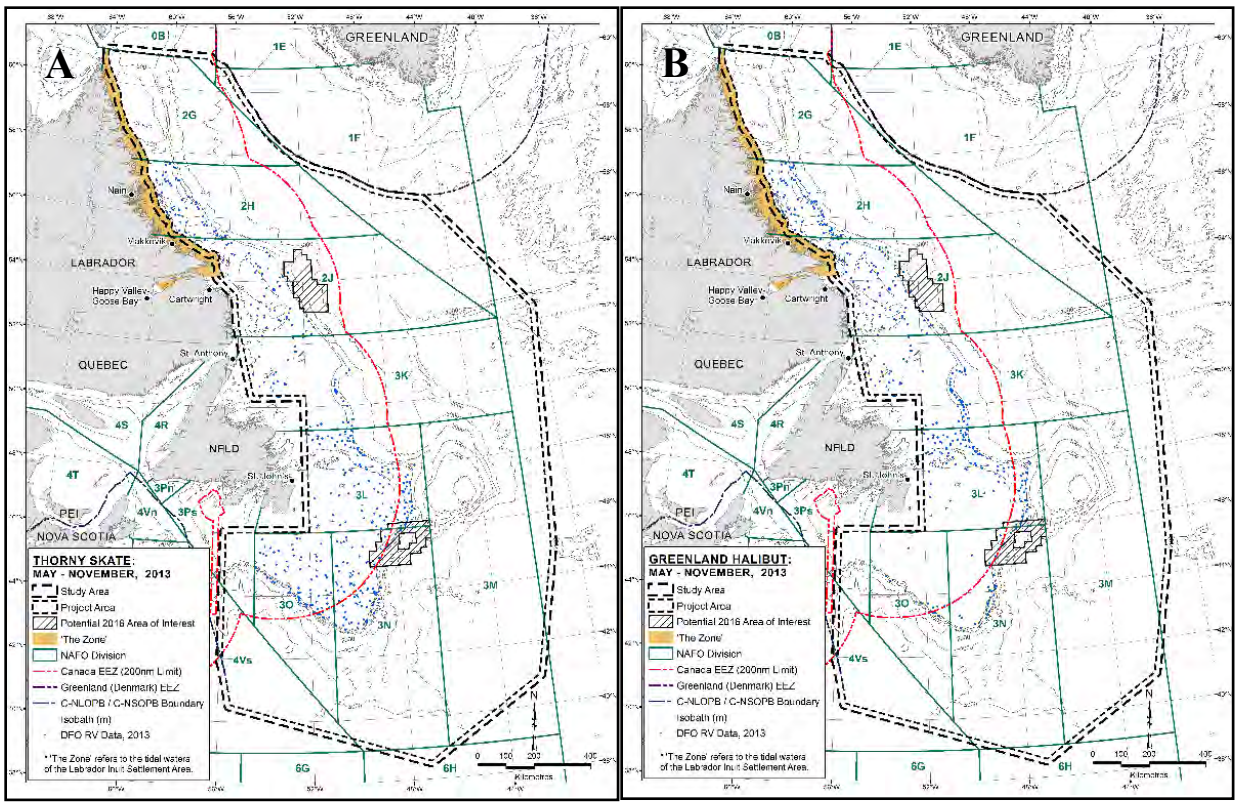


Figure 4.24 (Continued) **Distribution of DFO RV Survey A) Deepwater Redfish, B) Northern Shrimp, C) American Plaice and D) Atlantic cod Catch Locations in the Study Area, 2013.**



Source: DFO Research Vessel Survey Database, 2013.

Figure 4.25 Distribution of DFO RV Survey A) Thorny Skate, B) Greenland Halibut, C) Sponge and D) Coral Catch Locations in the Study Area, 2013.

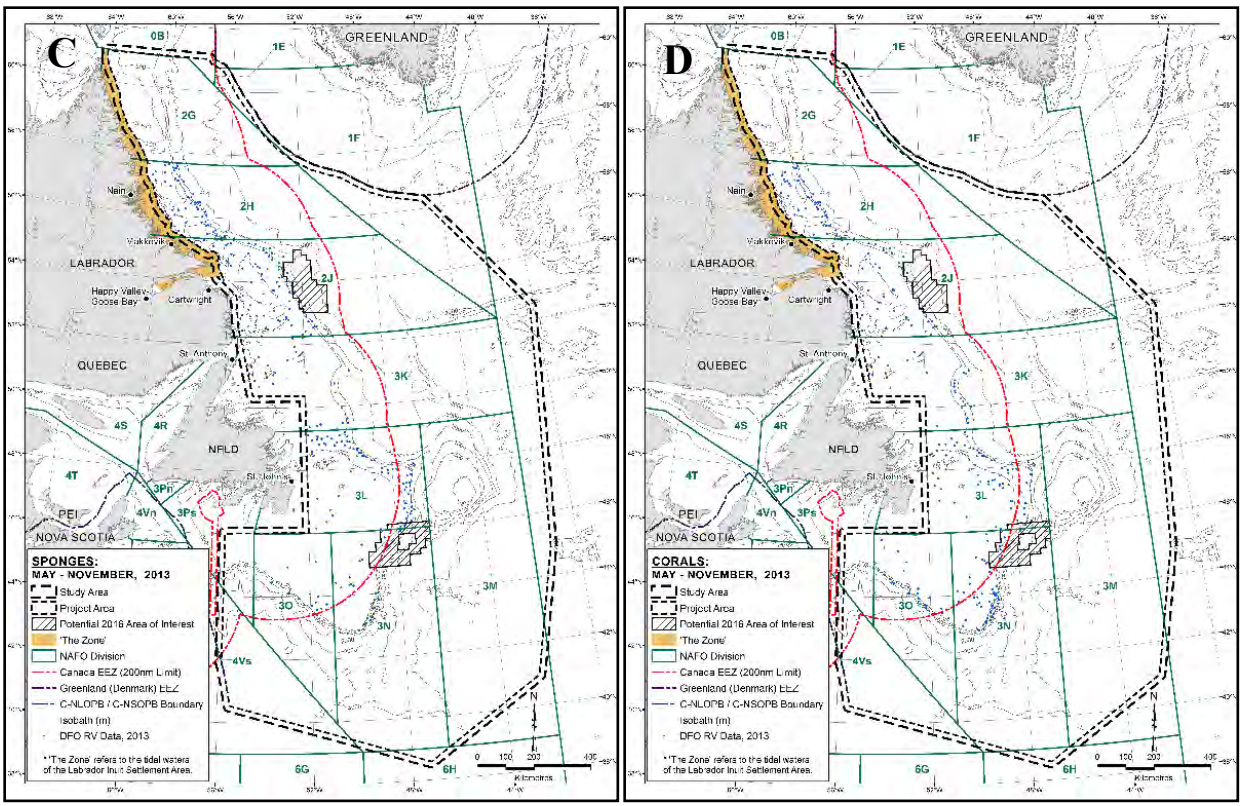
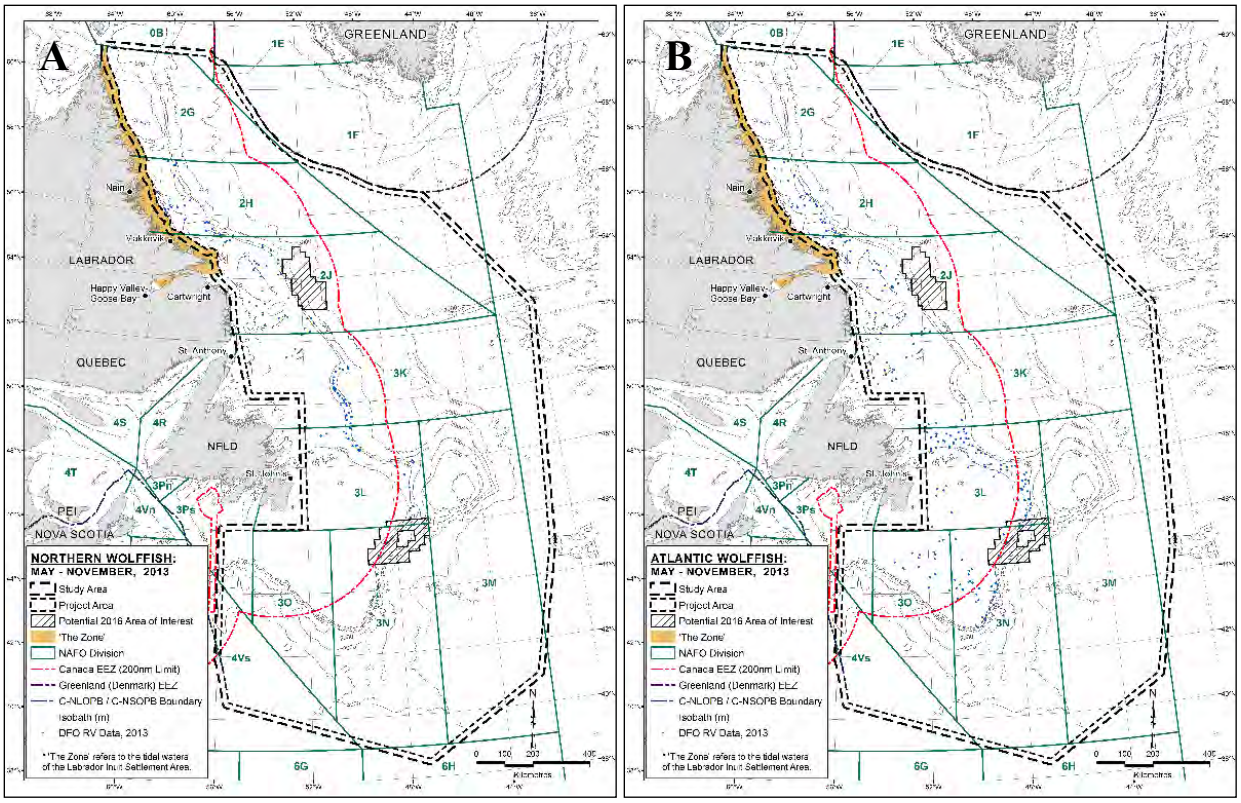


Figure 4.25 (Continued) **Distribution of DFO RV Survey A) Thorny Skate, B) Greenland Halibut, C) Sponge and D) Coral Catch Locations in the Study Area, 2013.**



Source: DFO Research Vessel Survey Database, 2013.

Figure 4.26 Distributions of DFO RV Survey A) Northern, B) Atlantic, and C) Spotted Wolffish, and D) Yellowtail Flounder Catch Locations within the Study Area, 2013.

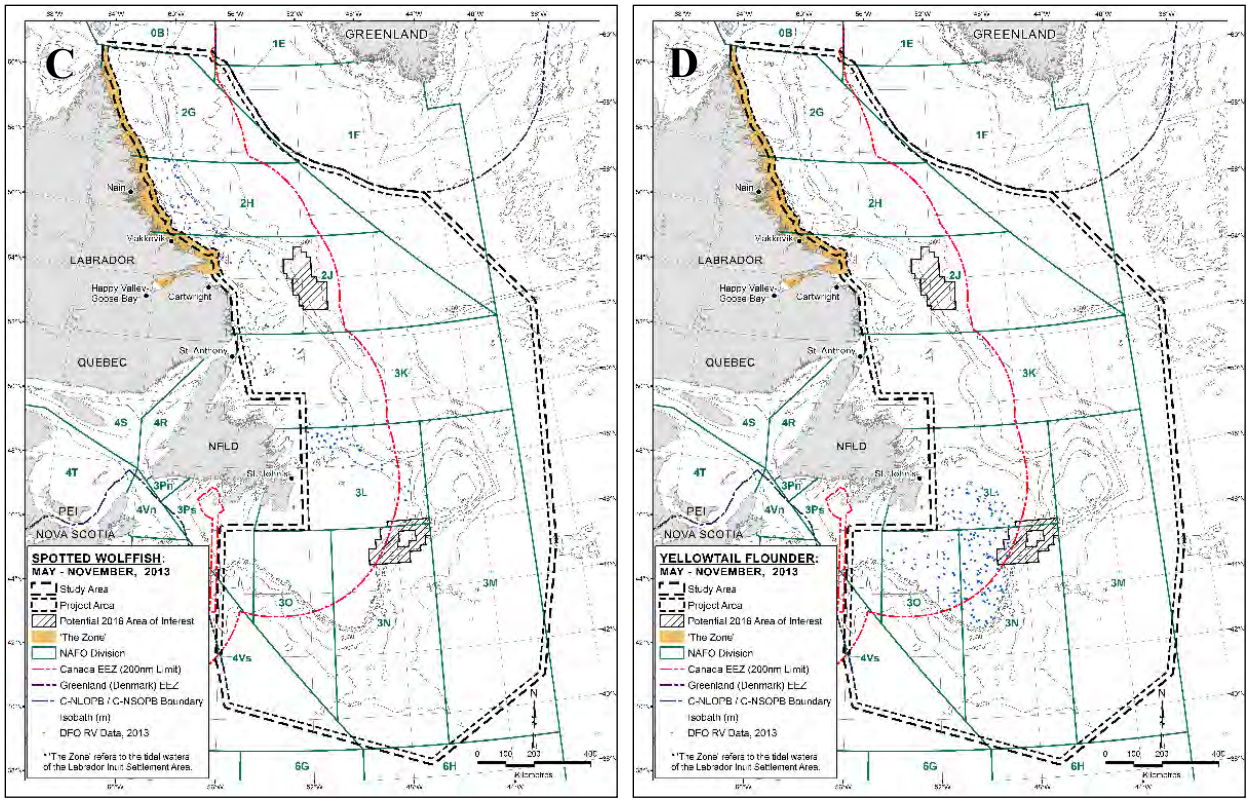


Figure 4.26 (Continued) **Distributions of DFO RV Survey A) Northern, B) Atlantic, and C) Spotted Wolffish, and D) Yellowtail Flounder Catch Locations within the Study Area, 2013.**

Catches at various mean depth ranges are also examined in this subsection. Table 4.10 presents total catch weights and predominant species caught within each mean depth range in the Study Area during the 2008–2013 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.

Table 4.10 Total Catch Weights and Predominant Species Caught at Various Mean Catch Depth Ranges, DFO RV Surveys, 2008–2013.

Mean Catch Depth Range (m)	Total Catch Weight (mt)	Predominant Species (% of Total Catch Weight)
<100	124	Yellowtail Flounder (79%) Sand Lance (offshore) (13%)
≥100 – <200	156	Atlantic Cod (39%) Capelin (24%)
≥200 – <300	181	Northern shrimp (55%) Thorny Skate (27%)
≥300 – <400	575	Deepwater redfish (90%) Sponges (4%)
≥ 400 – <500	51	Greenland Halibut (88%) Longfin Hake (9%)
≥500 – <600	24	Roughhead Grenadier (48%) Jellyfishes (22%) Northern Wolffish (15%) Marlin Spike (11%)
≥600 – <700	5	Longnose Eel (51%) Spinytail Skate (28%) Greenland Shark (20%)
≥700 – <800	4	Blue Hake (100%)
≥800 – <900	4	Roundnose Grenadier (58%) Black Dogfish Shark (42%)
≥900 – <1,000	-	-
≥1,000	-	-

Source: DFO Research Vessel Survey Database, 2008–2013.

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 any year, there will be spatial overlap between the Study Area and research surveys in NAFO Divisions 2J, 3K, 3L, 3N, 3O and 3Ps.

The tentative schedule of DFO RV surveys in the Study Area in 2016 is indicated in Table 4.11. Spring surveys within the Study Area are currently set to begin at the end of March and continue into early-June. DFO fall research surveys will occur in the Study Area from mid-September until early-December.

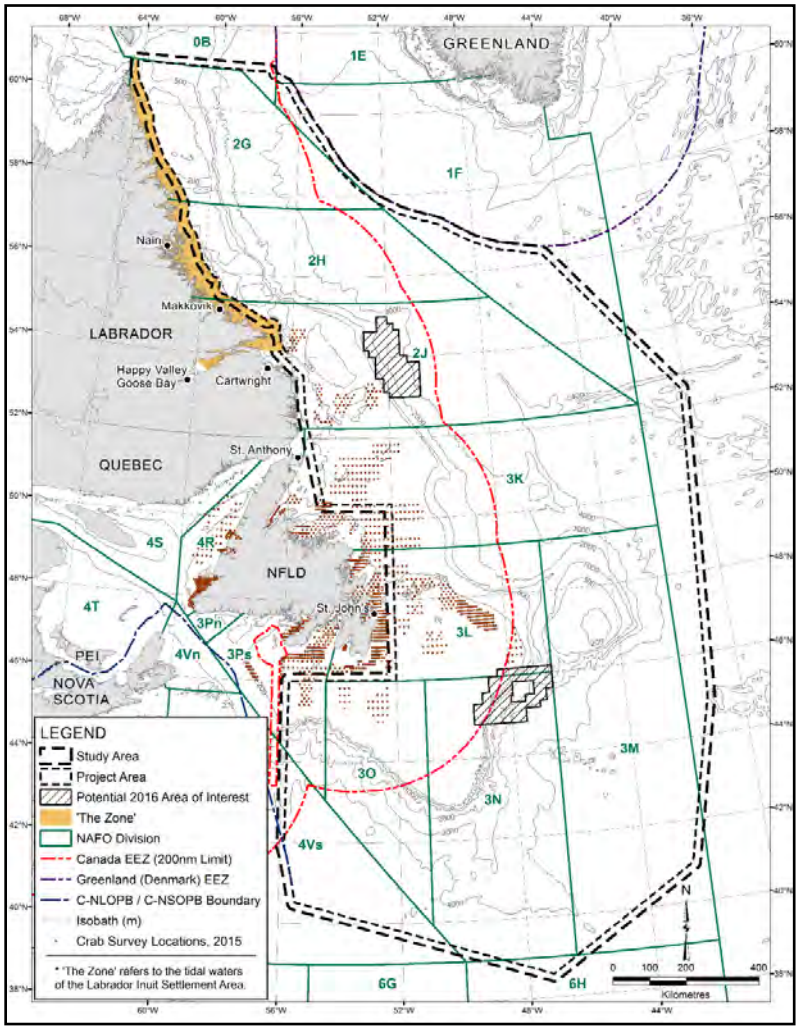
Table 4.11 Tentative 2016 Schedule of DFO RV Surveys in the Region of the Study Area.

NAFO Division	Start Date	End Date	Vessel
3P	29 Mar	12 Apr	*Needler*
3L	05 Apr	26 Apr	*Teleost*
3P	12 Apr	26 Apr	*Needler*
3L	26 Apr	02 May	*Vladykov*[a]
3P + 3KLMNO	27 Apr	02 May	*Teleost*
3P + 3O	27 Apr	10 May	*Needler*
3KL	03 May	21 May	*Teleost*
3O + 3N	10 May	21 May	*Needler*
3L + 3N	24 May	10 Jun	*Needler*
3K	06 Jul	18 Jul	*Vladykov*
3K	20 Jul	24 Jul	*Vladykov*
3L	15 Aug	21 Aug	*Vladykov*
3K	23 Aug	25 Aug	*Vladykov*
3O	14 Sep	27 Sep	*Needler*
3L	17 Sep	24 Sep	*Vladykov*
3O + 3N	27 Sep	08 Oct	*Needler*
2H	04 Oct	08 Oct	*Teleost*
3N + 3L	11 Oct	25 Oct	*Needler*
2H + 2J	11 Oct	25 Oct	*Teleost*
3L	17 Oct	26 Oct	*Vladykov*
3L	25 Oct	08 Nov	*Needler*
2J + 3K	25 Oct	08 Nov	*Teleost*
3K + 3L	09 Nov	19 Nov	*Needler*
3K	09 Nov	22 Nov	*Teleost*
3K + 3L Deep	22 Nov	06 Dec	*Teleost*

[a] The *Vladykov* will be partaking in science surveys (e.g., cod tagging, Trinity Bay Ecosystem), but not in the spring or fall NL RV surveys. Start/end dates subject to change as trip plans are finalized (G. Sheppard, DFO, Technician, pers. comm., 27 January 2016).

Members of the FFAW have been involved in a DFO-industry collaborative post-season snow crab trap survey for over 10 years. This survey is intended to "allow the fishing industry to more accurately assess and ultimately better manage the valuable snow crab resource" (FFAW|Unifor 2014). 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 2014). This annual survey typically starts in early September, often continuing until November. The station

locations, about 1,500 in total, remain constant from year to year. Numerous stations fall within the western portions of the Study Area, in NAFO Divisions 2J, 3K, 3L, 3O and 4Ps. Numerous stations are also immediately adjacent to the western portion of the Study Area, in Divisions 3K, 3L, 3O and 3Ps. The survey station locations in relation to the Study Area and Project Area are shown in Figure 4.27.



Source: DFO 2015e.

Figure 4.27 Locations of DFO-Industry Collaborative Post-season Snow Crab Trap Survey Stations in Relation to the Study Area and Project Area.

4.3.9 Fisheries Data Gaps Identified in Relevant SEAs

The following data gaps associated with the Fish and Fish Habitat VEC was 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.

The following data gap associated with the Fisheries VEC was identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- DFO datasets are known to not be entirely comprehensive, particularly with regard to important inshore fisheries.

The following data gaps associated with the Fisheries VEC were identified in the Southern Newfoundland SEA (§ 3.3.6 of C-NLOPB 2010).

- DFO data related to certain inshore fisheries (e.g., lobster) are lacking.
- Data related to foreign fisheries outside the 200 nm limit have poor spatial resolution. These data are currently available on a NAFO Division basis only.

DFO commercial fishery landings data are no longer provided as empirical data, restricting analysis options. Ranges of landed catch weight and catch value are now provided for 6' x 6' grid cells. Foreign fishery data still have poor spatial resolution.

4.4 Marine-associated Birds

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), the Eastern Newfoundland SEA (§ 4.2.2 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.4 of C-NLOPB 2010), and three project-specific EAs (§ 4.4 of LGL 2014, 2015a, b). 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 SEAs and EAs is also summarized. Data gaps regarding marine-associated birds identified in the three SEAs 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 to 1994 (Lock et al. 1994). The more recent (2006 to 2009) CWS Eastern Canadian Seabirds at Sea (ECSAS) survey program sampled areas off eastern and southern Newfoundland (Fifield et al. 2009). Results from surveys conducted during 2010 to 2015 were not available at the time this EA was written. These results will be provided in subsequent EA Updates once the data become available.

Since the late 1990s, seabird observations have been collected on the northeast Grand Banks by the offshore oil and gas industry from drill platforms and supply vessels (Baillie et al. 2005; Burke et al. 2005; Fifield et al. 2009). Seabird surveys were also conducted from vessels

conducting geophysical surveys within the Study Area during 2004 to 2008 as part of marine bird monitoring programs required by the C-NLOPB (Moulton et al. 2005, 2006a; Lang et al. 2006; Lang 2007; Lang and Moulton 2008; Abgrall et al. 2008a,b, 2009). The most current census results of important seabird nesting colonies in Newfoundland and Labrador have been acquired from the CWS.

The Study Area encompasses a wide range of marine habitats extending from the Labrador Sea to the deep water south of the Grand Banks of Newfoundland. 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 south along the edge of continental shelf edge from the northern tip of Labrador to the northern Grand Banks 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). South of Flemish Cap and the Grand Banks, the Gulf Stream meets the Labrador Current, causing more mixing of different water types and potentially rich zones for marine productivity.

Seabird abundance (all species combined) derived from PIROP during January to March was 1.0 to 99.99 birds/linear km in most of the 15'N x 30'W blocks that have been surveyed in the Study Area in offshore far Labrador Coast and northern Newfoundland (Lock et al. 1994). Seabird abundance closer to shore in the Study Area was 0.10 to 9.99 birds/linear km category in most blocks. In one block off the northeast Newfoundland Shelf, >100 birds/linear km were recorded. During April to June, abundance also ranged from 1.0 to 99.99 birds/linear km in most blocks. However, abundance averaged >100 birds/km in one block far off the shelf. During July to September, abundance averaged 1.0 to 99.99 birds/linear km over much of the Study Area. A few survey blocks at the Labrador Shelf edge and beyond showed an abundance of >100 birds/linear km. October to December data are available for only a small portion of the Study Area but abundance in most survey blocks dropped to the 1.0 to 99.99 birds/linear km range. More than 100 birds/linear km were recorded in a few blocks at or beyond the continental shelf edge. Northern Fulmar, Black-legged Kittiwake and murres accounted for most of the birds during these surveys. However, shearwater species made a large contribution from June to August and Dovekie was a large component during October and November (Lock et al. 1994). During the ECSAS surveys, seabird density (all species combined) during March to April ranged from 3.3 to 20.3 birds/km^2 in the four 1°N x 1°W blocks that were surveyed in the Study Area (Fifield et al. 2009). During May to August, density ranged from 1.5 to 48.8 birds/km^2 in most of the survey blocks. During September and October, density was 4.9 to 46.7 birds/km^2. From November to February, density ranged from 3.7 to 45.1 birds/km^2 in most blocks. The majority of the bird species recorded during these surveys off Labrador and northern Newfoundland were Northern Fulmar, Black-legged Kittiwake, murres and Dovekie in all seasons (Fifield et al. 2009).

During the ECSAS surveys of Newfoundland waters, the Sackville Spur, Orphan Basin, Flemish Pass, Grand Banks and the edge of the Grand Banks were all identified as important areas for one or more seabird species/groups during one or more seasons (Fifield et al. 2009). In the Newfoundland and Labrador shelves region, Northern Fulmar and gulls were found in the highest concentrations on the Sackville Spur during spring. Significant numbers of these birds were also present in winter. Northern Fulmars, Leach's Storm-petrels and shearwaters were observed during the summer along the southern edge of the Orphan Basin. ECSAS surveys in the Flemish Pass and Flemish Cap indicated local hotspots during winter and spring for Northern Fulmar, Black-legged Kittiwake, Dovekie and murres. Gulls occurred at these locations primarily in the spring. The Grand Banks were found to be important for a variety of seabirds throughout the year.

Offshore Labrador is a known wintering area for the Ivory Gull, a species with *endangered* status under Schedule 1 of *SARA*, COSEWIC, and the Newfoundland and Labrador *Endangered Species Act*. Ivory Gull occur in the Study Area mainly outside the time frame of the proposed seismic exploration period (i.e., May to November). This species is typically associated with pack ice which will be avoided during seismic exploration. Harlequin Duck and Barrow's Goldeneye 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. Details on Barrow's Goldeneye and Harlequin Duck are in § 4.4.2.1, while Ivory Gull is discussed in § 4.6, Species at Risk. Shorebirds and other species found on the coast but not in the Study Area are not discussed in detail 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 world range, seasonal occurrence and seasonal abundance of seabirds occurring regularly in the Study Area are described below. Tables 4.12 and 4.13 summarize the predicted abundance status for each species in the Study Area by month. 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.

A species world population estimate is taken into consideration when assessing relative abundance. For example, Great Shearwater is far more numerous on a worldwide scale compared to a predator like the Great Skua. Seasonal occurrence and abundance information was derived from Brown (1986), Lock et al. (1994), Baillie et al. (2005), Moulton et al. (2005, 2006a,b), Lang et al. (2006), Lang (2007), Abgrall et al. (2008a,b), and Fifield et al. (2009).

There are over 30 species of marine-associated birds occurring regularly on the Labrador coast and the east and south coast of Newfoundland (Tables 4.12 and 4.13). Note that Table 4.12 refers to pelagic seabirds that occur in the portion of the Study Area north of 52°N, and that Table 4.13 refers to pelagic seabirds that occur in the portion of the Study Area south of 52°N. Large numbers of seabirds occur in parts of the Study Area at all times of the year.

Table 4.12 Monthly Occurrence and Abundance of Pelagic Seabirds in Offshore Labrador (52°N to 60°N).

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

Notes: * Breeds in Newfoundland and Labrador.

[1] Abundance definitions valid for at least part of Study Area but not necessarily the whole Study Area. Common = likely present daily in moderate to high numbers; Uncommon = likely present daily in small numbers; Scarce = likely present regularly in very small numbers; Rare = usually absent, individuals occasionally present. 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) and Fifield et al. (2009).

Table 4.13 Monthly Occurrence and Abundance of Pelagic Seabirds in Offshore Newfoundland and South of Grand Banks (38°N to 52°N).

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

Notes: * Breeds in Newfoundland and Labrador.

[1] Abundance definitions valid for at least part of Study Area but not necessarily the whole Study Area. Common = likely present daily in moderate to high numbers; Uncommon = likely present daily in small numbers; Scarce = likely present regularly in very small numbers; Rare = usually absent, individuals occasionally present. Blank spaces indicate not expected to occur in that month. Predicted monthly occurrences derived from 2004, 2005, 2006, 2007 and 2008 monitoring studies in the Orphan Basin, Jeanne d'Arc Basin, Laurentian Sub-basin and extrapolation of marine bird distribution at sea in eastern Canada in Brown (1986); Lock et al. (1994) and Fifield et al. (2009).

Sources: Brown (1986); Lock et al. (1994); Baillie et al. (2005); Moulton et al. (2005, 2006a,b); Lang et al. (2006); Lang (2007); Lang and Moulton (2008); Abgrall et al. (2008a,b, 2009.)

4.4.2 Breeding Seabirds in Southeastern Labrador, Eastern Newfoundland and Southeastern Newfoundland

Significant seabird breeding colonies are established in southeast Labrador and eastern Newfoundland (Tables 4.14 and 4.15). Just over five million pairs of seabirds nest on the east coast and southeast coast of Newfoundland. This includes 3.7 million pairs of Leach's Storm-Petrels and 760,000 pairs of Common Murres (Tables 4.14 and 4.15). The seabird breeding colonies on Funk Island, Baccalieu Island, the Witless Bay Islands and Cape St. Mary's are among the largest in Atlantic Canada. More than 4.8 million pairs nest at these three locations alone (Tables 4.14 and 4.15). This includes the largest Atlantic Canadian colonies of Leach's Storm-petrel (3,336,000 pairs on Baccalieu Island), Common Murre (470,000 pairs on Funk Island), Black-legged Kittiwake (13,950 pairs on Witless Bay Islands), and Atlantic Puffin (324,650 pairs on Witless Bay Islands). Many of these breeding birds may use the western edge of the Study Area during the breeding season. After the nesting season, breeding seabirds disperse over a large area of the Newfoundland and Labrador offshore area, including the Study Area. Large numbers of seabirds spend part of their non-breeding season within the Study Area. Besides supporting nesting seabirds during the breeding season, large numbers of other seabirds are sustained during the non-breeding seasons. Several million Great Shearwater and Sooty Shearwater migrate from breeding islands in the south Atlantic to spend the summer in the waters offshore Newfoundland and Labrador. Many of the 3.8 million Thick-billed Murres breeding in the eastern Canadian Arctic and up to 10 million Dovekies from Greenland either winter in the Labrador Sea or cross it on the way to the Grand Banks and other parts of southern Atlantic Canada. Large numbers of sub-adults of Northern Fulmar and Black-legged Kittiwake from breeding colonies in the eastern Arctic and Europe spend the early parts of their lives in the Labrador Sea.

Important Bird Areas (IBAs) form a network composed of sites that are important to the natural diversity of Canadian bird species and are critical for the long-term viability of naturally occurring bird populations. The Canadian IBA program (www.ibacanada.ca) was launched in 1996 by BirdLife International partners Bird Studies Canada and the Canadian Nature Federation (now Nature Canada). The goal of the IBA program is to ensure the conservation of sites through the development and implementation of conservation plans in partnership with local stakeholders for priority IBAs. There are 31 IBAs along coastal Labrador and the east and south east coast of Newfoundland. Figures 4.96 in C-NLOPB 2008, 4.110 in C-NLOPB 2014 and 3.69 in C-NLOPB 2010) show the IBA locations in and proximate to the Study Area.

The following subsections address the distribution and abundance of various species of eight marine-associated bird families that breed in eastern Newfoundland.

Table 4.14 Numbers of Pairs of Seabirds Nesting at Colonies in Labrador and Northeastern Newfoundland (60°N to 49°30'N)

Species	Southeast of Nain	Quaker Hat	Northeast Groswater Bay	Gannet Islands	Bird Island	Northern Groais Island	Wadham Islands	Funk Island	Cape Freels/ Cabot Island
Northern Fulmar	-	-	-	16[a]	-	-	-	13[a]	-
Leach's Storm-Petrel	-	-	10[a]	20[a]	present	-	6,000	-	250[a]
Northern Gannet	-	-	-	-	-	-	-	6,075[a]	-
Herring Gull	-	-	present	-	-	-	-	150[a]	-
Glaucous Gull	350	-	-	-	-	-	-	-	-
Great Black-backed Gull	-	-	100[a]	120[a]	20	-	-	75[a]	-
Black-legged Kittiwake	-	4[a]	-	72[a]	-	2,400	-	100[a]	-
Arctic and Common Terns	376	-	-	-	-	-	376[b]	-	250[a]
Common Murre	2,260	-	2,060[a]	31,170[a]	3,100	-	-	470,000[a]	2,600[a]
Thick-billed Murre	8,000	126[a]	365[a]	1,846[a]	present	-	-	250[a]	-
Razorbill	815	-	3,714[a]	14,801[a]	1,530	-	30	200[a]	25[a]
Black Guillemot	341	-	present	110[a]	-	-	25	1[b]	-
Atlantic Puffin	12,240	-	17,404[a]	38,666[a]	8,070	-	7,140	2,000[a]	20[a]
Totals	**24,382**	**130**	**23,653**	**86,821**	**12,720**	**2,400**	**13,571**	**478,864**	**3,145**

Source: [a] EC-CWS unplublished data, [b] Cairns et. al 1989.

Table 4.15 Numbers of Pairs of Seabirds Nesting at Colonies in Eastern Newfoundland (49°30'N to 46°N).

Species	Baccalieu Island	Witless Bay Islands	Mistaken Point	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island	Grand Colombier Island	Miquelon Cape
Northern Fulmar	-	13[a]	-	Present[a]	-	-	-		
Manx Shearwater	-	-	-	-	7[c]	-	-		
Leach's Storm-Petrel	2,022,000 [a,b]	314,020[a]	-	-	13,879[d]	100,000[b]	103,833[b]	363,787[e]	
Northern Gannet	2,564[a]	-	-	14,789[a]	-	-	-		
Herring Gull	46[a]	2,045[a]	-	Present[b]	20[b]	5,000[b]	Present[b]	60[f]	265[d]
Great Black-backed Gull	2[a]	15[a]	-	Present[b]	6[b]	25[b]	-	10[f]	
Black-legged Kittiwake	5,096[a]	13,950[a]	4,750[a]	10,000[b]	-	50[b]	-	196[f]	2,415[d]
Arctic and Common Terns	-	-	-	-	-	-	Present[b]		
Common Murre	1,440[a]	268,660[a]	100[b]	15,484[a]	-	-	-	3[f]	
Thick-billed Murre	73[a]	240[a]	-	1,000[b]	-	-	-		
Razorbill	406[a]	846[a]	Present[b]	100[b]	-	-	-	50[f]	
Black Guillemot	113[a]	20[a]	Present[b]	Present[b]	-	-	-	46[f]	Present[d]
Atlantic Puffin	45,300[a]	324,650[a]	40[b]	-	-	-	-	9,543[f]	
TOTALS	**2,077,040**	**924,459**	**4,890**	**41.373**	**13,912**	**105,075**	**103,833**	**373,695**	**2,680**

Sources: [a] EC-CWS unpublished data, [b] Wilhelm et al., submitted; [c] Fraser et al. (2013); [d] Cairns et al. (1989); [e] Lormée et al. (2012).

4.4.2.1 Anatidae (Ducks and Geese)

The Study Area extends close to the coastline of Labrador where there are many important areas for sea ducks. The largest nesting colonies of Common Eider in Newfoundland and Labrador occur in the area of Table Bay to Groswater Bay, with a secondary concentration in Nain Bight, reflecting a level of productivity in these areas also noted for breeding seabirds. Although there are few published estimates of numbers, probably >10,000 pairs of Common Eiders nest in the Hamilton Inlet area (Lock 1986; Lock et al. 1994). Less is known of the moulting distribution of these stocks although large numbers of males (~ 9,000) were recorded moulting in the mouth of Table Bay in July 1989 (Goudie et al. 1994), and more than 5,000 were recorded in St. Peter Bay in 1998 (IBA site data). Other moult aggregations are likely localized in the Labrador coastal area. Surf, Black and White-winged Scoters breed in interior Labrador and by mid-summer, relatively large aggregations moult in Hamilton Inlet and Nain Bight. Sites such as Backway off Lake Melville and Nain Bight typify traditional sites where large groupings of males and

non-breeders aggregate annually to complete the feather moult. After mid-September, numbers of eiders north of Hamilton Inlet have diminished considerably, suggesting some redistribution (Lidster et al. 1993). Common Goldeneye, Barrow's Goldeneye, and Red-breasted Merganser moult in coastal areas of Labrador in smaller aggregations, generally hundreds of individuals. Barrow's Goldeneye and Harlequin Duck both have *special concern* status under Schedule 1 of *SARA*. A detailed profile of Barrow's Goldeneye is provided in § 4.6.1.11 of the MKI Labrador Sea EA (LGL 2014), and a detailed profile of Harlequin Duck is provided in § 4.6.1.10 of the MKI Labrador Sea EA (LGL 2014).

4.4.2.2 Procellariidae (Fulmars and Shearwaters)

Five species from this family occur regularly in the Study Area: Northern Fulmar, Great Shearwater, Cory's Shearwater, Sooty Shearwater and Manx Shearwater.

Northern Fulmar

Northern Fulmar are expected to be common throughout the Study Area year-round (see Tables 4.12 and 4.13). Numbers of breeding pairs and their breeding locations are indicated in Tables 4.14 and 4.15.

Subsections 4.4.2.2 of LGL (2014), 4.4.4.1 of LGL (2015a) and 4.4.3.2 of LGL (2015b) provide more information on Northern Fulmar occurrence and abundance in the Study Area.

Great Shearwater

Great Shearwater are expected to be common throughout the Study Area during June to October but either uncommon or scarce during May and November (see Tables 4.12 and 4.13).

Subsections 4.4.2.2 of LGL (2014), 4.4.4.1 of LGL (2015a) and 4.4.3.3 of LGL (2015b) provide more information on Great Shearwater occurrence and abundance in the Study Area.

Other Shearwaters

Cory's Shearwater are expected to be scarce in the southern part of the Study Area during June to September, and to not occur in the northern part of the Study Area (see Tables 4.12 and 4.13). Sooty Shearwater are expected to be uncommon in the northern part of the Study Area during June to September, and scarce during May and October (see Table 4.12). In the southern part of the Study Area, Sooty Shearwater are expected to be uncommon during June to October, and scarce during May and November (see Table 4.13). Manx Shearwater are expected to be scarce in the northern part of the Study Area during June to September (see Table 4.12), and scarce in the southern part of the Study Area during May to October (see Table 4.13). Manx Shearwater have a breeding colony at Middle Lawn Island (see Table 4.15).

Subsections 4.4.2.2 of LGL (2014), 4.4.4.1 of LGL (2015a) and 4.4.3.3 of LGL (2015b) provide more information on occurrence and abundance of these three shearwater species in the Study Area.

4.4.2.3 Hydrobatidae (Storm-Petrels)

Leach's Storm-Petrel

Leach's Storm-Petrel are expected to be uncommon in the northern part of the Study Area during May to October (see Table 4.12), and common in the southern part of the Study Area during May to October (see Table 4.13). Numbers of breeding pairs and their breeding locations are indicated in Tables 4.14 and 4.15.

A Leach's Storm-Petrel, outfitted with a transmitter in the Gull Island, Newfoundland colony, migrated to Cape Verde Islands off the west coast of Africa in early December. It averaged 420 km/day during its 12-day migration, and it remained in this area for at least five weeks before the transmitter stopped functioning (Pollet et al. 2014).

The ECSAS survey data collected during 2006–2009 indicated storm-petrel densities per 1º survey block ranged from 0 to 4.2 birds/km^2 during the May to October period (Fifield et al. 2009). Slightly higher concentrations were recorded on the northern Grand Banks and southern Orphan Basin.

Subsections 4.4.2.3 of LGL (2014), 4.4.4.2 of LGL (2015a) and 4.4.3.4 of LGL (2015b) provide more information on Leach's Storm-Petrel occurrence and abundance in the Study Area.

Wilson's Storm-Petrel

Wilson's Storm-Petrel are expected to be scarce in the northern part of the Study Area during June to September (see Table 4.12), and either uncommon or scarce during June to September in the southern part (see Table 4.13).

Subsections 4.4.4.2 of LGL (2015a) and 4.4.3.4 of LGL (2015b) provide more information on Wilson's Storm-Petrel occurrence and abundance in the Study Area.

4.4.2.4 Sulidae (Gannets)

Northern Gannet

Northern Gannet are expected to be uncommon in the northern part of the Study Area during June to September, and scarce during May and November (see Table 4.12). In the southern part of the Study Area, Northern Gannett are expected to be uncommon during May to November

(see Table 4.13). Numbers of breeding pairs and their breeding locations are indicated in Tables 4.14 and 4.15.

Subsections 4.4.2.4 of LGL (2014), 4.4.4.3 of LGL (2015a) and 4.4.3.5 of LGL (2015b) provide more information on Northern Gannet occurrence and abundance in the Study Area.

4.4.2.5 Phalaropodinae (Phalaropes)

Red and Red-necked Phalarope

Red Phalarope are expected to be common in the northern part of the Study Area during July to September, and uncommon during May to June and October (see Table 4.12). In the southern part of the Study Area, Red Phalarope are expected to be uncommon during August and September, and scarce during May to July and October (see Table 4.13).

Red-necked Phalarope are expected to be uncommon in the northern part of the Study Area during May to September, and scarce October (see Table 4.12). In the southern part of the Study Area, Red-necked Phalarope are expected to be scarce during May to October (see Table 4.13).

Subsections 4.4.2.5 of LGL (2014) and 4.4.4.4 of LGL (2015a) provide more information on Red and Red-necked Phalarope occurrence and abundance in the Study Area.

4.4.2.6 Laridae (Gulls and Terns)

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

Great Black-backed Gull, Herring Gull, Glaucous Gull are expected to be common in the northern part of the Study Area during May to November (see Table 4.12). In the southern part of the Study Area, Great Black-backed Gull and Herring Gull are expected to be either uncommon or scarce during May to November, while Glaucous Gulls are expected to be either uncommon, scarce or rare during May to November (see Table 4.13).

Iceland Gulls are expected to be either uncommon or scarce in the northern part of the Study Area during June to September, and common in May, October and November (see Table 4.12). In the southern part of the Study Area, Iceland Gull are expected to be scarce in May and October, common in November and absent during June to September (see Table 4.13).

Lesser Black-backed Gulls are expected to be scarce in the northern part of the Study Area during May to September (see Table 4.12), and rare in the southern part during May to November (see Table 4.13).

Numbers of breeding pairs of Herring and Great Black-backed Gulls and their breeding locations are indicated in Tables 4.14 and 4.15, while the same information for Glaucous Gull is indicated in Table 4.14.

Subsections 4.4.2.6 of LGL (2014), 4.4.4.5 of LGL (2015a) and 4.4.3.6 of LGL (2015b) provide more information on the occurrence and abundance of these gull species in the Study Area.

Black-legged Kittiwake

Black-legged Kittiwake are expected to be common during May to November in the entire Study Area (see Tables 4.12 and 4.13). Numbers of breeding pairs of Black-legged Kittiwake and their breeding locations are indicated in Tables 4.14 and 4.15.

Subsections 4.4.2.6 of LGL (2014), 4.4.4.5 of LGL (2015a) and 4.4.3.6 of LGL (2015b) provide more information on the occurrence and abundance of Black-legged Kittiwake in the Study Area.

Ivory Gull

The Ivory Gull likely occurs in small numbers in the portion of the Study Area north of 50°N during periods when sea ice is present (i.e., late-winter and early-spring). It probably occurs irregularly south of 50°N among the ice pack during heavier ice years. As indicated in Tables 4.12 and 4.13, Ivory Gull are expected to be either uncommon or scarce during May and November in the northern part of the Study Area, and to not occur in the southern part during May to November.

The Ivory Gull has an *endangered* status under both Schedule 1 of *SARA* and COSEWIC (COSEWIC 2015). More information on this gull species is presented in § 4.6, Species at Risk.

Arctic and Common Tern

Arctic Tern and Common Tern are expected to be common in the northern part of the Study Area during May to August, and either uncommon or scarce in September (see Table 4.12). In the southern part of the Study Area, both tern species are expected to be either rare or scarce during May to September (see Table 4.13). Numbers of breeding pairs of Arctic Tern and Common Tern and their breeding locations are indicated in Tables 4.14 and 4.15.

Subsections 4.4.2.6 of LGL (2014), 4.4.4.5 of LGL (2015a) and 4.4.3.6 of LGL (2015b) provide more information on tern occurrence and abundance in the Study Area.

4.4.2.7 Stercorariidae (Skuas and Jaegers)

Great and South Polar Skua

In the northern part of the Study Area, Great Skua are expected to be rare in May, scarce in June and uncommon during July to October (see Table 4.12). In the southern part of the Study Area, this skua species is expected to be scarce during May to November (see Table 4.13).

South Polar Skua are expected to be rare during June to September in the northern part of the Study Area (see Table 4.12), and scarce during May to October in the southern part (see Table 4.13).

Subsections 4.4.2.7 of LGL (2014) and 4.4.4.6 of LGL (2015a) provide more information on skua occurrence and abundance in the Study Area.

Pomarine, Parasitic and Long-tailed Jaeger

These three jaeger species are expected to be uncommon in the northern part of the Study Area during May to November (see Table 4.12), and scarce in the southern part during the same period (see Table 4.13).

Subsections 4.4.2.7 of LGL (2014), and 4.4.4.6 of LGL (2015a) 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 breeding in the North Atlantic. All of these except for Dovekie nest in large numbers in eastern Newfoundland (see Tables 4.14 and 4.15). Dovekies nest 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

In the northern part of the Study Area, Dovekie are expected to be common in May, October and November, uncommon in June and September, scarce in July and August (see Table 4.12). In the southern part of the Study Area, Dovekie are expected to be uncommon in May, rare during June to August, scarce in September, and common in October and November (see Table 4.13).

Subsections 4.4.2.8 of LGL (2014), 4.4.4.7 of LGL (2015a) and 4.4.3.7 of LGL (2015b) provide more information on Dovekie occurrence and abundance in the Study Area.

Murres

Since the two species of murre, Common and Thick-billed, are often difficult to differentiate with certainty at sea, they are often aggregated as "murres" during offshore seabird surveys.

Common Murre are expected to be common in the northern part of the Study Area during May to October, and uncommon in November (see Table 4.12). This murre species is expected to be common in the southern part of the Study Area during May to November (see Table 4.13).

Thick-billed Murre are expected to be common in the northern part of the Study Area during May, June, October and November, and uncommon during July to September (see Table 4.12). In the southern part, this murre is expected to be common in May, October and November, scarce during June to August, and uncommon during September (see Table 4.13).

Numbers of breeding pairs for each species and their breeding locations are indicated in Tables 4.14 and 4.15.

Subsections 4.4.2.8 of LGL (2014), 4.4.4.7 of LGL (2015a) and 4.4.3.7 of LGL (2015b) provide more information on murre occurrence and abundance in the Study Area.

Atlantic Puffin

Atlantic Puffin are expected to be common in the entire Study Area during May to November (see Tables 4.12 and 4.13). Numbers of breeding pairs for each species and their breeding locations are indicated in Tables 4.14 and 4.15.

Subsections 4.4.2.8 of LGL (2014) and 4.4.4.7 of LGL (2015a) provide 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 northern part of the Study Area during May to November (see Table 4.12). In the southern part of the Study Area, Black Guillemot and Razorbill are expected to be rare and uncommon, respectively, during May to November (see Table 4.13).

Black Guillemot is expected to be common nearshore in Newfoundland and 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. Numbers of breeding pairs for each species and their breeding locations are indicated in Tables 4.14 and 4.15.

Subsections 4.4.2.8 of LGL (2014) and 4.4.4.7 of LGL (2015a) provides more information on Razorbill and Black Guillemot occurrence and abundance 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 (Table 4.16). The estimated head submergence time and diving depth of various seabirds are also provided in Table 4.16.

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), § 4.4.5 of LGL (2015a), and § 4.4.4 of LGL (2015b).

4.4.4 Marine-associated Bird Data Gaps Identified in Relevant SEAs

The following data gaps associated with the Fish and Fish Habitat 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 following data gap associated with the Marine-associated Bird VEC was identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- Detailed information on the occurrence, abundance and distribution of marine-associated birds is not available for all locations and times in the Study Area.

The following data gaps associated with the Marine-associated Bird VEC were identified in the Southern Newfoundland SEA (§ 3.4.9 of C-NLOPB 2010).

- Knowledge of the offshore distribution and abundance of seabirds is incomplete;
- Seabird data for areas that have been surveyed typically do not cover all seasons;
- Pelagic seabird distribution data are lacking during winter on much of the continental shelf and the deep waters beyond the shelf; and
- Much of the existing data on seabirds are outdated.

All of the data gaps indicated above still exist. Efforts are being made during seismic surveys to collect more distribution and abundance data for seabirds; however, these data are not available for inclusion in assessments. Limited data are also being collected from production platforms on the offshore.

Table 4.16 Foraging Strategy, Prey, Time with Head Submerged and Dive Depth of Seabirds in the Study Area.

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

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

4.5 Marine Mammals and Sea Turtles

The Marine Mammal and Sea Turtle VEC of the Study Area has been recently described in the Labrador Shelf SEA (§ 4.9.1 to 4.9.7 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.3 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.5 and 3.6 of C-NLOPB 2010), and three project-specific EAs (§ 4.5 of LGL 2014, 2015a, b). 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 SEAs 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 in the Study Area. Historical and more recent sightings of cetaceans 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 three SEAs are also discussed in terms of current status.

4.5.1 Marine Mammals

Twenty-six marine mammal species are known to occur near or within the Study Area, including 19 species of cetaceans (whales, dolphins, and porpoises), six species of phocids (true seals), and polar bear. Most marine mammals use the area seasonally, and the region likely represents important foraging habitat for many.

Information on the occurrence, habitat, and conservation status for each of the marine mammal species that could occur near the Study Area is presented in Table 4.17.

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., November 2015), 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 indication of survey effort. Therefore, while these data can be used to indicate what species may occur in the Study Area, they cannot be used to 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, 2015a,b).

Cetacean sightings in the Study Area compiled from the DFO sightings database (1947-2008) are summarized in Table 4.18. Sightings include baleen whales, large toothed whales, and dolphins and porpoises.

Table 4.17 Marine Mammals with Reasonable Likelihood of Occurrence in the Study Area.

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Baleen Whales (Mysticetes)					
North Atlantic Right Whale (*Eubalaena glacialis*)	Rare	Summer	Coastal, shelf & pelagic	Schedule 1: Endangered	E
Humpback Whale (*Megaptera novaengliae*)	Common	Year-round, but mostly May–Sept	Coastal & banks	Schedule 3: Special Concern	NAR
Minke Whale (*Balaenoptera acutorostrata*)	Common	Year-round, but mostly May–Oct	Shelf, banks & coastal	NS	NAR
Sei Whale (*Balaenoptera borealis*)	Uncommon	May-Nov	Pelagic	NS	DD; HPC
Fin Whale (*Balaenoptera physalus*)	Common	Year-round, but mostly summer	Shelf breaks, banks & pelagic	Schedule 1: Special Concern	SC
Blue Whale (*Balaenoptera musculus*)	Uncommon	Year-round	Pelagic & coastal	Schedule 1: Endangered	E
Toothed Whales (Odontocetes)					
Sperm Whale (*Physeter macrocephalus*)	Common	Year-round, but mostly summer	Pelagic, slope & canyons	NS	NAR; MPC
Northern Bottlenose Whale (*Hyperoodon ampullatus*)	Common	Year-round	Pelagic, slope & canyons	Schedule 1: Endangered [c] / NS [d]	E [c] / SC [d]
Sowerby's Beaked Whale (*Mesoplodon bidens*)	Rare	Year-round	Pelagic, slope & canyons	Schedule 1: Special Concern	SC
Beluga Whale (*Delphinapterus leucas*)	Rare	Winter or summer	Coastal & ice edge	NS	E
Striped Dolphin (*Stenella coeruleoalba*)	Rare	Summer	Shelf & pelagic	NS	NAR
Short-beaked Common Dolphin (*Delphinus delphis*)	Common	Summer	Pelagic & shelf	NS	NAR
White-beaked Dolphin (*Lagenorhynchus albirostris*)	Common	Year-round, but mostly June–Sept	Pelagic & shelf	NS	NAR
Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)	Common	Year-round, but mostly summer–fall	Coastal & shelf	NS	NAR
Common Bottlenose Dolphin (*Tursiops truncatus*)	Rare	Summer	Coastal & pelagic	NS	NAR
Risso's Dolphin (*Grampus griseus*)	Rare	Year-round	Continental slope	NS	NAR
Killer Whale (*Orcinus orca*)	Uncommon	Year-round	Coastal & pelagic	NS	SC
Long-finned Pilot Whale (*Globicephala melas*)	Common	Year-round, but mostly spring–fall	Pelagic, shelf break & slope	NS	NAR
Harbour Porpoise (*Phocoena phocoena*)	Uncommon	Year-round, but mostly spring–fall	Shelf, coastal & pelagic	Schedule 2: Threatened	SC
True Seals (Phocids)					
Harp Seal (*Pagophilus groenlandicus*)	Common	Year-round, but mostly winter–spring	Pack ice & pelagic	NS	NC; HPC

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Hooded Seal (*Cystophora cristata*)	Common	Year-round, but mostly winter–spring	Pack ice & pelagic	NS	NAR; HPC
Grey Seal (*Halichoerus grypus*)	Uncommon	Year-round, but mostly summer	Coastal & shelf	NS	NAR
Harbour Seal (*Phoca vitulina*)	Uncommon	Year-round	Coastal	NS	NAR
Ringed Seal (*Phoca hispida*)	Common	Winter-spring	Landfast ice with snow cover	NS	NAR; HPC
Bearded Seal (*Erignathus barbatus*)	Uncommon	Year-round	Coastal, shallow & ice edge	NS	DD;MPC
Bears (Urcids)					
Polar Bear (*Ursus maritimus*)	Uncommon	Winter-summer	Coastal & pack ice	Schedule 1: Special Concern	SC

Notes:
[a] Species designation under the Species at Risk Act (GC 2015); NS = No Status.
[b] Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC 2015); E = Endangered, SC = Special Concern, DD = Data Deficient, NAR = Not at Risk, NC = Not Considered, MPC = Mid-priority Candidate, HPC = High-priority Candidate.
[c] Scotian Shelf population.
[d] Davis Strait-Baffin Bay-Labrador Sea population.

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 4.17). Given that the Atlantic population of blue whale and North Atlantic right whales each have *endangered* status under Schedule 1 of *SARA*, they are 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 winter months (C-NLOPB 2014).

Humpback Whale

Two humpbacks outfitted with satellite transmitters near the Dominican Republic travelled near or within the Study Area. One whale was recorded on the eastern edge of Cabot Strait in May 2011, and a second whale was recorded on the Grand Banks in June 2012 (Kennedy et al. 2014). Humpbacks are the most commonly recorded mysticete in the Study Area in the DFO sightings database (14,387 individuals). While humpback sightings occur year-round (Table 4.18; Figure 4.28), they are predominant during June to November. Humpback whales are expected to be common throughout the Study Area.

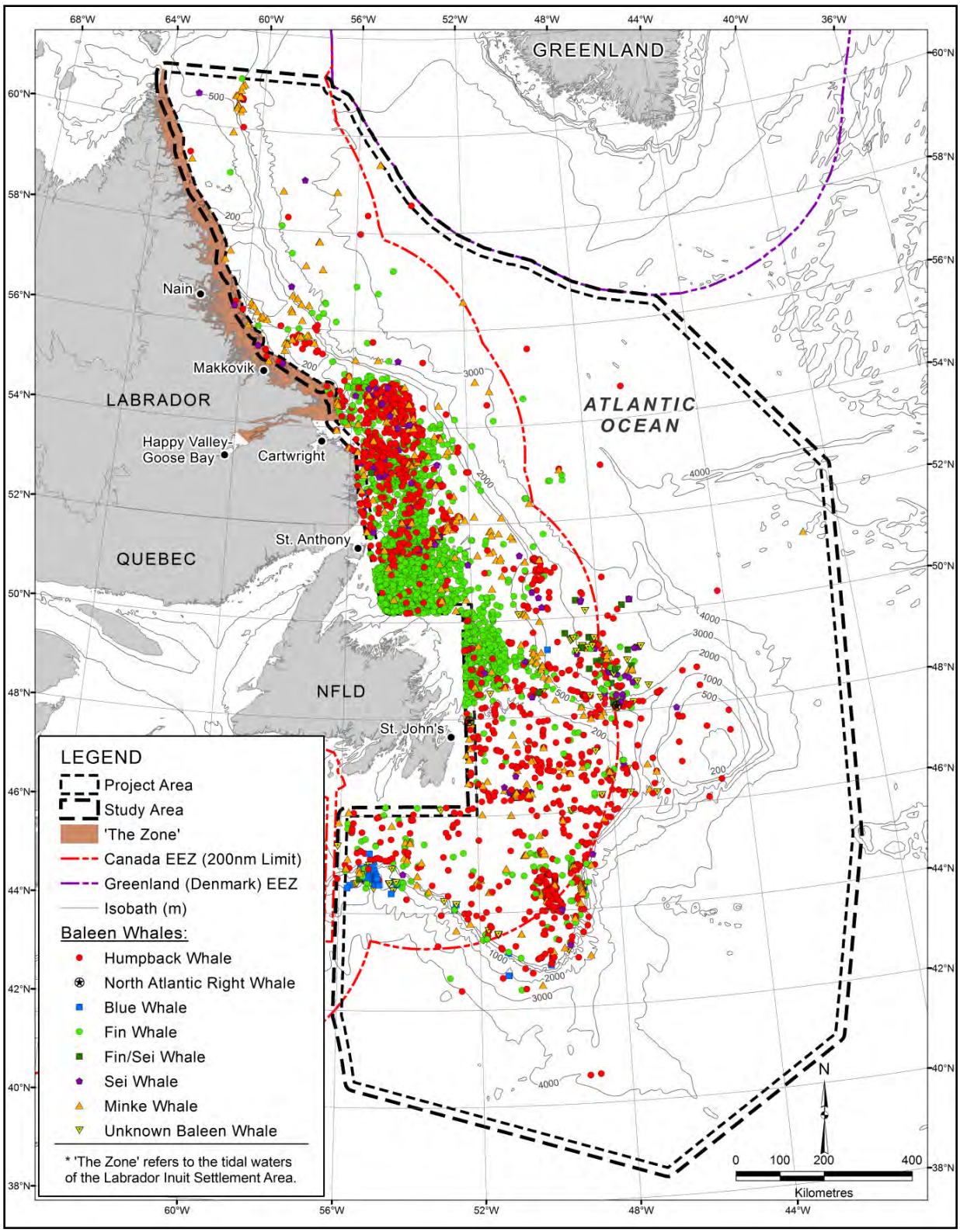
Table 4.18 Cetacean Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

Species	Number of Sightings	Number of Individuals	Months Sighted
Mysticetes			
North Atlantic Right Whale	2	3	June
Humpback Whale	2,310	14,387	Jan–Dec
Minke Whale	514	1,948	Jan, Mar–Dec
Sei Whale	119	260	Feb, May–Dec
Fin Whale	3,530	4,444	Mar–Dec
Sei/Fin Whale	35	72	June–Oct, Dec
Blue Whale	53	59	Apr–Sept
Unidentified Baleen Whale	64	94	May–Oct, Dec
Odontocetes			
Sperm Whale	342	897	Jan–Dec
Pygmy Sperm Whale	1	2	June
Northern Bottlenose Whale	147	712	Mar–Dec
Sowerby's Beaked Whale	1	4	Sept
Beluga	3	3	July, Sept
Striped Dolphin	7	181	Aug, Sept
Common Dolphin	251	3,822	Jan, Mar–Apr, Jun–Dec
White-beaked Dolphin	206	1,519	Feb–Mar, May–Nov
Atlantic White-sided Dolphin	265	3,964	Feb, Apr–Dec
Bottlenose Dolphin	3	17	Aug–Oct
Risso's Dolphin	12	52	June–Sept, Nov
False Killer Whale	1	2	June
Killer Whale	148	968	Jan, Mar–Dec
Long-finned Pilot Whale	737	11,569	Jan–Dec
Harbour Porpoise	207	1,875	Feb, Mar, May–Dec
Unidentified Dolphin	617	12,559	Jan–Dec
Unidentified Beaked Whale	1	2	Aug
Unidentified Toothed Whale	7	27	July–Sept
Other			
Unidentified Cetacean	1,060	4,106	Jan–Dec

Note: see § 4.3.1.1 for description of DFO sightings database and caveats associated with these data.

Minke Whale

The minke whale is the third most commonly recorded mysticete in the Study Area in the DFO sightings database (1,948 individuals), with most sightings recorded during June to November (see Table 4.18; Figure 4.28). Minke whales were commonly recorded in Jeanne d'Arc Basin during seismic monitoring programs in 2008, 2013, and 2015 (Abgrall et al. 2009; Holst and Lang 2014; Keats 2015). Minke whales are considered common throughout the Study Area.



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

Figure 4.28 Baleen Whale Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

Sei Whale

Sei whales were occasionally sighted in the Orphan Basin during the seismic monitoring programs in 2004 and 2005 (6 and 15 sightings, respectively; Moulton et al. 2005, 2006a). One sei whale sighting was recorded in Jeanne d'Arc Basin during seismic monitoring programs in 2008 and 2013 (Abgrall et al. 2009). One sei whale was observed off Southern Newfoundland during a summer 2007 aerial survey (Lawson and Gosselin 2009). One sei whale that was tagged in the Azores during 2005 (Olsen et al. 2009) and seven individuals that were tagged in the Azores during 2008–2009 travelled to the Labrador Sea, where they spent extended periods of time on the northern shelf, presumably to feed (Prieto et al. 2010, 2014).

Based on the DFO sightings database, there are 119 sightings (260 individuals) of sei whales in the Study Area. Sightings occurred mainly during June to October (see Table 4.18; Figure 4.28). Sei whales are considered uncommon in the Study Area.

Fin Whale

The current estimate for the western North Atlantic stock is 1,618 individuals (CV = 0.33; Waring et al. 2015). Fin whales are the second most commonly recorded mysticete in the Study Area in the DFO sightings database (4,444 individuals), sightings occurring primarily during June to November (see Table 4.18; Figure 4.28). Fin whales were commonly observed in Orphan Basin during the 2004 and 2005 seismic monitoring programs (Moulton et al. 2005, 2006a). This whale was also sighted during the seismic monitoring programs in Jeanne d'Arc Basin in 2008 and 2013 (Abgrall et al. 2009; Holst and Lang 2014). Fin whales are expected to be common throughout the Study Area during late spring to fall.

The Atlantic population of fin whale currently has a *special concern* status under Schedule 1 of *SARA* (GC 2015) and COSEWIC (COSEWIC 2005).

4.5.1.3 Toothed Whales (Odontocetes)

Thirteen species of toothed whales are likely to occur in the Study Area (see Table 4.17), ranging from the largest of all odontocetes, the sperm whale, to one of the smallest whales, the harbour porpoise. Several of these species only occur in the Study Area seasonally, but generally there is little information about the distribution and abundance of these species. Note that the Scotian Shelf population of northern bottlenose whale has *endangered* status under Schedule 1 of *SARA* and its profile is included in § 4.6, Species at Risk.

Sperm Whale

Sperm whales were regularly sighted in the deep waters of Orphan Basin during the summers of 2004–2007 (Moulton et al. 2005, 2006a; Abgrall et al. 2008b) but were not observed in the shallower waters of Jeanne d'Arc Basin in 2005–2008, 2013, and 2015 (Lang et al. 2006; Lang and Moulton 2008; Abgrall et al. 2008a, 2009). There were two sightings in the Flemish Pass Basin during a monitoring program in 2014 (Thomas et al. 2014). Sperm whales were observed in small numbers (11 sightings of 11 individuals) in the waters off eastern and southern Newfoundland during aerial surveys conducted in the summer of 2007 (Lawson and Gosselin 2009). There are 342 sightings (897 individuals) of sperm whales in the Study Area in the DFO sightings database. These sightings occurred year-round but primarily during March to November (see Table 4.18; Figure 4.29). Sperm whales are expected to be common in deep water areas the Study Area.

Sowerby's Beaked Whale

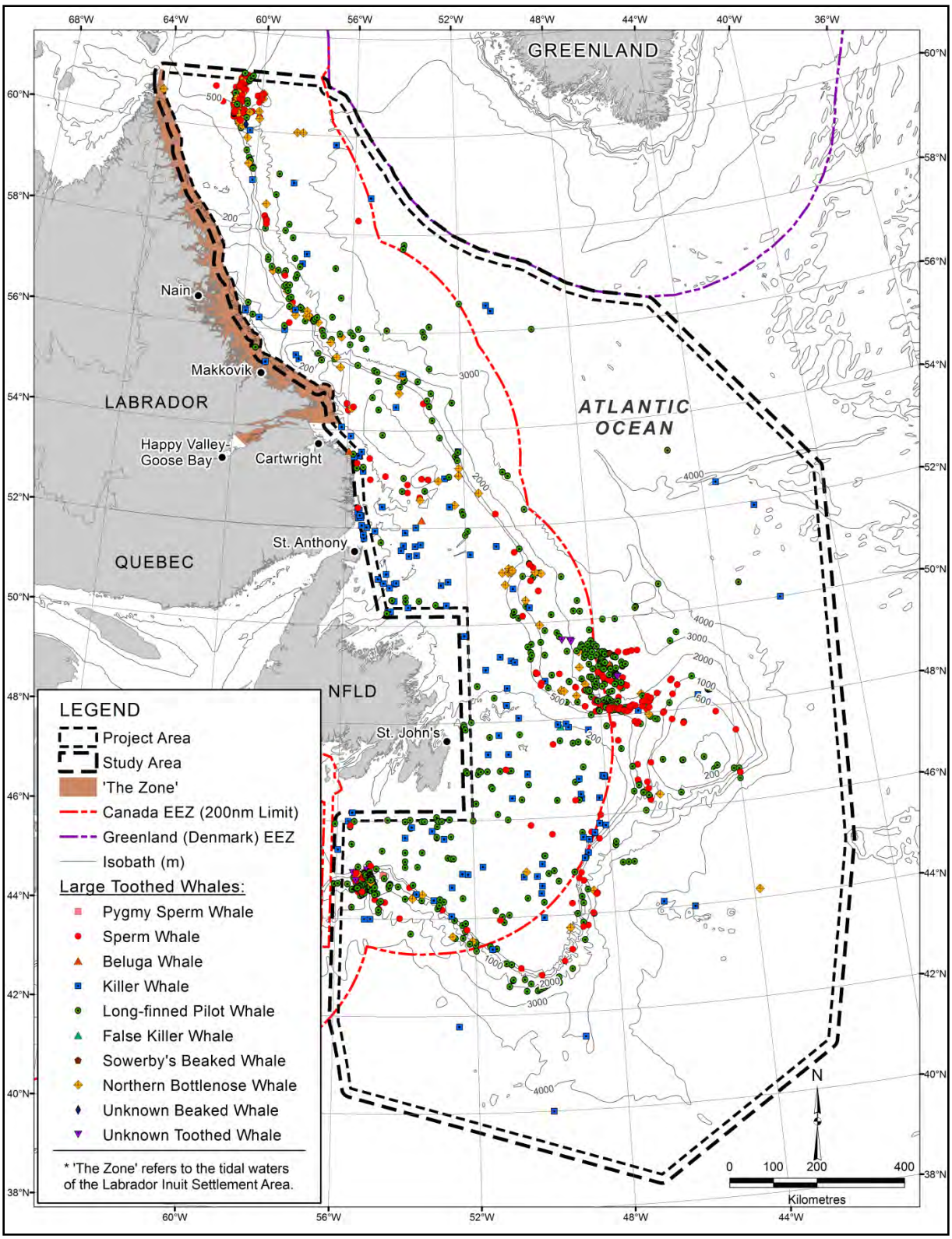
There is one sighting of four Sowerby's beaked whales in the Study Area in the DFO sightings database (see Table 4.18; Figure 4.29). This sighting was made during a seismic survey in Orphan Basin in September 2005 (Moulton et al. 2006a). Sowerby's beaked whale is considered rare in the Study Area.

Sowerby's beaked whale has a *special concern* status under Schedule 1 of *SARA* (GC 2015) and COSEWIC (COSEWIC 2006).

Beluga Whale

Based on distinct summer distributions and genetic isolation, seven populations of beluga are recognized in Canadian waters. The beluga occurring offshore of Labrador likely represent either the Ungava Bay population or the eastern Hudson Bay population (COSEWIC 2004). The Ungava Bay population is too small to estimate and might have been extirpated. The eastern Hudson Bay population includes ~2,000 individuals (COSEWIC 2004). Based on the DFO cetacean sightings database, there were three beluga sighting, two in July and one in September, in the Study Area (see Table 4.18; Figure 4.29). Beluga whales are considered rare in the Study Area.

Although they have no status under *SARA*, the Ungava Bay and eastern Hudson Bay populations of beluga currently have *endangered* status under COSEWIC.



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

Figure 4.29 Toothed Whale Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

Striped Dolphin

Based on the DFO sightings database, there are seven sightings (181 individuals) of striped dolphins in the Study Area. All sightings occurred in August and September (see Table 4.18; Figure 4.30). Striped dolphins are considered rare in the Study Area.

Short-beaked Common Dolphin

An estimated 173,486 (CV = 0.55) individuals reside in the NW Atlantic (Waring et al. 2015) but an unknown number occur in eastern Canada (Gaskin 1992). Based on the DFO sightings database, there are 251 sightings (3,822 individuals) of short-beaked common dolphin in the Study Area. Most of these sightings occurred during July to September (see Table 4.18). Sightings occurred in shelf, upper slope and deepwater regions (Figure 4.30). The short-beaked common dolphin is considered common in the Study Area.

White-beaked Dolphin

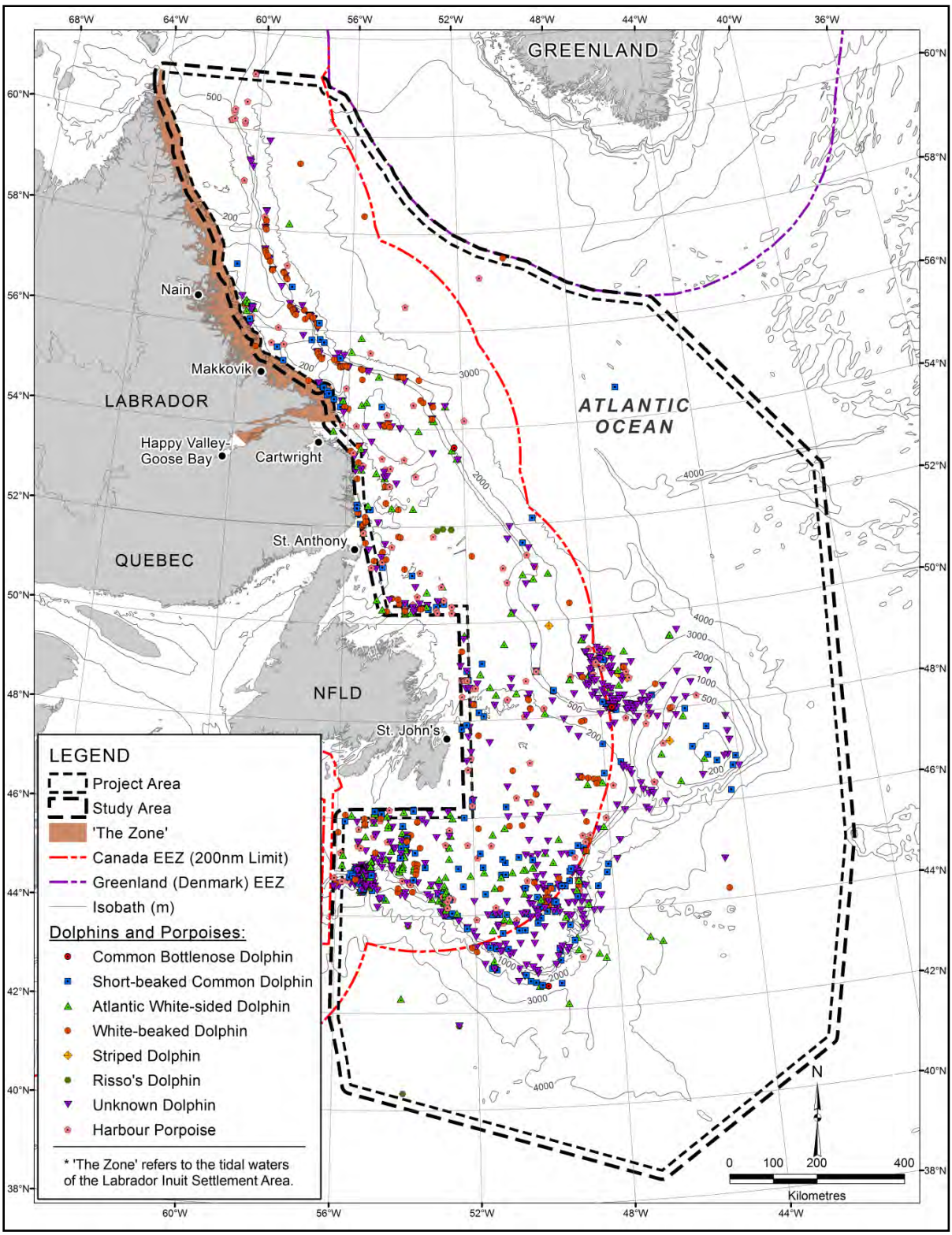
Based on the DFO sightings database, there are 206 sightings (1,519 individuals) of white-beaked dolphins in the Study Area. Most sightings occurred during June to August (see Table 4.18; Figure 4.30). Two rare sightings in high latitudes of the Canadian Arctic off south-eastern Baffin Island, Nunavut, have also been reported (Reinhart et al. 2014). The white-beaked dolphin is considered common in the Study Area.

Atlantic White-sided Dolphin

Based on the DFO sightings database, there are 265 sightings (3,964 individuals) of white-sided dolphins in the Study Area. Sightings occurred primarily during July to September (see Table 4.18; Figure 4.30). The Atlantic white-sided dolphin is considered common in the Study Area.

Common Bottlenose Dolphin

Two morphologically and genetically distinct stocks occur in the NW Atlantic, referred to as the coastal and offshore forms (Hoelzel et al. 1998). The best population estimate for the offshore form is 77,532 (CV = 0.40) (Waring et al. 2015), but abundance in the Study Area is unknown. There are only three bottlenose dolphin sightings (17 individuals) in the Study Area in the DFO cetacean sighting database. They occurred during August to October (see Table 4.18; Figure 4.30). The common bottlenose dolphin is considered rare in the Study Area.



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

Figure 4.30 Dolphin and Porpoise Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

Risso's Dolphin

The best abundance estimate for Risso's dolphins in the NWAtlantic is 18,250 (CV = 0.46) (Waring et al. 2015), but there is no current population estimate off Newfoundland. There are 12 sightings (52 individuals) of this dolphin species in the Study Area in the DFO sightings database. Most sightings occurred during the summer (see Table 4.18; Figure 4.30). Risso's dolphins are considered rare in the Study Area.

Killer Whale

Based on the DFO sightings database, there are 148 sightings (968 individuals) of killer whales in the Study Area. Most sightings occurred during June to August (see Table 4.18; Figure 4.29). Sightings of killer whales were recorded in Jeanne d'Arc Basin during seismic monitoring programs in 2008, 2013 and 2015 (Abgrall et al. 2009; Holst and Lang 2014; Keats 2015). One sighting was also recorded in the Flemish Pass during a seismic monitoring program in 2014 (Thomas 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 in the Study Area in the DFO sightings database with sightings occurring year-round (see Table 4.18; Figure 4.29) but predominantly during July and August. Long-finned pilot whales are considered common in the Study Area.

Harbour Porpoise

Based on the DFO sightings database, there are 207 sightings (1,875 individuals) of harbour porpoise in the Study Area. While the sightings occurred during February to December, the majority occurred from June to October (see Table 4.18; Figure 4.30). Harbour porpoises are considered uncommon in the Study Area.

4.5.1.4 True Seals (Phocids)

Six seal species occur in the Project Area (see Table 4.17). Given their preference for nearshore areas, grey and harbor seals are likely to be uncommon in the Study Area. The updated estimate for the NW Atlantic harbour seal stock for 2012 was 75,834 individuals (Waring et al. 2015).

4.5.1.5 Polar Bear

Polar bears have *special concern* status under Schedule 1 of *SARA* (GC 2015) and COSEWIC (COSEWIC 2015).

4.5.2 Sea Turtles

While four species of sea turtles have been reported in Newfoundland waters, only three are likely to occur in the Study Area. Information on the occurrence, habitat, and conservation status for the three sea turtle species that may occur in the Study Area is presented in Table 4.19. The Kemp's ridley sea turtle (*Lepidochelys kempii*) is unlikely to occur in the Study Area. No loggerhead sea turtles or green sea turtles were recorded within the Study Area in the DFO sightings database. Note that the leatherback sea turtle has an *endangered* status under Schedule 1 of *SARA* and is profiled in § 4.6, Species at Risk. Figure 4.31 shows locations of leatherback sea turtle sightings in the Study Area, based on the DFO sightings database.

Table 4.19 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 (*Dermochelys coriacea*)	Rare	April to December	Pelagic & Shelf	Schedule 1: Endangered	E
Loggerhead Sea Turtle (*Caretta caretta*)	Rare	Summer and fall	Pelagic	NS	E
Green Sea Turtle (*Chelonia mydas*)	Extremely rare	Summer	Pelagic	NS	NC; LPC

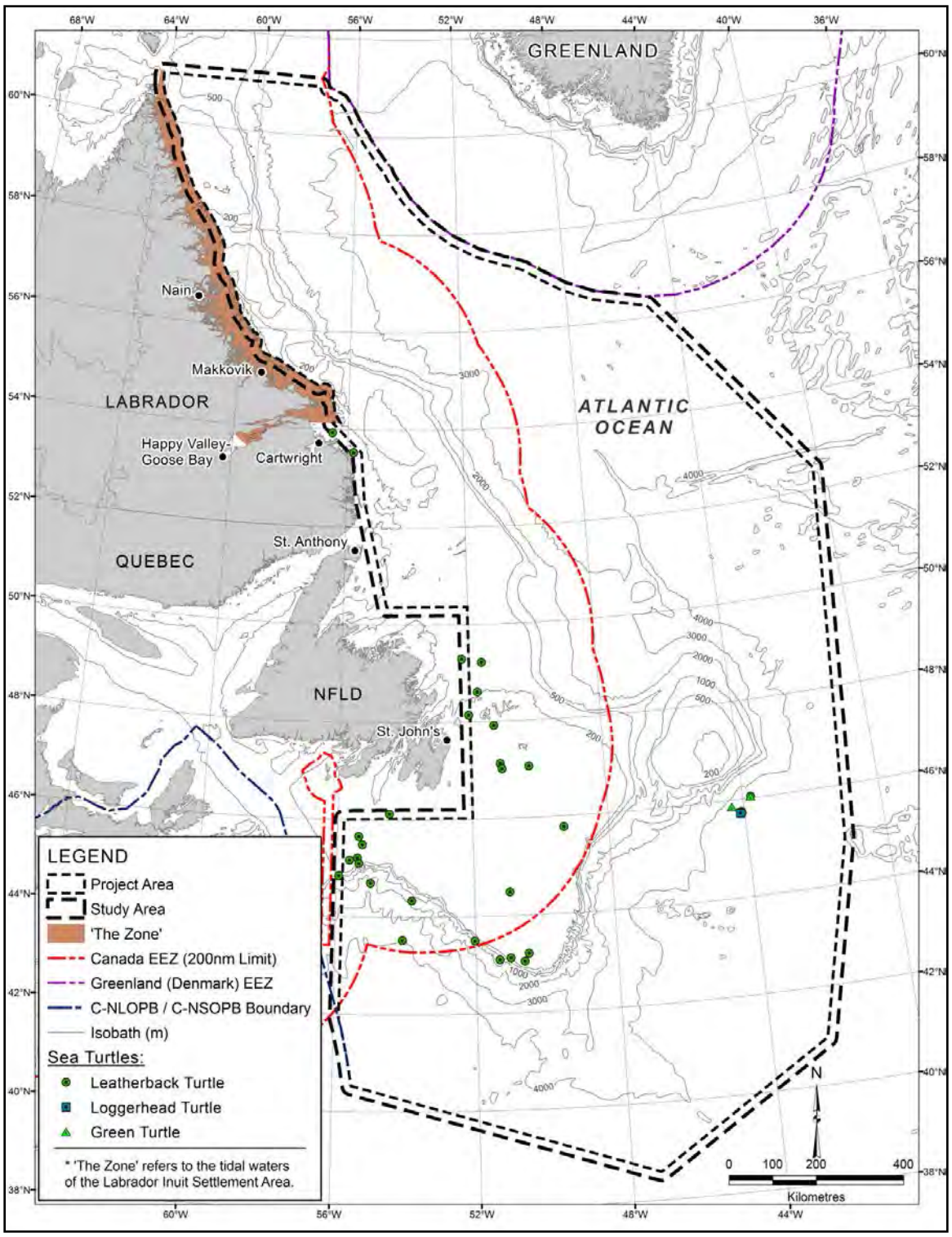
Notes:
[a] Species designation under the *Species at Risk Act* (GC 2015); NS = No Status.
[b] Species designation by COSEWIC (Committee on the Status of Endangered Wildlife in Canada; COSEWIC 2015); E = Endangered, NC = Not Considered, LPC = Low priority Candidate

4.5.2.1 Loggerhead Sea Turtle

Loggerhead turtles are likely to be rare in the Study Area. There is one record of a loggerhead turtle in the Study Area in July in the DFO sightings database (see § 4.5.1.1 for caveats). The sighting was in the eastern part of the Study Area where water depth >4,000 m (Figure 4.31).

4.5.2.2 Green Sea Turtle

Green sea turtles are expected to be very rare in the Study Area. Nonetheless, there are two records of green turtles in the Study Area in July in the DFO sightings database (see § 4.5.1.1 for caveats). Both sightings were in the eastern part of the Study Area where water depth >4,000 m (Figure 4.31).



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

Figure 4.31 Sea Turtle Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

4.5.3 Marine Mammal and Sea Turtle 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 (§ 4.9.6 of C-NLOPB 2008).

- There is limited information on distribution and abundance of marine mammals and sea turtles that occur in Labrador waters.

The following data gap associated with the Marine Mammal and Sea Turtle VEC was identified in the Eastern Newfoundland SEA (§ 6.1.6 of C-NLOPB 2014).

- Detailed information on the occurrence, abundance and distribution of marine mammals and sea turtles is not available for all locations and times in the Study Area.

The following data gaps associated with the Marine Mammal and Sea Turtle VEC were identified in the Southern Newfoundland SEA (§3.5.7 and 3.6.4 of C-NLOPB 2010).

- There is limited information on distribution and abundance of marine mammals and sea turtles;
- Potential migration routes and foraging areas of marine mammals and sea turtles are poorly understood;
- There is limited understanding of basic life history characteristics of marine mammals and sea turtles which leads to uncertainty in the global and regional abundance estimates and population trends for many marine mammal and sea turtle species;
- There is a lack of identification of marine mammal and sea turtle critical habitat; and
- Most available data on marine mammal and sea turtle species occurrence are opportunistic or incidental in nature (i.e., few directed surveys).

All of the data gaps indicated above still exist. Opportunistic efforts are being made during seismic surveys to collect more distribution and abundance data for marine mammals and sea turtles.

4.6 Species at Risk

The Species at Risk VEC of the Study Area has been recently described in the Labrador Shelf SEA (§ 4.2 and 4.3 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.1.7, 4.2.2.5 and 4.2.3.5 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.7 of C-NLOPB 2010), and three project-specific EAs (§ 4.6 of LGL 2014, 2015a,b). An overview of the species at risk of the Study Area, based primarily on information from the three SEAs and three EAs, is provided below. New information not included in the three SEAs and the three EAs is also included in this section. Relevant data gaps identified in the two SEAs are also discussed in terms of current status.

The *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* statuses 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. Three fish species/populations, one seabird species, three cetacean species/populations and one sea turtle species, one seabird species, and three fish species/populations that have the potential to occur in the Study Area are legally protected under *SARA* (Table 4.20). In addition, Sowerby's beaked whale, the Atlantic population of fin whale, and the Atlantic wolfish have a *special concern* status under Schedule 1 of *SARA*. 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 4.20, as are species/populations with *endangered*, *threatened,* or *special concern* statuses 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* statuses 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 (Environment Canada 2014); (4) the blue whale (Beauchamp et al. 2009); (5) the North Atlantic right whale (Brown et al. 2009); (6) the Scotian Shelf population of the northern bottlenose whale (DFO 2010c); and (7) the leatherback sea turtle. The recovery strategy for the North Atlantic right whale (Brown et al. 2009) was amended in 2014 to incorporate changes made pertaining to the critical habitat of the population (DFO 2014b).

A management plan has been prepared for the Atlantic wolffish (Kulka et al. 2007) which currently has *special concern* status under Schedule 1 of *SARA*.

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

Table 4.20 *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							
White Shark (Atlantic population)	*Carcharodon carcharias*	Schedule 1			X		
Northern Wolffish	*Anarhichas denticulatus*		Schedule 1			X	
Spotted Wolffish	*Anarhichas minor*		Schedule 1			X	
Atlantic Wolffish	*Anarhichas lupus*			Schedule 1			X
Atlantic Cod	*Gadus morhua*			Schedule 3			
Atlantic Cod (Newfoundland and Labrador population)	*Gadus morhua*				X		
Atlantic Bluefin Tuna	*Thunnus thynnus*				X		
Porbeagle Shark	*Lamna nasus*				X		
Roundnose Grenadier	*Coryphaenoides rupestris*				X		
Cusk	*Brosme brosme*				X		
American Eel	*Anguilla rostrata*					X	
Shortfin Mako Shark (Atlantic	*Isurus oxyrinchus*					X	
American Plaice (Newfoundland and Labrador population)	*Hippoglossoides platessoides*					X	
Atlantic Salmon (South Newfoundland population)	*Salmo salar*					X	
Acadian Redfish (Atlantic population)	*Sebastes fasciatus*					X	
Deepwater Redfish (Northern population)	*Sebastes mentella*					X	
White Hake (Atlantic population)	*Urophycis tenuis*					X	
Blue Shark (Atlantic population)	*Prionace glauca*						X
Basking Shark (Atlantic population)	*Cetorhinus maximus*						X
Spiny Dogfish (Atlantic population)	*Squalus acanthias*						X
Roughhead Grenadier	*Macrourus berglax*						X
Thorny Skate	*Amblyraja radiata*						X
Marine-associated Birds							
Ivory Gull	*Pagophila eburnea*	Schedule 1			X		

SPECIES		*SARA*[a]			COSEWIC[b]		
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Special Concern**	**Endangered**	**Threatened**	**Special Concern**
Marine Mammals							
Blue Whale (Atlantic population)	*Balaenoptera musculus*	Schedule 1			X		
North Atlantic Right Whale	*Eubalaena glacialis*	Schedule 1			X		
Northern Bottlenose Whale (Scotian Shelf population)	*Hyperoodon ampullatus*	Schedule 1			X		
Fin Whale (Atlantic population)	*Balaenoptera physalus*			Schedule 1			X
Sowerby's Beaked Whale	*Mesoplodon bidens*			Schedule 1			X
Harbour Porpoise (Northwest Atlantic population)	*Phocoena phocoena*		Schedule 2				X
Humpback Whale (Western North Atlantic population)	*Megaptera novaeangliae*			Schedule 3			
Killer Whale (Northwest Atlantic/Eastern Arctic populations)	*Orcinus orca*						X
Northern Bottlenose Whale (Davis Strait-Baffin Bay-Labrador	*Hyperoodon ampullatus*						X
Sea Turtles							
Leatherback Sea Turtle	*Dermochelys coriacea*	Schedule 1			X		
Loggerhead Sea Turtle	*Caretta caretta*				X		

Sources: [a]*SARA* website (http://www.sararegistry.gc.ca/search/SpeciesSearch_e.cfm), accessed January 2016; [b]COSEWIC website (http://www.cosewic.gc.ca/index.htm); accessed January 2016.

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

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

The statuses of all species/populations profiled below are current as of January 2016.

4.6.1.1 Fishes

Three fish species/populations have either an *endangered* or *threatened* status under Schedule 1 of the *SARA*: (1) Atlantic population of white shark; (2) northern wolffish; and (3) spotted wolffish. Profiles of these three species are provided in this section. Some of the other fish species/populations that are included in Table 4.20 above (e.g., Atlantic wolffish, Atlantic cod) are profiled in § 4.2 of this EA.

White Shark

The Atlantic population of the white shark currently has an *endangered* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of this population of white shark are provided in § 4.6.1.5 of LGL (2014) and 4.6.1.1 of LGL (2015a,b).

An adult female, 'Katharine,' originally tagged in August 2013 off Cape Cod was present either within or close to the southern part of the Study Area during November 2015 to January 2016 (OCEARCH website Global Shark Tracker accessed January 13, 2016 @ http://www.ocearch.org/tracker/).

Northern Wolffish

The northern wolffish currently has a *threatened* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of this species at risk are provided in § 4.6.1.6 of LGL (2014) and 4.6.1.1 of LGL (2015a,b).

During DFO RV surveys conducted in the Study Area during 2013, northern wolffish were caught primarily in the slope areas of southeastern, eastern and northeastern Grand Banks and off Labrador (see Figure 4.26 in § 4.3.7).

Spotted Wolffish

The spotted wolffish currently has a *threatened* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of this species at risk are provided in § 4.6.1.6 of LGL (2014) and 4.6.1.2 of LGL (2015a,b).

During DFO RV surveys conducted in the Study Area during 2013, spotted wolffish were caught in the slope areas of southeastern, eastern and northeastern Grand Banks and off Labrador, as well as on shelf regions in the Northern Grand Banks and Labrador (see Figure 4.26 in § 4.3.7).

4.6.1.2 Marine-associated Birds

Only one marine-associated bird species has either an *endangered* or *threatened* status under Schedule 1 of *SARA* – Ivory Gull.

Ivory Gull

The Ivory Gull currently has an *endangered* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of this species at risk are provided in § 4.6.1.4 of LGL (2014) and 4.6.1.2 of LGL (2015a,b).

4.6.1.3 Marine Mammals and Sea Turtles

Three marine mammal and one sea turtle species/populations have either an *endangered* or *threatened* status under Schedule 1 of the *SARA*: (1) the blue whale (North Atlantic population); (2) the North Atlantic right whale; (3) the northern bottlenose whale (Scotian Shelf population); and (4) the leatherback sea turtle. Profiles of these four species/populations are provided in this section. Some of the other marine mammal and sea turtle species/populations that are included in Table 4.20 above (e.g., Atlantic population of fin whale, Sowerby's beaked whale, loggerhead sea turtle) are profiled in § 4.5 of this EA.

Blue Whale

The North Atlantic population of the blue whale currently has an *endangered* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of this population of blue whale are provided in § 4.6.1.3 of LGL (2015a,b).

A blue whale tagged in the St. Lawrence Estuary, Quebec, on 4 November 2014 travelled to the south coast of Newfoundland, west of the Study Area, in March 2015 (V. Lesage, DFO Research Scientist, pers. comm., 15 December 2015). Two sightings of blue whales were made in the Orphan Basin in August-September 2007 (Abgrall et al. 2008b). Sightings were also made during a 3D seismic program that occurred from June to September 2005 in the Laurentian

Sub-basin. In total, there were 49 sightings (53 individuals) of blue whales recorded by MMOs aboard the seismic vessel (Moulton et al. 2006b). There are 53 sightings (59 individuals) of blue whales in the Study Area in the DFO sightings database. Blue whales were observed during spring, summer and fall within the Study Area in the DFO sightings database, with peak numbers in July and August (see Table 4.18 in § 4.5). Sightings were made primarily in upper slope regions, particularly in the area of the St. Pierre Bank and Laurentian Channel (see Figure 4.28 in § 4.5). Blue whales considered uncommon in the Study Area.

North Atlantic Right Whale

The North Atlantic right whale currently has an *endangered* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of this species at risk are provided in § 4.6.1.3 of LGL (2015a,b).

There are two sightings (three individuals) of right whales in the Study Area, both in June, in the DFO sightings database (Figure 4.25 in § 4.5). This species is expected to be rare in the Study Area.

Northern Bottlenose Whale

There are two genetically distinct populations of northern bottlenose whales in Canada (Dalebout et al. 2006). The Scotian Shelf population has *endangered* status under Schedule 1 of *SARA* (GC 2015) and COSEWIC (COSEWIC 2002, 2011). The Davis Strait-Baffin Bay-Labrador Sea population has no status under *SARA* (GC 2015) and *special concern* status under COSEWIC (COSEWIC 2011). Profiles northern bottlenose whale are provided in § 4.6.1.2 of LGL (2014) and 4.6.1.3 of LGL (2015a,b).

Recent acoustic evidence indicates that the population remains within the Gully and adjacent submarine canyons year-round (H. Moors-Murphy, DFO Biologist, pers. comm., 18 December 2015). There are 147 sightings (712 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 March to December (see Table 4.18 and Figure 4.29 in § 4.5). Northern bottlenose whales are expected to be common in the Study Area.

Leatherback Sea Turtle

The leatherback sea turtle currently has an *endangered* status under Schedule 1 of *SARA*. The Atlantic population of leatherback sea turtle currently has an *endangered* status under COSEWIC. Profiles of this species/population of leatherback sea turtle are provided in § 4.6.1.4 of LGL (2015a,b).

There are 30 sightings (34 individuals)) of leatherback turtles within the Study Area (see Figure 4.31 in § 4.5) in the DFO sightings database. These sightings occurred during June

to September. There was also a sighting of a leatherback turtle in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). Leatherback turtles outfitted with satellite telemetry tag have also been tracked near or within the Study Area (DFO 2012). Leatherback sea turtles are considered rare in the Study Area.

4.6.2 Species at Risk Data Gaps Identified in Relevant SEAs

The data gaps already indicated in § 4.2.3 (Fish and Fish Habitat VEC), 4.3.9 Fisheries VEC), 4.4.4 (Marine-associated Bird VEC) and 4.5.3 (Marine Mammal and Sea Turtle VEC) are all applicable to data gaps related to the Species at Risk VEC.

4.7 Sensitive Areas

The Sensitive Areas VEC of the Study Area has been recently described in the Labrador Shelf SEA (§ 4.11 of C-NLOPB 2008), the Eastern Newfoundland SEA (§ 4.2.4 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.8 of C-NLOPB 2010), and three project-specific EAs (§ 4.7 of LGL 2014, 2015a, b). An overview of the sensitive areas of the Study Area, based primarily on information from the three SEAs and the three EAs, is provided below. New information not included in the three SEAs and the three EAs is also included in this section. Relevant data gaps identified in the two SEAs are also discussed in terms of current status.

The sensitive areas that occur either entirely or partially within the Study Area are as follow (see Figure 4.32)

- Fourteen NAFO coral/sponge fishery closure areas, including the 3O Coral Protection Zone.
- One coral protection zone off northern Labrador that was established voluntarily by the fishing industry.
- Four seamount fishery closure area: (1) Orphan Knoll Seamount; (2) Newfoundland Seamount; (3) Fogo Seamount 1; and (4) Fogo Seamount 2.
- Thirteen NL Shelves Bioregion Ecologically and Biologically Significant Areas (EBSAs) (numerically labelled as per Figure 4.32): (1) Northern Labrador; (2) Outer Shelf Saglek Bay; (3) Outer Shelf Nain Bank; (4) Nain Area; (5) Hopedale Saddle; (6) Labrador Slope; (7) Labrador Marginal trough; (8) Hamilton Inlet; (9) Gilbert Bay; (10) Orphan Spur; (11) Grey Islands; (12) Notre Dame Channel; and (13) Fogo Shelf.
- Five Placentia Bay-Grand Banks Large Ocean Management Area (LOMA) EBSAs (alphabetically labelled as per Figure 4.32: (A) Northeast Shelf and Slope; (B) Virgin Rocks; (C) Lilly Canyon-Carson Canyon; (D) Southwest Shelf Edge and Slope; and (E) Southeast Shoal and Tail of the Banks.
- One Scotian Shelf Bioregion EBSA: Laurentian Fan Cold Seep Communities.
- Bonavista Cod Box.

- Two Candidate National Marine Conservation Areas.
- Hawke Channel (DFO fishery closure area).
- Funk Island Deep (DFO fishery closure area).

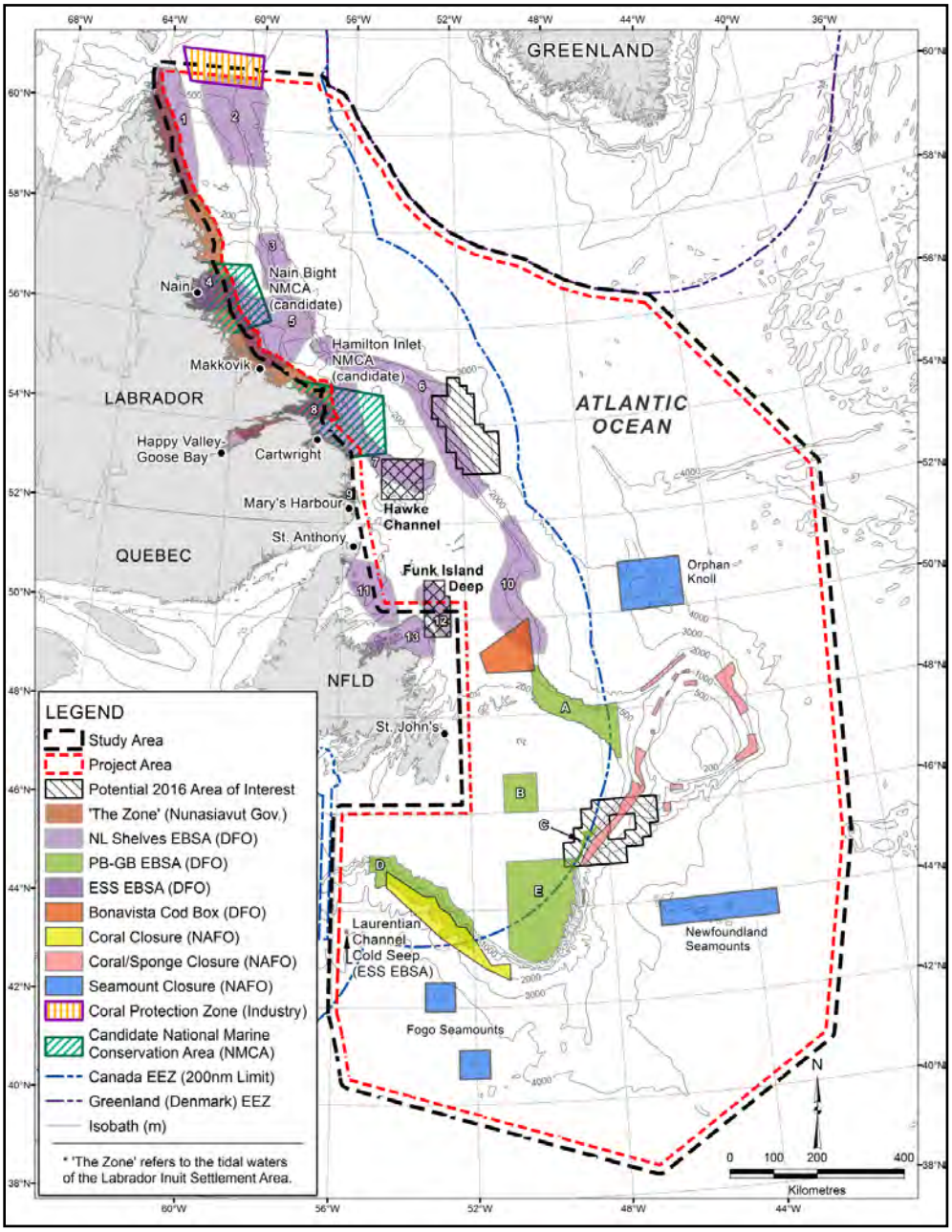


Figure 4.32 Locations of Sensitive Areas that Overlap with the Seitel Study Area.

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), the WesternGeco Eastern Newfoundland EA (§ 5.0 of LGL 2015a) and the WesternGeco Southeastern Newfoundland EA (§ 5.0 of LGL 2015b).

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 2015; dated December 21 2015) 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 SEAs (C-NLOPB 2008, 2010, 2014) and EAs (LGL 2014, 2015a,b).

5.1.1 Consultations

5.1.1.1 Seitel's Consultation Approach

Seitel'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. Seitel will initiate meetings and respond to requests for meetings with the interested groups throughout this period. After the survey is complete Seitel will conduct follow-up communications. The same approach would be followed before, during and after any survey work conducted in 2016-2025. In summary, each year Seitel will consult with stakeholders after the survey is permitted and during survey activities to report on the progress of the survey, as follows:

- Before the survey is permitted to provide Project information, gather information about area fisheries, determine issues or concerns, and discuss communications and mitigation measures, and to discuss potential solutions; and
- After the survey is completed to provide an update on the Project, to be informed of any issues that arose, and to present results of the MMO and FLO reports.

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

5.1.1.2 Program Consultations

Consultations were held with groups in both St. John's and at various locations in Labrador.

St. John's

The program consultations held in St. John's were organized and coordinated by Canning & Pitt. Project information packages were sent to all relevant stakeholder groups in November 2015. In addition to a representative of Canning & Pitt, representatives of Seitel and LGL also attended the consultation meetings in St. John's which were conducted during December 7 to 10, 2015.

During each requested face-to-face meeting, a PowerPoint presentation with details regarding the proponent and the proposed Project was provided. The presentations included a map showing the Project Area, Study Area and potential 2016 3D survey areas, as well as several maps (as appropriate) showing fish-harvesting locations (key species) in relation to these areas. Detailed notes were made during the meetings, documenting all comments and issues.

Stakeholder groups that were engaged include the following.

- Fisheries and Oceans Canada (DFO);
- Environment Canada (EC);
- Nature Newfoundland and Labrador (NNL);
- One Ocean;
- Fish, Food and Allied Workers Union (FFAW)/Unifor;
- Association of Seafood Producers (ASP);
- Ocean Choice International (OCI);
- Groundfish Enterprise Allocation Council (GEAC) Ottawa;
- Canadian Association of Prawn Producers;
- Clearwater Seafoods;
- Icewater Fisheries; and
- Newfound Resources Ltd. (NRL).

Key points raised during the consultations in St. John's are as follow:

- EC: Discussion of updated protocols for marine bird mitigation measures which are still in draft format [addressed in § 5.9 of the EA].
- NNL: It was pointed out that the physical oceanographic conditions in the northern part of the Study Area are quite different from those in the southern part [addressed in § 3.0 of the EA].
- FFAW/Unifor: Temporal and spatial avoidance protocol associated with the Industry-DFO Collaborative Post-Season Trap Survey for Snow Crab – a fisher who attended this meeting indicated that in his opinion, the 7-day/30-km temporal/spatial

avoidance protocol used for DFO RV surveys is also sufficient for the stations used in the Industry-DFO Collaborative Post-Season Trap Survey for Snow Crab [addressed in § 5.5 and 5.9 of the EA].

- FFAW/Unifor: Need for better communication between the seismic and fishing industries [addressed in § 5.5, 5.7 and 5.9 of the EA].
- FFAW/Unifor: Feedback regarding fishing activities typically conducted in the two potential 2016 survey areas presented by Seitel [addressed in § 4.3 of the EA].
- FFAW: there was considerable discussion about compensation for fishers that experience either gear damage or gear loss due to physical conflict with vessels and equipment associated with the seismic surveying [addressed in § 5.5, 5.7 and 5.9 of the EA].
- FFAW: Fishers reiterated their concerns that exposure to seismic sound may be causing snow crab mortality [addressed in § 5.7.4 and 5.7.5 of the EA].
- OCI: Need for better communication between the seismic and those companies involved in the offshore sector fishing industry [addressed in § 5.5, 5.7 and 5.9 of the EA].
- OCI: Results of study of the interactions between redfish harvesting and seismic activities [Seitel has not yet seen the results].
- OCI: Feedback regarding fishing activities typically conducted in the two potential 2016 survey areas presented by Seitel [addressed in § 4.3 of the EA].
- OCI: Historical catch data for key groundfish species – OCI indicated that it has been assembling these data for the 1993-2015 period and that it would provide these data for each of Seitel's potential 2016 survey areas [Seitel has not yet received any OCI data].
- OCI: GEAC will likely become the Single Point of Contact (SPOC) for the relevant corporate fishing companies.
- Clearwater Seafoods: Concern regarding the potential effects of seismic sound on Arctic surf clam [addressed in § 5.7.4 of the EA].

Other topics of discussion are included in the full consultation report in Appendix 1.

Labrador

The consultations in Labrador have not yet been conducted, at the request of the Nunatsiavut Government (NG). The NG requested that Labrador consultations be delayed until the EA has been posted on the C-NLOPB website for at least 10 days. The intention is to conduct the Labrador consultations in late February/early March 2016 and to present the results of these consultations in the EA Addendum that will follow receipt of EA reviewer comments. The Project information package was sent to the following groups in Labrador in December 2015.

- Nunasiavut Government (Happy Valley-Goose Bay; HVGB);
- Nunasiavut Government (Department of Lands and Natural Resources in Nain);
- Government of Newfoundland and Labrador – Labrador Affairs, and Aboriginal Affairs (HVGB);
- NunatuKavut Community Council (HVGB);
- Nunacor Development Corporation (HVGB);
- Nain Inuit Community Government (Nain);
- Postville Inuit Community Government (Postville);
- Rigolet Inuit Community Government (Rigolet);
- Sheshatshiu First Nation Innu Band Council (Sheshatshiu);
- Innu Nation (Sheshatshiu);
- Innu Development Limited Partnership (Sheshatshiu);
- Sivunivut Inuit Community Corporation Inc. (North West River);
- Mushua First Nation Innu Band Council (Natuashish);
- Innu Nation (Natuashish);
- Makkovik Inuit Community Government (Makkovik);
- Hopedale Inuit Community Government (Hopedale);
- Labrador Fishermen's Union Shrimp Company Ltd. (L'Anse au Loup);
- Labrador Choice Seafoods Inc. (Charlottetown);
- Cartwright Town Council;
- Town of Charlottetown;
- Forteau Town Council;
- Town of HVGB;
- Torngat Fish Producers Co-operative Society Ltd. (HVGB);
- Torngat Secretariat (HVGB);
- Town of L'Anse au Loup;
- Town of Mary's Harbour;
- Town of North West River;
- Community of Pinsent's Arm; and
- Town of Port Hope Simpson.

5.1.1.3 Consultation Follow-Up

As described above, Seitel 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 (2014, 2015a,b).

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, 2016-2025.

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.

More details on the effects assessment procedures are provided in § 5.4 of LGL (2014, 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 impacts that might affect the area VECs. Seitel 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 2015), and the Environmental Planning, Mitigation and Reporting guidance in Appendix 2 of the Board's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012);
- DFO's *Statement of Canadian Practice with Respect to the Mitigation of Seismic Sound in the Marine Environment;*
- National and international acts, regulations or conventions, such as the *Fisheries Act* and Regulations, *International Convention for the Prevention of Pollution from Ships* (MARPOL), and International Maritime Organization (IMO) standards;
- Other standards and guidance, such as the One Ocean *Protocol for Seismic Survey Programs in Newfoundland and Labrador* (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 deter marine mammals 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.

Details of the seven mitigation categories are provided in in § 5.5 of LGL (2014, 2015a,b).

5.5.1 Summary of Mitigation Measures

Table 5.1 summarizes mitigation measures by potential effect on the VECs.

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, the regulatory authority. 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 3.19 and Figure 3.10 in § 3.4.2). Within the Project time frame, icebergs may require the vessels to detour in May and June when almost 45% of the yearly total of icebergs are expected to occur, based on monthly iceberg distribution data (see Table 3.19 in § 3.4.2).

Table 5.1 Summary of Mitigations Measures by Potential Effect.

Potential Effects	Primary Mitigations
Interference with fishing vessels/mobile and fixed gear fisheries	• Upfront communications, liaison and planning to avoid fishing activity • Continuing communications throughout the program • FLOs • SPOC • Advisories and communications • VMS data • Avoidance • Start-up meetings on ships
Fishing gear damage	• Upfront communications, liaison and planning to avoid fishing gear • Use of support vessel • SPOC • Advisories and communications • FLOs • Compensation program • Reporting and documentation • Start-up meetings on ships
Interference with shipping	• Advisories and at-sea communications • FLOs (fishing vessels) • Use of support vessel • SPOC (fishing vessels) • VMS data
Interference with DFO/FFAW research program	• Communications and scheduling • 7-day/30-km temporal/spatial avoidance protocol
Temporary or permanent hearing damage/disturbance to marine animals (marine mammals, sea turtles, seabirds, fish, invertebrates)	• Pre-watch of safety zone • Delay start-up if marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations
Temporary or permanent hearing damage/ disturbance to Species at Risk or other key habitats	• Pre-watch of safety zone • Delay start-up if marine mammals or sea turtles are within 500 m • Ramp-up of airguns • Shutdown of airgun arrays for *endangered* or *threatened* marine mammals and sea turtles within 500 m • Use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations. [No critical habitat has been identified in or near the Study Area.]
Injury (mortality) to stranded seabirds	• Daily monitoring of vessel • Handling and release protocols • Minimize lighting if safe
Seabird oiling	• Adherence to MARPOL • Spill contingency and response plans • Use of solid streamer

Most environmental constraints on seismic surveys on the Grand Banks are those imposed by wind and wave. If the Beaufort wind scale is six or greater, there is generally too much noise for seismic data to be of use. A Beaufort wind scale of six is equivalent to wind speeds of 22-27 knots (11.3-13.9 m/s), and is associated with wave heights ranging from 2.4-4.0 m. In the Study Area, these conditions are somewhat consistent in the late autumn and winter months.

Certainly, if the sea state exceeds 3.0 m or winds exceed 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 to April period.

Poor visibility can constrain helicopter operations and streamer repair. It also may hinder sightings of 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., picket 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 anecdotal accounts of sharks attacking and damaging streamers.

The Department of National Defense (DND) records indicate that there are at least 27 shipwrecks and five legacy sites present within the Study Area. It is understood that the proposed seismic activities will only have interaction with the sea floor if OBNs are deployed. 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. A detailed effects assessment then follows, which focuses on the effects of noise (primarily on marine mammals, fish and fisheries) and the towed seismic streamer array (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 will use low sulphur content (no more than 1%) fuel (following Canadian 2012 ECA regulations) and that it will add negligible atmospheric emissions (relative to total northwest Atlantic ship traffic) to a windy oceanic environment, there will be no measureable adverse effect on air quality or human health in the Project Area.

5.7.2 Generic Activities - Marine Use

Project-related traffic will include one seismic survey vessel and one picket vessel. 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.

Other ships operating in the area could include freighters, tankers, fishing vessels, research vessels, naval vessels, and private yachts. Mitigations (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;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact (SPOC).

Seitel will also coordinate with DFO, St. John's, to avoid any potential conflicts with research vessels that may be operating in the area. Given the expected vessel density conditions and 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 55-60 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

Although there will be 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 *negligible* residual effects are predicted to be *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) of large enough magnitude to cause a significant effect on fish habitat. Therefore, other than 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

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		X	X	X	X	X	X
Supply		X	X	X	X	X	X
Picket		X	X	X	X	X	X
Helicopter							
Echo						X	
Side Scan						X	
Grav/Mag							
Vessel Lights		X				X	
Vessel/Equipment Presence							
Seismic Vessel and							
Supply							
Picket							
Ocean Bottom Nodes			X		X		X
Sanitary/Domestic Waste	X	X		X		X	
Atmospheric Emissions	X	X		X		X	
Garbage [b]							
Helicopter Presence							
Grav/Mag Aircraft							
Shore Facilities [c]							
Accidental Releases	X	X	X	X	X	X	X
Other Projects and Activities in Region of Study Area							
Oil and Gas	X	X	X	X	X	X	X
Fisheries	X	X	X	X	X	X	X
Marine	X	X	X	X	X	X	X

[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 on interactions between underwater sound and invertebrates and fishes is available in § 5.7.4 and Appendices 2 and 3 of the WesternGeco Eastern Newfoundland EA (LGL 2015a) and the WesternGeco Southeastern Newfoundland EA (LGL 2015b), § 5.1.2 of the Labrador Shelf SEA (C-NLOPB 2008), § 5.1 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § .5.1.2 of the Southern Newfoundland SEA (C-NLOPB 2010). 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.

Sound Exposure Effects Assessment

The assessment in this subsection is structured such that the reader should first refer to the interaction table (e.g., Table 5.2) to determine if there are any interactions 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).

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 strongest sound source, in this case the seismic airgun sound, and (2) several species that are representative of the different types of sensitivities and have a representative literature base (e.g., snow crab and Atlantic cod).

The most notable criteria 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 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 swimbladder and cod with swimbladder), and (4) reproductive strategy (snow crabs carry fertilized eggs at the bottom until larval hatch, and cod eggs are planktonic).

Potential impacts on other marine invertebrate and fish species are inferred from the assessment using snow crab and Atlantic cod as 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, many data gaps remain (Hawkins et al. 2015). Available experimental data suggest that there may be physical impacts on the fertilized eggs of snow crab and on the egg, larval, juvenile and adult stages of cod at very close range. Considering the typical source levels associated with commercial seismic airgun arrays, close proximity to the source could result in exposure to very high sound levels. While egg and larval stages are not able to actively escape such an exposure scenario, juvenile and adult cod would most likely avoid it. Developing embryos, juvenile and adult snow crab are benthic and generally far enough from the sound source to receive energy levels well below levels that may have impact. 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 mitigate the population-level effects of exposure to airgun sound.

Snow crab, thought to be sensitive to the particle motion component of sound only, will be a considerable distance from the airguns and will not likely be affected by any particle motion 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 impacts on fish and invertebrates indicate that these impacts 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.

Table 5.3 provides the details of the assessment of the effects of exposure to Project-related sound on the Fish and Fish Habitat VEC.

As indicated in Table 5.3, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual effects on the Fish and Fish Habitat VEC that are *negligible* to *medium* in magnitude for a duration of *<1 month* to *1 to 12 months* over a geographic area of *<1* to *101-1,000 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of sound associated with Seitel'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).

5.7.4.2 Effects Assessment of other Routine Project Activities

Vessel Lights

As indicated in Tables 5.2 to 5.4, vessel lights might attract plankton and pelagic fishes towards the upper water column, resulting in a neutral effect. Therefore, the effects of vessel lights associated with Seitel'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).

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

Valued Environmental Component: Fish and Fish Habitat								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Sound								
Airgun Array (2D, 3D and 4D)	Physical effects (N); Disturbance (N)	Ramp-up of array; Spatial & temporal avoidance	0-2	1-4	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
Picket 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	Neutral effect	-	-	-	-	-	-	-
Vessel/Equipment Presence								
Ocean Bottom Nodes	Benthic disturbance (N)	Small footprint for each OBN; Short deployment time	0-1	1-4	1	1-2	R	2
Sanitary/Domestic Waste	Pathological effects (N); Contamination (N)	Treatment	0-1	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 plan	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 essentially no effect
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
4 = 101-1,000 km^2
5 = 1,001-10,000 km^2
6 = >10,000 km^2

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not negatively affected by human activity
2 = Evidence of existing negative effects 3 3 = 11-100 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	2-3	-	-
Seismic Vessel	NS	2-3	-	-
Supply Vessel	NS	2-3	-	-
Picket Vessel	NS	2-3	-	-
Echo Sounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Ocean Bottom Nodes	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

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

Vessel/Equipment Presence

As indicated in Table 5.2, ocean bottom nodes (OBNs) will interact with certain aspects of the Fish and Fish Habitat, specifically benthos, juvenile fishes associated with the sea bottom and groundfishes. Given that each OBN has a very small footprint (~.20-.25 m^2; total footprint for 10,000 nodes would be 2,500 m^2, equivalent to an area 50 m x 50 m) and the short deployment time, OBN use is predicted to have residual effects on the Fish and Fish Habitat VEC that are *negligible* to *low* in magnitude for a duration of *<1 month* to *1 to 12 months* over a geographic area of *<1* to *101-1,000 km²*. Based on these criteria ratings, the *reversible* residual effects of OBN use associated with Seitel'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).

Sanitary/Domestic Waste

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 to 12 months* over a geographic area of *<1 km²* (see Table 5.3). Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic wastes produced during Seitel'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).

Atmospheric Emissions

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 to 12 months* over a geographic area of *<1 km²*. Based on these criteria ratings, the *reversible* residual effects of atmospheric emissions produced during Seitel'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 mitigations in place, the residual effects of an accidental release associated with Seitel's proposed seismic program on the Fish and Fish habitat VEC would be *negligible* to *low* in magnitude for a duration of *<1 month* over an area of *<1* to *1-10 km*^{2} (see Table 5.3). 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 Seitel'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

All 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.

Behavioural changes relating to catchability of commercial species, and conflict with harvesting activities, fishing gear and lost fishing time were raised as potential issues during the consultations and issues scoping for this assessment (§ 5.1.1). Conflicts between seismic vessels and associated gear and fishing activities or fishing gear have occurred in the past in Atlantic Canada when seismic vessels were operating in areas with high levels of fishing activity. This is a particular possibility in relation to fixed gear (i.e., crab pots and gillnets in 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 in the same general area at the same time, 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 fishery activities is to avoid active fishing areas, particularly fixed gear zones. For the commercial fisheries, gear damage compensation provides a means of final mitigation of impacts, in case a conflict does occur with fishing gear (i.e., accidental contact of gear with the survey airgun array, seismic vessel, streamers or ocean bottom nodes). Subsection 5.5 provides information on mitigation measures, including those associated with 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	X	X	X
Seismic Vessel	X	X	X
Supply Vessel	X	X	X
Picket 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
Picket 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 Region of Study Area			
Oil and Gas Activities	X	X	X
Marine Transportation	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] There will not be any new onshore facilities. Existing infrastructure will be used.

The document *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) provides guidance aimed at minimizing any impacts of petroleum industry geophysical surveys on commercial fish harvesters and other marine users. The mitigations described below are also relevant to DFO and joint DFO/Industry research surveys. Development of the guidelines was based on best practices applied during previous 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. Operations being conducted in offshore Labrador will include a second FLO who represents Inuit/Nunatsiavut interests.

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. With application of the mitigation measures indicated in § 5.5 and above, the residual effects of Project-related sound (airgun array sound being the worst-case scenario) 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 *101-1,000 km*^{2} (Table 5.6). Based on these criteria ratings, the *reversible* residual effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the Fisheries VEC are predicted to be *not significant* (Table 5.7). The level of confidence associated with this prediction is *medium* to *high* (Table 5.7).

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	0-1	1-4	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
Picket 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
Picket 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

[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	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket 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	-	-
Picket Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

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

5.7.5.2 Vessel/Equipment Presence

Commercial fish harvesting activities occur throughout the May to November temporal scope period for the proposed Project. Fishing with fixed gear (e.g., pot fishery for snow crab, and to a lesser extent the yellowtail flounder and Greenland halibut gillnet fisheries) 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 (7,000-12,000 m) used during Seitel's seismic operations during 2016–2025 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.

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. Operations being conducted in offshore Labrador will include a second FLO who represents Inuit/Nunatsiavut interests;
- 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 km*^{2} (see Table 5.6). Based on these criteria ratings, the *reversible* residual effects of vessel/gear presence associated with Seitel'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 to 12 months* over a geographic area of *<1 km*^{2} (see Table 5.6). Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic wastes produced during Seitel'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 some possibility of the perception of tainting of invertebrate and fish resources in the proximity of a release, even if there is no actual tainting. Perception alone can have economic effects if the invertebrates and fish lose marketability. Preventative measures / protocols, 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 2012).

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 km*^{2} (see Table 5.6). Based on these criteria ratings, the *reversible* residual effect of accidental releases associated with Seitel'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
Picket Vessel	X
Helicopter	X
Echo Sounder	X
Side Scan Sonar	X
Grav/Mag Aircraft	X
Vessel Lights	X
Vessel/Equipment Presence	
Seismic Vessel and Equipment	X
Supply Vessel	X
Picket Vessel	X
Ocean Bottom Nodes	
Sanitary/Domestic Waste	X
Atmospheric Emissions	X
Garbage[a]	
Helicopter Presence	X
Grav/Mag Aircraft	X
Shore Facilities[b]	
Accidental Releases	X
Other Projects And Activities in Region of Study Area	
Oil and Gas Activities	X
Fisheries	X
Marine Transportation	X

[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 5.8.6.4 of LGL (2014) and 5.7.6.1 of LGL (2015a), and LGL (2015b) describe the interaction between birds and sound.

As indicated in Table 5.9, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* to *low* in magnitude for a duration of *<1 month* to *1 to 12 months* over a geographic area of *<1* to *1-10 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (Table 5.10). The level of confidence associated with this prediction is *medium* to *high* (Table 5.10).

5.7.6.2 Vessel Light

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). Subsections 5.8.6.1 of LGL (2014) and 5.7.6.2 of LGL (2015a,b) describe 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. 2008c; Rodríguez and Rodríguez 2009; Williams and Chardine 1999). 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).

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 to 12 months* over a geographic area of *<1* to *11-100 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of artificial light associated with Seitel's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not significant* (Table 5.10). 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
Picket 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
Grav/Mag Aircraft	Disturbance (N)		0-1	2	1	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
Picket 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
Grav/Mag Aircraft	Disturbance (N)		0-1	2	1	1	R	2
Accidental Releases	Mortality (N)	Solid streamer; spill response	1-2	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

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	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Grav/Mag Aircraft	NS	3	-	-
Vessel Lights	NS	2-3	-	-
Vessel/Equipment Presence				
Seismic Vessel and Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Grav/Mag Aircraft	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

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

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, picket 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.

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 to 12 months* over a geographic area of *<1* to *11-100 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of the presence of vessels and equipment associated with Seitel'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.

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 to 12 months* over a geographic area of *<1 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic waste associated with Seitel'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 directly related to the Project.

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 to 12 months* over a geographic area of *<1* to *1-10 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of atmospheric emissions associated with Seitel'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 and Grav/Mag Aircraft Presence

The potential effects of helicopters and fixed-wing aircraft 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.

As indicated in Table 5.9, helicopter and grav/mag aircraft 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 to 12 months* over a geographic area of *<1* to *1-10 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of the presence of helicopters associated with Seitel'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 suffer negative effects from an accidental release of hydrocarbons. Northern Fulmar, the shearwaters and storm-petrels are attracted to sheens but would not likely confuse them with a natural oceanic "sheen" comprised of zooplankton or offal. 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. O'Hara and Morandin (2010) 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.

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 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of the accidental release of hydrocarbons associated with Seitel'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, Eastern Newfoundland and Southern Newfoundland SEAs (C-NLOPB 2008, 2010, 2014), 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. 2008c). 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.

5.7.7.1 Sound

The potential effects of sound from airgun arrays on marine mammals and sea turtles are a common concern associated with seismic programs. Airgun arrays used during marine seismic operations introduce strong sound pulses into the water. These sound pulses could have several types of effects on marine mammals and sea turtles and are the main issue associated with the proposed seismic surveys. The effects of human-generated noise on marine mammals are quite variable and depend on numerous factors, including: species, activity of the animal when exposed to the noise, and distance of the animal from the sound source. This section includes 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 § 5.8.7.1 and Appendices 4 and 5 of LGL (2014), § 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 (2014, 2015a,b). Descriptions of the hearing abilities of marine mammals and sea turtles are also provided in Appendices 4 and 5, respectively, of LGL (2014, 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). 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.

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**	**Seals**	**Sea Turtles**
Sound				
Airgun Array (2D, 3D and 4D)	X	X	X	X
Seismic Vessel	X	X	X	X
Supply Vessel	X	X	X	X
Picket Vessel	X	X	X	X
Helicopter	X	X	X	X
Echo Sounder	X	X	X	X
Side Scan Sonar	X	X	X	X
Grav/Mag Aircraft	X	X	X	X
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	X	X	X	X
Supply Vessel	X	X	X	X
Picket Vessel	X	X	X	X
Ocean Bottom Nodes				
Vessel Lights				
Helicopter Presence	X	X	X	X
Grav/Mag Aircraft Presence	X	X	X	X
Sanitary/ Domestic Wastes	X	X	X	X
Atmospheric Emissions	X	X	X	X
Accidental Releases	X	X	X	X
Garbage[a]				
Shore Facilities[b]				
Other Projects and Activities in Region of Study Area				
Oil and Gas Activities	X	X	X	X
Fisheries	X	X	X	X
Marine Transportation	X	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b]There will not be any new onshore facilities. Existing infrastructure will be used.

Masking

Erbe et al. (2015) recently reviewed communication masking in marine mammals. 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 past and current reviewed research, the potential for masking of marine mammal calls and/or important environmental cues is considered low from the proposed seismic program. Thus, masking is unlikely to be a significant issue for either marine mammals or sea turtles exposed to the sounds from the proposed seismic survey.

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

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Stone (2015) examined data from 1,196 seismic surveys in UK and adjacent waters and reported that a significant response to airgun arrays of 500 in^3 or more in volume were found for minke and fin whales. This included lateral displacement, change in swimming or surfacing behaviour, and indications that cetaceans remained near the water surface. Bröker et al. (2015) did not observe any large changes in gray whale movement, respiration, or distribution patterns during a 4D seismic survey off Sakahlin Island, Russia.

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. Small and medium-sized odontocetes, including beaked whales, showed a significant response (e.g., lateral displacement, localised avoidance, or change in behaviour) to large airgun arrays of 500 in^3 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 to 210 dB re 1 μPa), two of the three dolphins tested exhibited anticipatory behavioural reactions to impulse sounds presented at fixed time intervals.

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 in^3 or more in volume as indicated by the lower detection rate during periods of seismic activity. Lalas and McConnell (2015) made observations of New Zealand fur seals from a seismic vessel operating a 3,090 in^3 airgun array in New Zealand during 2009. However, the results from the study were inconclusive in showing whether New Zealand fur seals respond to seismic sounds.

Based on available data, it is likely that sea turtles would exhibit behavioural changes and/or localized avoidance near a seismic vessel. Turtles are also considered rare in the Study Area.

Hearing Impairment

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (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.

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. However, Hermannsen et al. (2015) concluded that there is little risk of hearing damage to pinnipeds and porpoise when using a single airgun in shallow water.

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 do show localized movement away from approaching airguns.

Nowacek et al. (2013) concluded that 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 (in theory) occur include stress, neurological effects, and organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, there is no definitive evidence that any of these effects occur even for marine mammals or sea turtles in close proximity to large arrays of airguns.

Sound Criteria for Assessing Impacts

Impact zones for marine mammals are commonly defined by the areas within which specific received sound level thresholds are exceeded. The U.S National Marine Fisheries Service (NMFS) (1995, 2000) concluded that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa_{rms}; the corresponding limit for seals was set at 190 dB re 1 μPa_{rms}. 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. For over a decade, it has been common for marine seismic surveys conducted in some areas of U.S. jurisdiction and in some areas of Canada (Canadian Beaufort Sea and on the Scotian Shelf), to include a "shutdown" requirement for cetaceans based on the distance from the airgun array at which the received level of underwater sounds is expected to diminish below 180 dB re 1 μPa_{rms}. An additional criterion that is often used in predicting "disturbance" impacts is 160 dB re 1 µPa; at this received level, some marine mammals exhibit behavioural effects. There is ongoing debate about which sound levels should be used to make impact predictions (for behavioural and hearing impairment effects) and define mitigation measure parameters (i.e., safety zones).

Recommendations for science-based noise exposure criteria for marine mammals were published quite some time ago by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. In July 2015, NOAA made available for public comment revised draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015). DFO has not adopted any noise exposure criteria.

For marine seismic programs in Newfoundland and Labrador, the C-NLOPB (2012) 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. The effects of underwater sound from vessels, the echo sounder and the side scan sonar are not further discussed as their effects are 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 whale). 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. The received sound level of 180 dB re 1 μPa_{rms} criterion is accepted by NMFS as a level that below which there is no physical effect on toothed whales; however, the sound level for harbour porpoise is likely lower. It is assumed that disturbance effects for toothed whales may occur at received sound levels at or above 160 dB re 1 μPa_{rms}. However, it is noted that there is no good scientific basis for using this 160 dB criterion for odontocetes and that 170 dB re 1 μPa_{rms} is likely a more realistic indicator of the area within which disturbance is possible, at least for delphinids.

Hearing Impairment and Physical Effects

As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying 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 to 12 months* over a geographic area of *<1* to *1-10 km*^{2}. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the toothed whales are predicted to be *not significant* (Table 5.13). The level of confidence associated with this prediction is *medium* (Table 5.13).

Disturbance

As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying 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 to 12 months* over a geographic area of *<1* to *101-1,000 km*^{2}. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the 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 the Marine Mammal VEC.

Valued Environmental Component: Marine Mammals								
			Evaluation Criteria for Assessing Environmental Effects					
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
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	1-4	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
Picket 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
Grav/Mag Aircraft	Disturbance (N)		0-1	1-2	1	1	R	2
Vessel/Equipment Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Picket Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0	1	1	1	R	2
Grav/Mag Aircraft 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:
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 negatively affected by human activity
2 = Evidence of existing negative effects

[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 *endangered* (or *threatened*) marine mammal is sighted within 500 m of the array.
[c] A solid streamer 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	2	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echo Sounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Grav/Mag Aircraft	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter Presence	NS	3	-	-
Grav/Mag Aircraft Presence	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

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

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). As with toothed whales, the 180 dB re 1 μPa_{rms} criterion is used when estimating the area where hearing impairment and/or physical effects may occur for baleen whales (although there are no data to support this criterion for baleen whales). For all baleen whale species, it is assumed that disturbance effects (avoidance) may occur at sound levels greater than 160 dB re 1 μPa_{rms}.

Hearing Impairment and Physical Effects

As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying 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 to 12 months* over a geographic area of *<1* to *1-10 km*^{2}. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the 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

As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying 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* to *1 to 12 months* over a geographic area of *<1* to *101-1,000 km*^{2}. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the 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).

Seals

Seals are not expected to be abundant within the Study Area, particularly in the time period when seismic operations will likely occur.

Hearing Impairment and Physical Effects

As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying 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 to 12 months* over a geographic area of *<1* to *1-10 km^2*. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the 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

As indicated in Table 5.12, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying being the worst-case scenario) is predicted to have residual disturbance effects on seals that are *low* to *medium* in magnitude for a duration of *<1* to *1 to 12 months* over a geographic area of *<1* to *11-100 km^2*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with Seitel's proposed 2D/3D/4D seismic program on the 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).

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). The effects of underwater sound from vessels, the echo sounder and the side scan sonar are not further discussed as their impact is minimal relative to airguns.

Hearing Impairment and Physical Effects

As indicated in Table 5.14, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying 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 to 12 months* over a geographic area of *<1* to *1-10 km^2*. Based on these criteria ratings, the *reversible* residual hearing impairment/physical effects of sound associated with Seitel'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

As indicated in Table 5.14, sound produced as a result of the proposed Project (airgun array sound during 2D, 3D and 4D seismic surveying 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 to 12 months* over a geographic area of *<1* to *11-100 km^2*. Based on these criteria ratings, the *reversible* residual disturbance effects of sound associated with Seitel'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* to *high* (Table 5.15).

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	1-3	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
Picket 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
Grav/Mag Aircraft	Disturbance (N)		0-1	1-2	1	1	R	2
Vessel Presence								
Seismic Vessel/Gear (2D, 3D and 4D)	Disturbance (N)		0-1	1	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Picket Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0	1	1	1	R	2
Grav/Mag Aircraft 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:
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 negatively affected by human activity
2 = Evidence of existing negative effects

[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 *endangered* (or *threatened*) 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	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echo Sounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Grav/Mag Aircraft	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter Presence	NS	3	-	-
Grav/Mag Aircraft Presence	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Accidental Releases	NS	2	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

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

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

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 to 12 months* over a geographic area of *<1* to *1-10 km*^{2}. Based on these criteria ratings, the *reversible* residual disturbance effects of helicopter sound associated with Seitel'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 the 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 a picket 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 (~4.5 knots; 8.3 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 demonstrate by blue whales, and perhaps other large whale species (McKenna et al. 2015). Marine mammal responses to ships are presumably responses to noise. 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 harbor 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.

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. Sea turtles may also become entangled with seismic gear (e.g., cables, buoys, streamers, etc.) or collide with the vessel.

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 to 12 months* over a geographic area of *<1 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of vessel/equipment presence associated with Seitel'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 5.12 to 5.15).

Accidental Releases

All petroleum hydrocarbon handling and reporting procedures on board will be consistent with Seitel'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 § 5.7.7.4 of the WesternGeco Eastern Newfoundland EA (LGL 2015a), § 5.7.7.5 the WesternGeco Southeastern Newfoundland EA (LGL 2015b), § 5.8.7.4 of the MKI Labrador Sea EA (LGL 2014), § 5.3 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.6.4.5 and 4.6.4.6 of the Southern Newfoundland SEA (C-NLOPB 2010). Based on multiple studies, whales and seals do not exhibit large behavioural or physiological responses to limited surface oiling, incidental exposure to contaminated food, or ingestion of oil. Sea turtles are thought to be more susceptible to the effects of oiling than marine mammals but effects are believed to be primarily sublethal.

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 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of accidental releases of hydrocarbons associated with Seitel'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 overviews of all species with either *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. Similarly, biological overviews of all species designated as *special concern* under Schedule 1 of *SARA* and with reasonable likelihood of occurrence in the Study Area were provided in § 4.2 on fish and fish habitat and § 4.5 on marine mammals and sea turtles. No critical habitat for any of these species/populations has been identified in the Study Area. As indicated in Table 4.20 in § 4.6, the eleven *SARA* Schedule 1 species/populations of relevance to the Study Area include:

- White shark (Atlantic population), northern wolffish, spotted wolffish, and Atlantic wolffish;
- Ivory Gull;
- Blue whale (Atlantic population), North Atlantic right whale, northern bottlenose whale (Scotian Shelf population), fin whale (Atlantic population), and Sowerby's beaked whale; and
- Leatherback sea turtle.

Species/populations currently without status on Schedule 1 of *SARA* but listed on Schedule 2 or 3, or being considered for addition to Schedule 1 (as per their current COSEWIC listing of *endangered, threatened* or *special concern*), are not included in 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 on Schedule 1 of *SARA* do become listed during the temporal scope of the Project (2016 to 2025), the Proponent will re-assess these species/populations considering the prohibitions of *SARA* and any recovery strategies or action plans that may be in place. Possible mitigation measures as they relate to species at risk will be reviewed with DFO and EC. Potential interactions between Project activities and the Species at Risk VEC are indicated in Table 5.16. Only those eight species/populations with either *endangered* or *threatened* status under Schedule 1 of the *SARA* (see Table 4.20) are included in the interactions table (Table 5.16).

The potential effects of activities associated with Seitel's proposed seismic program are not expected to contravene the prohibitions of *SARA* (§ 32(1), 33, 58(1)).

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

Valued Environmental Component: Species at Risk					
Project Activities	**White Shark**	**Wolffishes**	**Ivory Gull**	**Blue Whale** **North Atlantic Right Whale** **Northern Bottlenose Whale**	**Leatherback Sea Turtle**
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
Picket Vessel	X	X	X	X	X
Helicopter			X	X	X
Echosounder	X	X	X	X	X
Side Scan Sonar	X	X	X	X	X
Grav/Mag Aircraft			X	X	X
Vessel Lights	X		X		
Vessel/Equipment Presence					
Seismic Vessel/Gear (2D, 3D and 4D)			X	X	X
Supply Vessel			X	X	X
Picket Vessel			X	X	X
Ocean Bottom Nodes		X			
Sanitary/ Domestic Waste	X	X	X	X	X
Atmospheric Emissions	X	X	X	X	X
Garbage[a]					
Helicopter Presence			X	X	X
Grav/Mag Aircraft Presence			X	X	X
Shore Facilities[b]					
Accidental Releases	X	X	X	X	X
Other Projects and Activities in Region of Study Area					
Oil and Gas Activities	X	X	X	X	X
Fisheries	X	X	X	X	X
Marine Transportation	X	X	X	X	X

[a] Not applicable as garbage will be brought ashore.
[b] 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 white sharks and wolffishes. As per the detailed effects assessment contained in § 5.7.4, physical effects of Project activities on the various life stages of the white shark and wolffishes will have *negligible* to *low* magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1 km*^{2} (Table 5.17). Based on these criteria ratings, the residual physical effects of activities associated with Seitel's proposed seismic program on white sharks and wolffishes are predicted to be *not significant* (Table 5.18). The level of confidence associated with this prediction is *high* (Table 5.18).

Behavioural effects of Project activities on the various life stages of the white shark and wolffishes will have *negligible* to *low* magnitude for a duration of *<1 month* to *1-12 months* over a geographic area of *<1* to *11-100 km*^{2} (Table 5.17). Based on these criteria ratings, the residual behavioural effects of activities associated with Seitel's proposed 2D/3D/4D seismic program on white sharks and wolffishes are predicted to be *not significant* (Table 5.18. The level of confidence associated with this prediction is *medium* to *high* (Table 5.18).

5.7.8.2 Marine-associated Bird Species at Risk

Ivory Gull foraging behaviour would not likely expose it to underwater sound, and this species is unlikely to occur in the Study Area, particularly during the time when seismic surveys are likely to being conducted. Furthermore, Ivory Gulls 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 did strand on the vessel) and ramping up the airgun array will minimize the potential effects on this seabird species at risk. As per the detailed effects assessment in § 5.7.6, the residual effects of activities associated with Seitel's proposed 2D/3D/4D seismic program on Ivory Gulls are predicted to be *negligible* and *not significant* (Table 5.18). The level of confidence associated with this prediction is *medium* to *high* (Table 5.18).

5.7.8.3 Marine Mammal and Sea Turtle Species at Risk

Based on available information, blue whales, North Atlantic right whales, northern bottlenose whales and leatherback 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:

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	1-4	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
Picket 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
Grav/Mag Aircraft	Disturbance (N)		0-1	1-2	1	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	6	1-2	R	2
Supply Vessel	Disturbance (N)		0-1	1	1	1	R	2
Picket Vessel	Disturbance (N)		0-1	1	6	1-2	R	2
Ocean Bottom Nodes	Benthic disturbance (N)	Small footprint for each OBN; Short deployment time	0-1	1-5	1	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
Grav/Mag Aircraft Presence	Disturbance (N)		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:
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 negatively affected by human activity
2 = Evidence of existing negative effects

[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 *endangered* (or *threatened*) marine mammal or sea turtle is sighted within 500 m of the array.
[c] A solid streamer 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	2-3	-	-
Seismic Vessel	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	3	-	-
Side Scan Sonar	NS	3	-	-
Grav/Mag Aircraft	NS	3	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Ocean Bottom Nodes	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Grav/Mag Aircraft Presence	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

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

- 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;
- Shutdown of the airgun array when an *endangered* or *threatened* marine mammal or sea turtle is sighted within the 500 m safety zone; and
- Delay of ramp-up if any marine mammal or sea turtle is sighted within the 500 m safety zone.

With these mitigation measures in place and as per the detailed effects assessment in § 5.7.7, the predicted effects of the Project on blue whales, North Atlantic right whales, northern bottlenose whales and leatherback 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 *101-1,000 km*^{2} (see Table 5.17). Based on these criteria ratings, the predicted effects of activities associated with Seitel's proposed 2D/3D/4D seismic program on blue whales, North Atlantic right whales, northern bottlenose whales and leatherback sea turtles 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).

5.7.9 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 Seitel's proposed 2D/3D/4D seismic program on sensitive areas within the Study Area are predicted to be *not significant*. The level of confidence associated with this prediction is *medium* to *high*.

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 Seitel seismic program activities in the Project Area. This includes the residual effects of two concurrent seismic surveys being conducted by Seitel (see § 2.0). Considering the size of the Project Area, the likely considerable separation of the two concurrent surveys, and the predictions of significance presented in § 5.7, the within-Project cumulative residual effects associated with two concurrent Seitel seismic surveys are predicted to be *not significant*.

It is also necessary to assess cumulative effects from 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); and
- Offshore oil and gas industry activities.

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 petrels) 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 (i.e., disturbance), if they occur, will be additive (not multiplicative or synergistic) and are predicted to be *not significant*.

5.8.2 Marine Transportation

Marine transportation within the Study Area is discussed in the Eastern Newfoundland SEA (§ 4.3.5.1 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 5.3 of C-NLOPB 2010), and the two WesternGeco EAs (§ 5.8.2 of LGL 2015a,b).

The seismic survey vessels are not likely to add much marine traffic congestion. Ships may need to divert around the immediate seismic survey area, but this will not prevent or impede the passage of either vessel as the *Shipping Act* and standard navigation rules will apply. Thus, potential for cumulative effects with other shipping is predicted to be *low* and *not significant*.

5.8.3 Other Oil and Gas Activities

Potential offshore oil and gas industry activities in the Regional Area (as per the C-NLOPB public registry, www.cnlopb.nl.ca) include:

- Multi Klient Invest ASA (MKI) 2D/3D seismic program on Southeast Grand Banks, 2014-2018;
- Multi Klient Invest ASA (MKI) 2D/3D seismic program on Northeast Newfoundland Shelf (i.e., Labrador Basin, Orphan Basin, Flemish Pass, Jeanne d'Arc Basin), 2012-2017;
- Multi Klient Invest ASA (MKI) 2D/3D seismic program in Labrador Sea, 2014-2018;
- Electromagnetic Geoservices Canada Inc. (EMGS) controlled-source electromagnetic (CSEM) program on Eastern Newfoundland Offshore, 2014-2018;
- ExxonMobil geophysical, geochemical, environmental and geotechnical program in the eastern Newfoundland offshore, 2015-2024;
- Statoil 3D/2D geophysical program including geohazard and electromagnetic surveys in Jeanne d'Arc and Central Ridge/Flemish Pass Basins, 2011-2019;

- GXT Technology Canada Ltd.'s GrandSPAN 2D seismic, gravity and magnetic survey, 2014-2018;
- Investcan Energy Corporation 2D/3D seismic program including geohazard and VSP surveys on Labrador Shelf, 2010-2017;
- Chevron Canada Resources 3D/2D seismic program including geohazard survey in offshore Labrador, 2010-2017;
- Chevron Canada Resources 3D and/or 2D seismic program including geohazard survey in the North Grand Banks Region, 2011-2017;
- Statoil exploration, appraisal, and delineation drilling program in Jeanne d'Arc Basin area, 2008-2016;
- Suncor exploration drilling in Jeanne d'Arc Basin, 2009-2017;
- Husky exploration and delineation drilling program in Jeanne d'Arc Basin, 2008-2017.

In addition, there are three existing offshore production developments (Hibernia, Terra Nova, and White Rose) on the northeastern part of the Grand Banks. A fourth development (Hebron) is anticipated to commence installation in the near future. The existing developments fall inside of the boundaries of Seitel's Regional Area but do not create the same types and levels of underwater noise as seismic, geohazard, or VSP programs. Any cumulative effects (i.e., disturbance), if they occur, will be additive (not multiplicative or synergistic) and predicted to be *not significant*.

There is potential for cumulative effects with other seismic programs proposed for 2016 (e.g., WesternGeco, MKI, Statoil, GXT). 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 (2016 and beyond) in the area will be assessed in the EA update process. Uncertainty due to the large identified Study Areas will be reduced as specific survey designs (covering smaller area) 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. Thus, it seems

likely that while some animals may receive sound from one or more geophysical programs, the current prediction is that *no significant residual effects* will result.

5.9 Mitigation Measures and Follow-up

Project mitigations are summarized in this section, both in the text and in Table 5.19. Seitel will adhere to mitigations detailed in Appendix 2 of the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) 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" and a "Notice to Fishers" on the CBC Radio Fisheries Broadcast. If necessary, individual fixed gear fishers will be contacted to arrange mutual avoidance. Any contacts 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). Seitel will advise the C-NLOPB prior to compensating and settling all valid lost gear/income claims promptly and satisfactorily.

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;
- MMO(s) on board;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast;
- Compensation program in the event any project vessels damage fishing gear; and
- Single Point of Contact (SPOC).

Seitel will also coordinate with the FFAW and DFO to avoid any potential conflicts with fishing and research surveys that may be operating in the area. Seitel 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.

Table 5.19 Summary of Mitigation Measures.

Potential Effects	Primary Mitigations
Interference with fishing vessels	• upfront planning to avoid high concentrations of fishing vessels • request input from fishing captains through FFAW PIL regarding streamer deploying and testing plan. • SPOC • advisories and communications • FLO • planned transit route to and between Survey Areas (if required)
Fishing gear damage	• upfront planning to avoid high concentrations of fishing gear • SPOC • advisories and communications • FLO • compensation program • planned transit route to and between Survey Areas (if required)
Interference with shipping	• SPOC • advisories and communications • FLO
Interference with DFO/FFAW research vessels	• communications and scheduling • 7-day/30-km temporal/spatial avoidance protocol
Temporary or permanent hearing damage/disturbance to marine animals	• delayed start-up if marine mammals or sea turtles are within 500 m. • ramp-up of airguns over 30 min-period • shutdown of airgun arrays for endangered or threatened marine mammals and sea turtles within 500 m • use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations
Temporary or permanent hearing damage/ disturbance to Species at Risk or key habitats	• delay start-up if any marine mammals or sea turtles are within 500 m • ramp-up of airguns • shutdown of airgun arrays for endangered or threatened marine mammals and sea turtles • use of qualified MMO(s) to monitor for marine mammals and sea turtles during daylight seismic operations.
Injury (mortality) to stranded seabirds	• daily monitoring of vessel • handling and release protocols • minimize lighting if safe
Exposure to hydrocarbons	• adherence to International Convention for the Prevention of Pollution from Ships (MARPOL) • spill contingency plans • use of solid streamer

Mitigation measures designed to reduce the likelihood of impacts on marine mammals and sea turtles will include ramp ups, no initiation of airgun array if a marine mammal or sea turtle is sighted 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 observed within the 500 m safety zone. Prior to the onset of the seismic survey, the airgun array will be gradually ramped up. One airgun will be activated first and then the volume of the array will be increased

gradually over a recommended 30 min period. An observer (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 sighted 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 sighting. The observers will watch for marine mammals and sea turtles when the airgun array is active (during daylight periods) and note the location and behaviour of these animals. The seismic array will be shut down whenever marine mammals or sea turtles with either *endangered* or *threatened* statuses under Schedule 1 of *SARA* is sighted within the safety zone. 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 (most likely Leach's Storm-petrel) 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 *Best Practices for Stranded Birds Encountered Offshore, Atlantic Canada [Draft]* (EC 2015b). Data collection for seabirds at sea will be in accordance with Gjerdrum et al. (2012). It is understood by Seitel that a CWS *Migratory Birds Permit* will be required and that it will be secured as it has been in the past. Seitel 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 (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 2012), 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.

Seitel will also coordinate with DFO, St. John's, and the FFAW 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 Collaborative Post-Season Trap Survey for Snow Crab. Seitel 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 Seitel's proposed seismic program on the environment are shown in Table 5.20. The levels of confidence are also provided in the table. In summary, the residual effects of Seitel's proposed seismic program on the VECS are predicted to be *not significant*.

Table 5.20 Significance of Potential Residual Environmental Effects of Seitel'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	2-3	-	-
Seismic Vessel	NS	2-3	-	-
Picket vessel	NS	2-3		
Supply Vessel	NS	2-3	-	-
Helicopter	NS	3	-	-
Echosounder	NS	2-3	-	-
Side Scan Sonar	NS	2-3	-	-
Grav/Mag Aircraft	NS	3	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Ocean Bottom Nodes	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	NS	3	-	-
Grav/Mag Aircraft Presence	NS	3	-	-
Accidental Releases	NS	2-3	-	-

Key:
Significance is defined as either a high magnitude, or a medium magnitude with duration greater than 1 year and a geographic extent >100 km^2.

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

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

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

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

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

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Personal Communication

D. Ball – Fisheries and Oceans Canada.
J. Lawson – Fisheries and Oceans Canada.
V. Lesage – Fisheries and Oceans Canada.
H. Moors-Murphy – Fisheries and Oceans Canada.
G. Sheppard – Fisheries and Oceans Canada.
D. Tobin – Fisheries and Oceans Canada.

Appendix 1

Seitel's Full Consultation Report

Industry and Agency Consultations for Seitel Canada Ltd. (Seitel) East Coast Offshore Seismic Program, 2016-2025

During preparation of the environmental assessment of Seitel Canada Ltd.'s proposed 2016-2025 seismic program, consultations were undertaken with relevant government agencies, representatives of the fishing industry and other interest groups. The purposes of these consultations were to describe the proposed seismic program, identify any issues and concerns, and gather additional information relevant to the EA.

A short description of the proposed program, including program location map and species harvesting activity maps, was sent to the relevant agencies and industry stakeholder groups in late October 2015. They were asked to review this information, provide any comments on the proposed activities, and indicate whether or not they would like to meet to discuss the proposed program in more detail.

Consultations for the proposed program were undertaken with the following agencies, stakeholders and interest groups:

- Fisheries and Oceans Canada (DFO);
- Environment Canada (EC);
- Nature Newfoundland and Labrador (NNL);
- One Ocean;
- Fish, Food and Allied Workers Union/Unifor (FFAW/Unifor)
- Association of Seafood Producers (ASP);
- Ocean Choice International (OCI);
- Groundfish Enterprise Allocation Council (GEAC);
- Canadian Association of Prawn Producers (CAPP);
- Clearwater Seafoods Limited Partnership;
- Icewater Fisheries; and
- Newfound Resources Ltd. (NRL).

Issues and Concerns

Comments and responses received to date from various stakeholders are provided below.

Fisheries and Oceans Canada

DFO managers will provide comments on the proposed Seitel program regarding potential interactions with fish and fish habitat, fisheries, marine mammals, sea turtles and DFO-associated science surveys through the C-NLOPB's EA review process.

Environment Canada (EC)

Following a presentation by Seitel representatives, EC managers had a number of comments and questions.

There was a brief discussion of the updated protocols for marine bird mitigation measures which are still in draft form. These include the requirement for onboard observers to be more specific in their reporting procedures.

Managers asked how long and at what maximum depth the 'ocean bottom nodes' would be deployed. These questions were answered by the Seitel representatives. EC managers noted that there was no issue witht oil in the streamers since the project would be using solid streamers.

Nature Newfoundland and Labrador (NNL)

Following Seitel's presentation, NNL's representative offered several comments. He noted that NNL has reservations about the large Study Area being assessed since it makes it more difficult to comment on potential interactions and suggest any mitigation measures. For example, oceanographic conditions in the southern portion of the Study Area are quite different than those in the northern portion of the Study Area. The Seitel representatives indicated that their immediate focus is on the areas included in the C-NLOPB Land Issuance Sectors NL02-LS off southeastern Labrador and Sector NL01-SEN southeast of the Avalon Peninsula.

NNL's representative also made the usual request that the survey proponent consider providing ADCP data to local researchers. The Seitel representatives said they would likely be willing to provide these data as long as they received credit for providing the data. They said they would mention this possibility to the vessel provider when planning the survey. The NNL representative agreed to provide further information about instrumentation requirements for collecting these data during the proposed survey.

One Ocean

One Ocean's Director of Operations attended the consultation meeting involving Seitel representatives and OCI managers, and provided comments to Seitel during that meeting.

Fish, Food and Allied Workers Union

Following Seitel's presentation, there were a number of comments and questions from FFAW representatives.

A fisher noted that Seitel's southernmost potential survey area for 2016 (i.e., C-NLOPB Land Issuance Sector NL01-SEN) is a prime snow crab ground fished by about 128 crab enterprises.

The Carson Canyon area was identified as another "hot spot" for this crab. Within this area, snow crab is fished on the shelf and slope in areas with water depths ≤300 fathoms (545 m). The crab fishing activity in this area typically occurs during April 1 to July 31. The fishers indicated that, in their opinion, no oil and gas development will ever occur in this area as long as the snow crab fishery continues.

FFAW representatives reported that in 2008, fishers had trouble getting their crab quota after a seismic vessel passed through their grounds. It was also noted that a few years ago seismic operations in that area resulted in serious problems for vessels catching northern shrimp, namely a drop in catch rate. FFAW's PIL also expressed concerns about the potential impacts of seismic surveys on the Industry-DFO Collaborative Post-Season Trap Survey for Snow Crab.

In response to these comments, Seitel representatives said that they will meet with the FFAW again once plans for 2016 seismic surveying focus are better determined.

The FFAW's PIL suggested that Seitel should also meet with Labrador fishers to discuss their concerns about proposed survey activities in the northernmost potential survey area for 2016 (i.e., C-NLOPB Land Issuance Sector NL02-LS). One fisher stated that in offshore Labrador, Greenland halibut are harvested in water depths ranging between 500 and 700 fathoms (900 to 1,270 m). He also indicated that there aren't any species harvested east of this Greenland halibut harvesting area.

In response to the various species activities maps, the FFAW PIL said that the EA should look at the older (geo-referenced) catch data (pre-2011) in order to show important fishing "hot spots". The LGL consultant said the EA would include reference to these older data.

With regard to potential impacts of seismic on fishes, it was noted that fishers have their own opinions on this matter. For example, they believe that some individual fish are killed when exposed to seismic activities, and they contend that seismic operations, in some instances, have caused a decrease in catch rates. Some also believe that seismic sound makes crab go "dormant" (i.e., they stop moving and hence are harder to catch). It was indicated that some fishers have been told to leave a particular area by a seismic operator.

There was also discussion about a recent incident involving the loss of some gear (10-12 pots) due to physical conflict with a seismic vessel. It was noted that the fisher in question did not receive any compensation for this loss. In response to this point, one of Seitel's consultants said that the fisher in question should have reported the incident and submitted a damage claim. He also noted that there have only been a small number of claims made during the past 6-7 years, and that in some of these cases, fishers have received compensation for "lost fishing time" as well as for any damaged gear.

Fishers re-iterated their two main concerns about the possible impacts of seismic activities on crab: (1) mortality of individual animals; and (2) the physical interference with fishing operations (i.e., gear damage and/or loss). It was noted that since some areas have been closed to the shrimp fishery, fishers' livelihoods depend more on crab. Consequently, they will do all they can to protect their industry.

Association of Seafood Producers (ASP)

ASP's Executive Director attended the consultation meeting that Seitel had arranged with Ocean Choice International managers.

Ocean Choice International (OCI)

Following Seitel's presentation, a review of relevant OCI species harvesting activities and locations was conducted. This was followed by a discussion about the utility and quality of the currently available DFO commercial landings database compared with the logbook-based geo-referenced catch and effort data that OCI has collected over the years.

With respect to Seitel's two potential survey areas in 2016 (i.e., C-NLOPB Land Issuance Sectors NL02-LS off southeastern Labrador and Sector NL01-SEN southeast of the Avalon Peninsula), OCI's fleet manger noted that the company is actively targeting Greenland halibut in the northernmost area and redfish and yellowtail flounder in the southernmost area, which includes the Lilly and Carson Canyons.

Given that the EA will be assessing the harvesting activities that occur during the May to November period (versus data on year-round fishing activities), OCI's fleet manager pointed out that this would not accurately indicate the potential long-term effects on certain species fisheries, such as OCI's harvesting activities that take place in the November–March period.

OCI's General Manager then explained the difference between "inshore" versus "offshore" harvesting operations/enterprises. He indicated that OCI is an "offshore" company and, as such, its views on the potential effects of seismic activities are very different from those held by most inshore fishers and the FFAW. He went on to say that the offshore stakeholders are trying to get GEAC and CAPP to be more heavily involved in ongoing discussions between the fishing industry and the oil industry. They are very keen to ensure that the views and concerns of the offshore sector are heard.

He said that the FFAW does not reflect our industry's concerns about the effects of seismic operations. OCI and other offshore corporate fishing companies believe that the potential impacts will be more significant for the offshore sector, and consequently, this fishing sector will require mitigation measures different from those for the inshore sector. OCI will need to ensure that seismic operators know where its fishing vessels are going to operate on any particular day.

Seismic operators also need to understand that it is not easy for a company like OCI to change its vessel fishing plans on short notice.

OCI's General Manager went on to say that the offshore fishing industry has been on a "5-year learning curve" with respect to understanding the potential interactions between offshore fisheries activities and the seismic operations. It is only in the last year or so that it has realized that their industry sector needs more consideration during any communications between the two industries. Considering this point, One Ocean's manager suggested that perhaps seismic operators should deal directly with OCI's Fleet Manager rather than communicate through One Ocean. In response, OCI's General Manager suggested that this would not work, primarily because there are twelve other offshore companies / licence holders in the offshore sector that need to be kept informed about offshore seismic operations.

OCI's General Manager will be proposing to One Ocean that GEAC become the "single point of contact" (SPOC) for all of the offshore sector stakeholders and represent fishing companies that are members of both GEAC and CAPP in any discussions and communications between the two industries.

Groundfish Enterprise Allocation Council (GEAC)

GEAC's Executive Director responded in writing and offered the following comments:

> "For your information, the Groundfish Enterprise Allocation Council represents the interests of the offshore groundfish licence holders in Atlantic Canada. This includes enterprises from across the region focused on a wide variety of groundfish species ranging from flatfish to cod and all points in between.
>
> Our licence holders have expressed some interest and questions about the past and future proposed seismic work as it effects catch rates and economic viability of their industry."

Canadian Association of Prawn Producers (CAPP)

To date, the CAPP has not responded with any comments or questions regarding the proposed survey program.

Clearwater Seafoods

Clearwater's spokesperson had the following written comment.

"Thank you for the opportunity to comment on Seitel's project proposal. The information below summarizes the breadth and depth of relevant information Clearwater holds about the commercial clam fishery.

The Canadian Offshore Arctic Surf clam (*Mactromeris polynyma*) fishery takes place on Banquereau Bank, southeast of Nova Scotia, and Grand Banks, southeast of Newfoundland. The proposed project area directly overlaps with the Grand Banks commercial fishing grounds. As well, the project timelines indicate that activity will occur between 1 May and 30 November annually from 2016-2025. Given that Arctic Surf clam fishery occurs year round, there is high potential for vessel and gear interference.

Arctic Surf clams are slow growing, with individual animals taking approximately twenty-three years to reach commercial size on the Grand Banks. As a result, the fishery is conducted very conservatively, as a substantial reduction in biomass would take decades to rebuild. The Arctic Surf clam is also a sedentary species, meaning the commercial concentrations of clams that make the offshore fishery viable are fixed. Any displacement of fishing activities or negative effects on the biomass quantity or quality resulting from the project would result in direct loss of economic opportunities.

Of particular concern is a 2013 study by Aguilar de Soto et al., published in nature, which found that noise exposure from seismic pulses during larval life stages of scallops led to 46% of the test subjects developing body malformations – compared with no malformations in the control group – as well as significant developmental delays. Given the similarities between scallops and clams, the potential effects of seismic exploration on maturation and recruitment suggested by this study, we are concerned about the cumulative impact of a multi-year seismic study on the Grand Banks. As such, we encourage serious consideration of this issue in the Environmental Assessment, including a strategy with specific mitigation and monitoring measures to reduce the risk of long-lasting damage to this sensitive fishery.

As well, the Canadian Science Advisory Secretariat (CSAS) conducted a literature review of scientific studies that examined the effects of seismic and marine noise on invertebrates. Although the studies relating to bivalves were inconclusive and not deemed scientifically rigorous, they nonetheless indicate possible negative effects on physical and physiological characteristics of bivalves. This, at minimum, suggests the need to proceed cautiously and for continuous monitoring to occur.

From an economic perspective, the Arctic Surf clam generates well-paying employment for hundreds of people living in and near the Town of Grand Bank,

and for our crewmembers from across Atlantic Canada. For over thirty years, Clearwater has been committed to value-creation in this fishery and in the region, recently demonstrated this past July by the addition of a $65m vessel to our fleet. It is estimated that our operations in the Arctic Surf clam fishery generate spin off benefits of $22 million to the Canadian economy. This success is predicated on the reputation of the Canadian seafood industry as a supplier of wild, sustainable, pristine product. Damage to this fishery or to its reputation could result in adverse economic effects at individual, company, and local levels, and beyond.

We trust that our concerns around the sustainability of the species and long term viability of the fishery will be appropriately incorporated into the project's Environmental Assessment. Please do not hesitate to contact me for further information. We look forward to continued engagement on this project."

Icewater Fisheries

To date, representatives of Icewater Fisheries have not responded with any comments or questions regarding the proposed program.

Newfoundland Resources Ltd. (NR)

The Newfoundland Resources Ltd. representative did not have any specific comments at this time. He noted that his company usually receives information gathered during consultation from OCI, as well as from GEAC and/or CAPP.

Agency/Stakeholder Individuals Involved in the Consultations

The following agencies, managers and fishing industry participants were consulted during preparation of Seitel's Environmental Assessment.

Fisheries and Oceans Canada

DFO's Triage & Planning Unit

Environment Canada (Environmental Protection Branch)

Jerry Pulchan, Environmental Assessment Analyst, Environmental Stewardship Branch
Joshua Mailhiot, EA Officer
Glen Troke, EA Coordinator

Nature NL

Dr. Len Zedel

One Ocean

Maureen Murphy, Director of Operations

Fish, Food and Allied Workers Union/Unifor (FFAW/Unifor)

Johan Joensen, Petroleum Industry Liaison
Robin Lee
Dwan Street
Nelson Bussey, Fisher
Wayne Russell, Fisher
Glen Winslow, Fisher

Association of Seafood Producers

E. Derek Butler, Executive Director

Ocean Choice International

Rick Ellis, Fleet Manager
Greg Viscount, General Manager

Groundfish Enterprise Allocation Council (GEAC)

Kris Vascotto, Executive Director

Canadian Association of Prawn Producers (CAPP)

Bruce Chapman, Executive Director

Clearwater Seafoods Limited Partnership

Catherine Boyd, Acting Director, Sustainability and Public Affairs

Icewater Seafoods

Dennis Slade, Procurement Coach
Tom Osbourne, Plant Manager, Arnold's Cove

Newfound Resources Ltd. (NRL)

Brian MacNamara, President