Environmental Assessment of CGG's Newfoundland Offshore Seismic Program, 2016-2025

Prepared by



Prepared for



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Environmental Assessment of CGG's Newfoundland Offshore Seismic Program, 2016-2025

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1.0 Introduction

This document is an Environmental Assessment (EA) of CGG Services (Canada) Inc.'s (CGG) proposed 2016-2025 2-Dimensional (2D), 3-Dimensional (3D), and/or 4-Dimensional (4D) marine seismic program in the Newfoundland 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 Section 138 (1)(b) of the *Canada-Newfoundland Atlantic Accord Implementation Act* and Section 134(1)(b) of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* (Accord Acts). This EA has been guided by the 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 portions of the Northern and Southern Grand Banks, the Northeast Slope of Newfoundland, the Flemish Pass, and Orphan Basin. CGG 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 fish and fish habitat, fisheries, marine-associated birds, marine mammals, and sea turtles, 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 and Labrador Atlantic Accord Implementation Act*;
- *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act*;
- *Oceans Act*;
- *Fisheries Act*;
- *Navigation Protection Act*;
- *Canada Shipping Act*;
- *Migratory Birds Convention Act*;
- *Species at Risk Act (SARA)*; and
- *Canadian Environmental Protection Act*.

CGG 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.

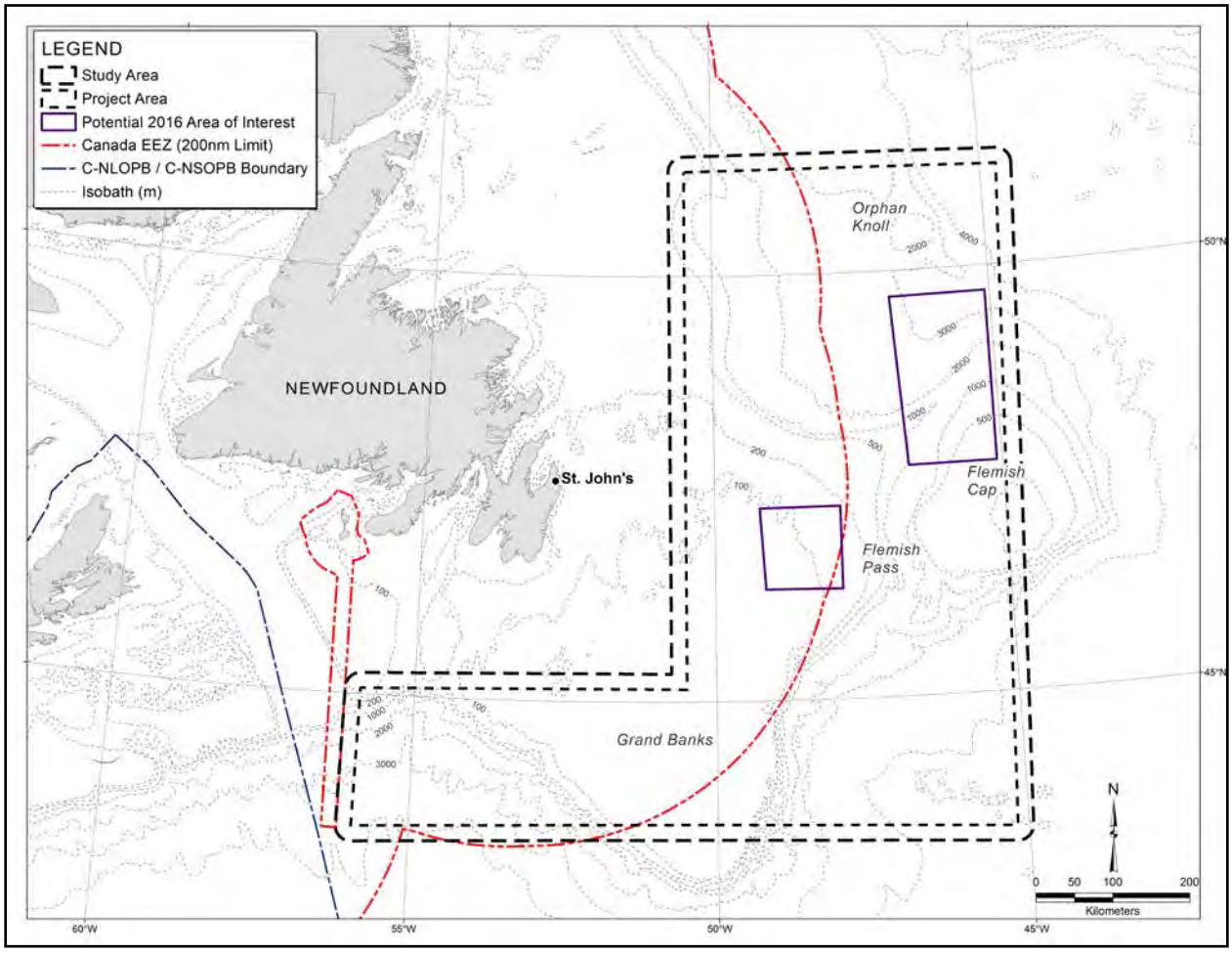


Figure 1.1 Locations of Project Area, Study Area and Two Potential 2016 Areas of Interest for CGG's Proposed Newfoundland Offshore Seismic Program, 2016-2025.

1.2 The Operator

CGG Services (Canada) Inc., a wholly owned subsidiary of CGG, is a fully integrated geoscience company providing leading geological, geophysical and reservoir capabilities to its broad base of customers primarily from the global oil and gas industry. CGG Services (Canada) Inc. is based in Calgary AB. Through its three complementary business divisions of Equipment, Acquisition, and Geology, and Geophysics & Reservoir (GGR), CGG brings value across all aspects of natural resource exploration and exploitation.

1.3 Canada-Newfoundland and Labrador Benefits

In full appreciation of the requirements of the Accord Acts, CGG 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 CGG's requirements.

CGG will manage the operations for these surveys from St. John's, Newfoundland and Labrador. CGG supports the principle that first consideration be given to personnel, support and other services that can be provided within Newfoundland and Labrador, and to goods manufactured in Newfoundland and Labrador, where such goods and services can be delivered at a high standard of Health, Safety and Environmental competency, be of high quality and are competitive in terms of fair market price. Contractors and subcontractors working for CGG 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 the CGG Newfoundland Offshore Seismic Program, 2016-2025. CGG 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 CGG will concurrently conduct two surveys in any given year. The timing of the surveys is subject to CGG 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 area of the Project Area is 436,168 km^2. Just over half of the Project Area (51.7%) is located outside of Canada's Exclusive Economic Zone (EEZ; 200 nm limit). Water depth within the Project Area ranges from <100 m to > 4,000 m (see Figure 1.1).

The six "corner" coordinates (decimal degrees, WGS84 Datum) of the Project Area are as follow:

- 51.227°N, 50.503°W;
- 51.173°N, 44.690°W;
- 43.411°N, 45.188°W;
- 43.445°N, 55.923°W;
- 45.066°N, 55.896°W; and
- 45.145°N, 50.495°W.

The six "corner" coordinates (decimal degrees, WGS84 Datum) of the Study Area are as follow:

- 51.407°N, 50.789°W;
- 51.352°N, 44.405°W;
- 43.232°N, 44.942°W;
- 43.265°N, 56.170°W;
- 45.245°N, 56.150°W; and
- 45.327°N, 50.751°W.

The temporal boundaries of the Project are May 1 to November 30 during 2016-2025. The typical duration of a seismic survey in any given year is 90-120 days.

2.2 Project Overview

The proposed Project is a ship-borne geophysical program that includes approximately 5,000 km^2 of 3D 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 3D survey in 2016, the seismic survey vessel will either be the *CGG Alize* (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. See Figure 1.1 for the locations of potential Areas of Interest in 2016.

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.

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 proposed 2016 3D survey is 90-120 days.

2.2.3 Site Plans

In 2016, it is planned that ~5,000 km^2 of 3D seismic data will be acquired. The 3D seismic survey lines will be primarily orientated north-south with an approximate 600 m separation between adjacent lines. The average survey line length is estimated to be 60 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, CGG will use either the *CGG Alize* (Figure 2.1) or a similar vessel. The *CGG Alize* was rebuilt in France in 1999 and is also registered in France. The vessel is 101 m long, 29 m wide, and has a maximum draft of 7.5 m. The vessel is equipped with two Alstom 4,200 Kw diesel electric motors and has a maximum cruising speed of 14 knots (25.9 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 3D seismic survey sound source proposed for 2016 will consist of two airgun arrays in a flip-flop arrangement, each array consisting of three subarrays of 12 airguns each. The total volume of the proposed sound source (i.e., one airgun array) for 2016 is 4,070 in^3. The maximum sound source volume that will be used during the 10 year program is 6,470 in^3. The airgun arrays will be deployed at a depth of 8-10 m. The airguns will be operated with compressed air at pressures of 2,000 psi. The peak-to-peak sound source level will be ~141.4 bar-m (~263 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.



Figure 2.1 ***CGG Alize.***

2.2.7 Seismic Streamers

In 2016, the 3D seismic survey vessel will tow 12 solid streamers, each 7,000-8,100 m long at a depth of 10-50 m. For subsequent seismic surveys during 2017-2025, the maximum number of streamers that will be used is 16, and the maximum streamer length will be 12,000 m.

2.2.8 Logistics/Support

2.2.8.1 Vessels

Primary support and supply will be provided by CGG's own vessel, MV *Bourbon Grebe*. This vessel was built in Dubai in 2014 and is registered in Cyprus. The vessel is 54 m long, 13 m wide, and has a maximum draft of 4.8 m. A photo of a Bourbon Class supply vessel is provided in Figure 2.2. CGG plans to hire a local supply vessel to supplement its own supply vessel. It is anticipated that one local picket vessel will accompany the seismic vessel. 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.

2.2.8.2 Helicopters

The *CGG Alize* is equipped with a helicopter deck suitable for helicopters like the Sikorsky S-92. Crew changes will be either by helicopter or ship-to-ship transfers.



Figure 2.2 Bourbon Class Supply Vessel.

2.2.8.3 Shore Base, Support and Staging

CGG 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.

2.2.9 Waste Management

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

2.2.10 Air Emissions

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

2.2.11 Accidental Events

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

2.3 Mitigation and Monitoring

Project mitigations are discussed later in the EA (§ 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 eastern and southern Newfoundland offshore area (see Figure 1.1), and includes portions of the Northern and Southern Grand Banks, the Northeast Slope of Newfoundland, the Flemish Pass, and Orphan Basin.

2.4.1 Environmental Features

The physical and biological environments of the general area have been described in the Eastern Newfoundland Strategic Environmental Assessment (SEA) (C-NLOPB 2014)[1], the Southern Newfoundland SEA (C-NLOPB 2010)[2] as well as in two relevant project-specific EAs: WesternGeco's Eastern Newfoundland Offshore Seismic Program, 2015-2024 (LGL 2015a)[3], and WesternGeco's Southeastern Newfoundland Offshore Seismic Program, 2015-2024 (LGL 2015b)[4]. Reviews of the physical and biological environments, based on the two SEAs, the two project-specific EAs and newly available information, are provided in § 3.0 and § 4.0 of this EA, respectively.

Figure 2.3 shows the extent to which the proposed CGG Project and Study areas overlap the study areas associated with the two SEAs and two project-specific EAs indicated above (i.e., 100%).

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

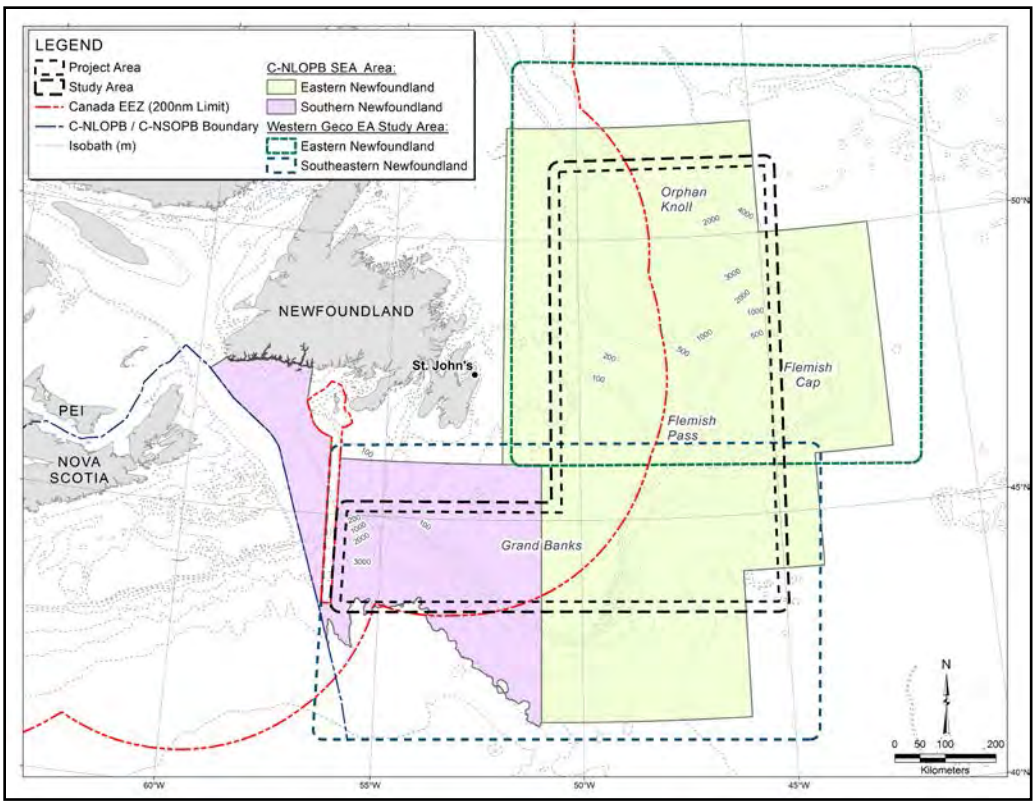


Figure 2.3 Location of CGG's Project and Study Areas Relative to Study Areas Associated with Relevant SEAs and EAs.

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 (2010, 2014) and LGL (2015a,b). The proposed seismic surveys could be conducted in areas with water depth ranging from <100 m 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 weather 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 Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), relevant project-specific EAs (LGL 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 considered in this document is varied and complex. The description of the biological environment is presented in § 4.0 on the basis of Valued Environmental Components (VECs), which include the following:

- 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

In order to assist in scoping the effects assessment and mitigation plan, and to aid in addressing any issues of concern, CGG consulted with the following stakeholders:

- Fisheries and Oceans Canada;
- Environment Canada;
- 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);
- Canadian Association of Prawn Producers;
- Clearwater Seafoods;
- Icewater Seafoods; and
- Newfound Resources Ltd. (NRL).

Results of these consultations are presented in § 5.1.1 and Appendix 1.

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 in the Eastern Newfoundland SEA (C-NLOPB 2014), the Southern Newfoundland SEA (C-NLOPB 2010), and the two relevant project-specific EAs prepared in 2015 (LGL 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 Eastern Newfoundland SEA (§ 4.1 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 2.0 of C-NLOPB 2010), and two project-specific EAs (§ 3.0 of LGL 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 13 areas reflect the bathymetric and geological variability within the Study Area.

1) Orphan Knoll (rising steeply from 3,000 to 1,800 m);
2) Orphan Basin proper (1,200 to 3,500 m);
3) Sackville Spur (≤ 1,000 m);
4) Flemish Pass (deep water > 1,000 m confined between the Grand Banks and the Flemish Cap (~130 m));
5) Eastern portion of the Northeast Newfoundland Shelf (200 to 300 m);
6) Northeast Newfoundland Shelf Slope and Flemish Cap Shelf (>200 to 2,000 m);
7) Jeanne d'Arc Basin (≤ 200 m);
8) 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);
9) 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);
10) Lilly Canyon - Carson Canyon, along the 200 m isobaths of the southeast slope of Grand Bank (> 200 m);
11) Laurentian Basin (500 to ~4,000 m);
12) Newfoundland Basin (2,000 to 5,000 m); and
13) Newfoundland Seamounts (peaks > 2,500 m, with most >3,500 m).

The surficial geology of the Study Area has been described in the Southern and Eastern Newfoundland SEAs (C-NLOPB 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).

Five surficial sedimentary formations are recognized within the Study Area (C-NLOPB 2010, 2014).

1) Grand Banks Drift – glacial till comprised of poorly sorted sand, silt, and clay;
2) Downing Silt – clayey and sandy silt, overlying and interbedded with Grand Banks Drift;
3) Adolphus Sand – fine to coarse-grained sand, containing some silt, clay-sized fractions, and gravel;
4) Placentia Clay – thin, homogeneous sandy to silty mud formation; and
5) Grand Banks Sand and Gravel – basal transgressive sand and gravel deposit.

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 Eastern Newfoundland SEA (C-NLOPB 2014) and two relevant EAs (LGL 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 six grid points to represent the Study Area: (1) grid point 17801 in Orphan Basin; (2) grid point 13912 in the Flemish Pass; (3) grid point 11595 on the Northern Grand Banks; (4) grid point 08026 on the Southern Grand Banks; (5) grid point 05000 in the Laurentian Basin; and (6) grid point 11154 in the Newfoundland Basin (Table 3.1, Figure 3.1). Continuous wind and wave hindcast data for grid points 17801 and 13451 are one-hour time steps from January 1954 to December 2011 (C-NLOPB 2014). Hindcast data for grid point 13912 are one-hour time steps from January 1954 to December 2005 (Oceans 2012). Hindcast data for grid points 05000 and 08026 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
Orphan Basin	17801	51.0°N	49.0°W
Flemish Pass	13912	48.3°N	46.3°W
Northern Grand Banks	11595	47.0°N	50.0°W
Southern Grand Banks	08026	45.0°N	50.0°W
Laurentian Basin	05000	43.5°N	54.5°W
Newfoundland Basin	11154	44.0°N	45.0°W

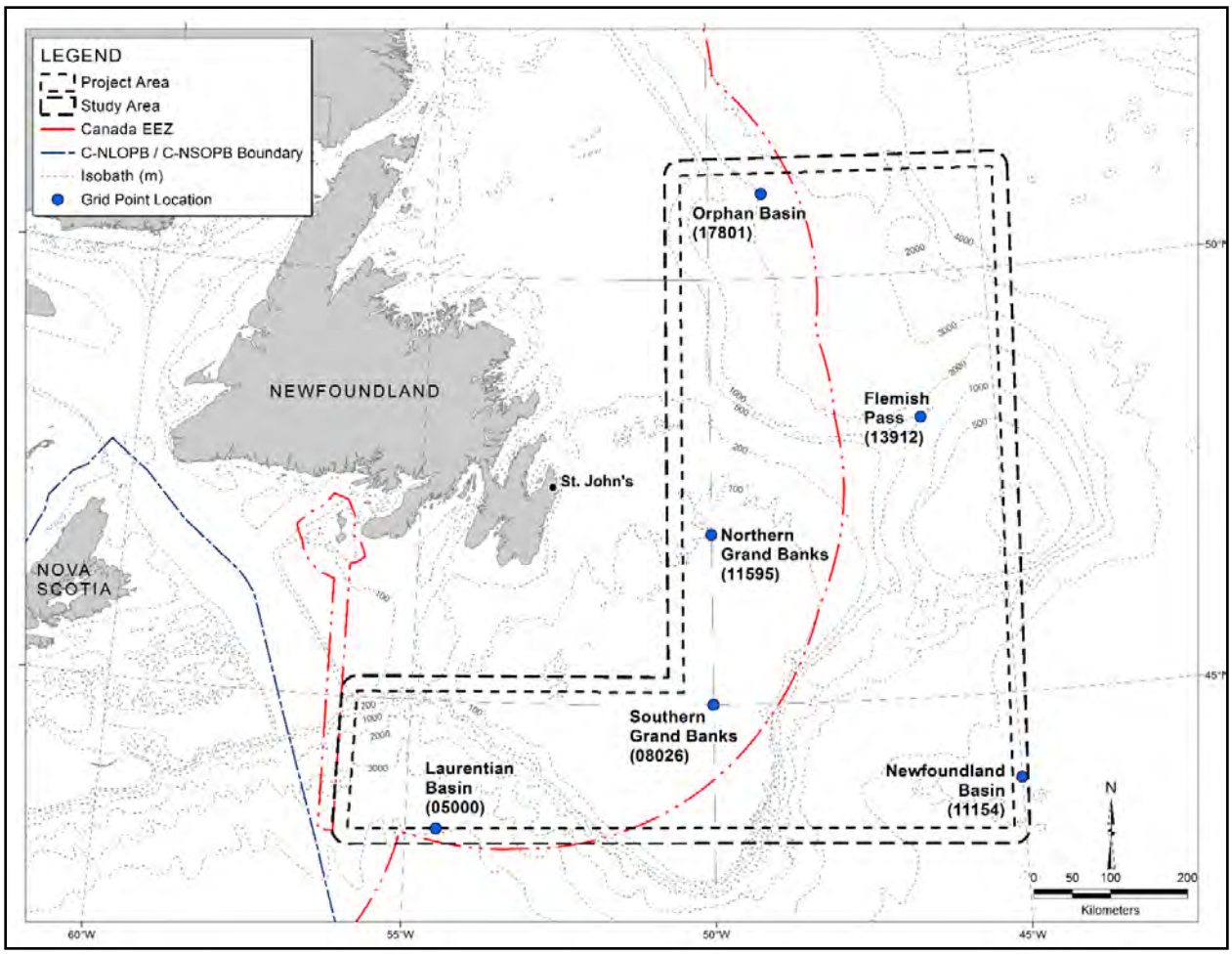


Figure 3.1 Location of MSC50 Grid Points and Regions used in the Physical Environment Analyses.

Data related to air temperature, sea surface temperature, visibility, and precipitation 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 Orphan Basin and the Northern Grand Banks (C-NLOPB 2014). A subset of observations covering the period from January 1980 to December 2010 was used in the analysis for the Flemish Pass (Oceans 2012), and a subset of observations covering the period from January 1980 to December 2013 was used in the analyses for the Southern Grand Banks, Laurentian Basin, and Newfoundland Basin (Oceans 2014).

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 direction. 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 peak during the winter and are highest during January and February 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 5.8 to 6.6 m/s, respectively.

Table 3.2 Mean Hourly Wind Speed Statistics for Offshore Newfoundland.

Month	Mean Wind Speed (m/s)					
	Orphan Basin (17801)	Flemish Pass (13912)	Northern Grand Banks (11595)	Southern Grand Banks (08026)	Laurentian Basin (05000)	Newfoundland Basin (11154)
January	12.4	12.0	11.0	10.4	11.2	11.2
February	12.0	11.6	10.8	10.3	11.2	11.2
March	11.0	10.5	9.8	9.3	10.3	10.2
April	9.6	8.8	8.4	8.0	9.0	9.0
May	8.1	7.6	7.1	6.6	7.5	7.6
June	7.1	6.9	6.6	6.2	6.8	7.0
July	6.6	6.4	6.2	5.8	6.3	6.2
August	7.3	6.7	6.6	6.1	6.7	6.5
September	8.6	8.1	7.7	7.1	7.9	7.6
October	10.0	9.5	8.9	8.3	9.1	8.9
November	11.1	10.3	9.7	9.1	10.1	9.7
December	12.0	11.4	10.6	10.1	11.2	10.9

Sources: C-NLOPB 2014; Oceans 2012, 2014.

3.2.2 Waves

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.

During autumn and winter, 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.

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 3.1 to 3.7 m and 1.6 to 1.8 m, respectively.

Table 3.3 Combined Significant Wave Height Statistics for Offshore Newfoundland.

Month	Significant Wave Height (m)					
	Orphan Basin (17801)	Flemish Pass (13912)	Northern Grand Banks	Southern Grand Banks	Laurentian Basin (05000)	Newfoundland Basin (11154)
January	4.3	4.6	3.7	3.8	4.0	4.3
February	3.6	4.2	3.3	3.7	3.9	4.3
March	3.3	3.6	2.8	3.2	3.5	3.7
April	2.9	3.0	2.5	2.7	2.9	3.1
May	2.3	2.4	2.2	2.1	2.2	2.3
June	1.9	2.0	1.9	1.8	1.9	2.0
July	1.7	1.8	1.7	1.6	1.7	1.7
August	1.8	1.9	1.8	1.7	1.8	1.8
September	2.6	2.6	2.3	2.2	2.3	2.4
October	3.2	3.2	2.9	2.8	2.8	2.9
November	3.7	3.6	3.2	3.1	3.3	3.4
December	4.3	4.3	3.8	3.7	4.0	4.0

Sources: C-NLOPB 2014; Oceans 2012, 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.

3.2.3 Wind and Wave Extreme Value Analysis

An analysis of extreme wind and waves was performed using the six grid points already indicated to represent the Study Area (see Table 3.1, Figure 3.1). The extreme value analysis was based on the Gumbel distribution, to which data were fitted using the peak-over-threshold method for grid points 13912, 08026, 05000, and 11154 (Oceans 2012, 2014) and the maximum likelihood method for grid points 17801 and 11595 (C-NLOPB 2014).

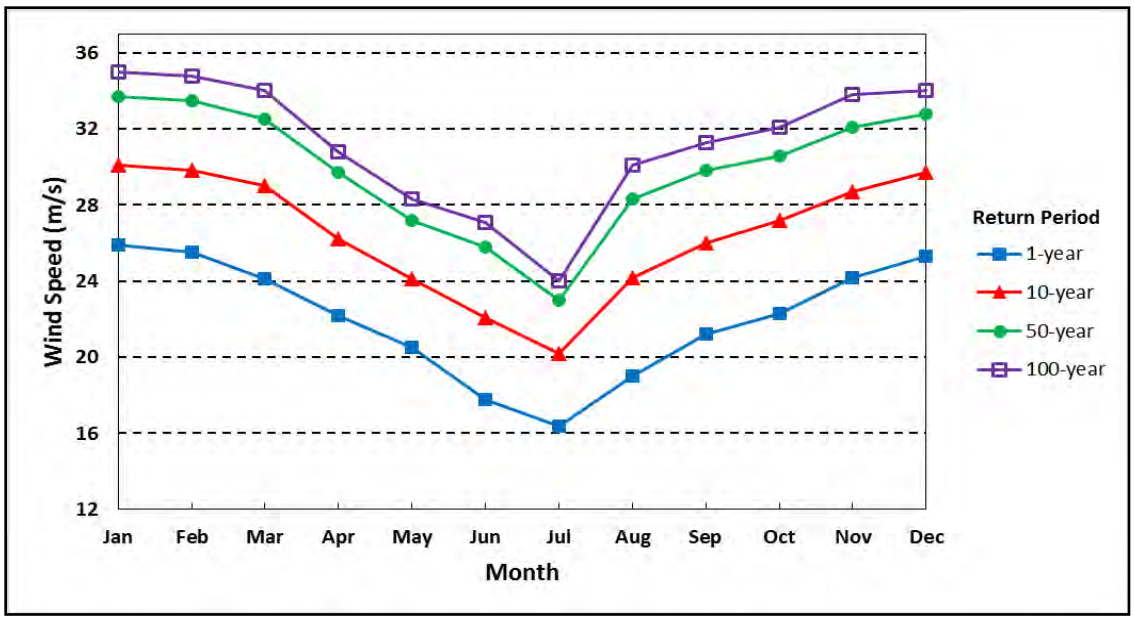
Table 3.4 Combined Maximum Wave Height Statistics for Offshore Newfoundland.

Month	Maximum Wave Height (m)					
	Orphan Basin (17801)	Flemish Pass (13912)	Northern Grand Banks (11595)	Southern Grand Banks (08026)	Laurentian Basin (05000)	Newfoundland Basin (11154)
January	15.9	14.2	11.5	14.1	14.1	15.4
February	13.4	15.3	13.3	12.8	13.3	14.1
March	12.1	13.1	10.4	12.3	12.6	13.1
April	11.5	11.0	10.3	10.7	11.2	10.2
May	10.9	11.7	9.6	7.9	10.2	9.2
June	8.7	10.5	9.1	8.2	9.7	7.7
July	6.3	7.1	6.0	7.0	6.7	7.1
August	11.1	8.2	8.5	9.4	10.1	7.9
September	12.1	13.3	12.8	11.0	13.0	11.3
October	12.7	12.5	10.5	10.8	12.7	12.0
November	13.1	13.2	10.7	11.1	11.8	12.0
December	15.1	15.3	12.1	12.6	12.6	12.9

Sources: C-NLOPB 2014; Oceans 2012, 2014.

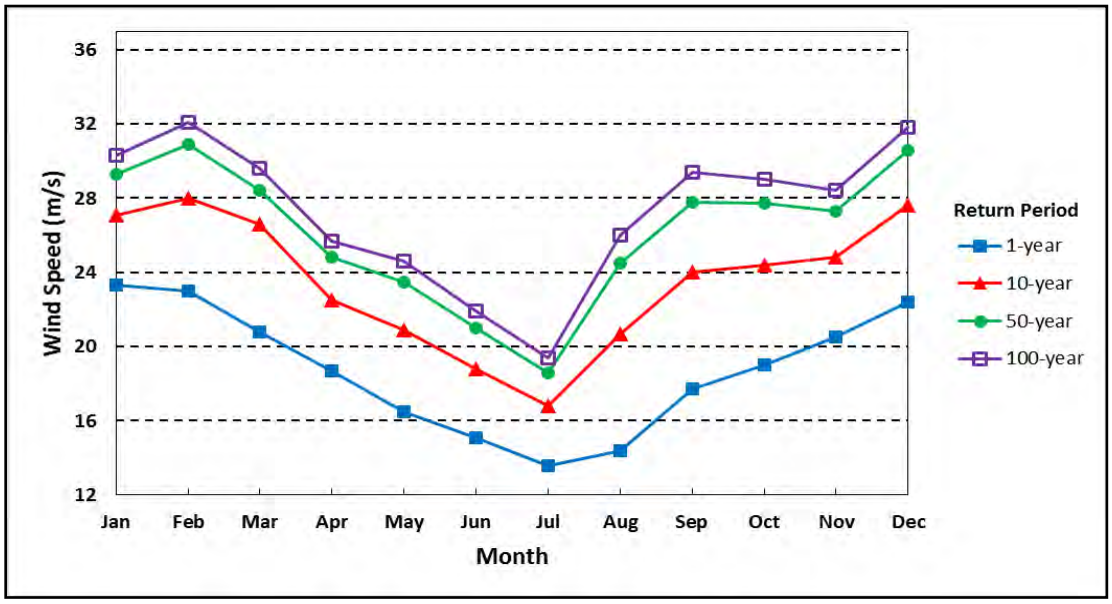
3.2.3.1 Extreme Value Estimates for Winds from the Gumbel Distribution

The extreme value estimates for wind were calculated using Oceanweather's Osmosis software for return periods of 1-year, 10-years, 50-years, and 100-years. 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 analysis used hourly mean wind speeds for a reference height of 10 m above sea level (C-NLOPB 2014; Oceans 2012, 2014). The calculated monthly extreme 1-hour wind speed estimates for grid points within the Study Area are presented in Figures 3.2 to 3.7. The calculated annual 100-year extreme 1-hour wind speed ranged from 30.8 to 35.8 m/s, and was determined to be 35.8 m/s for Orphan Basin (17801), 33.1 m/s for the Flemish Pass (13912), 34.8 m/s for the Northern Grand Banks (11595), 32.3 m/s for the Southern Grand Banks (08026), 31.8 m/s for the Laurentian Basin (05000), and 30.8 m/s for the Newfoundland Basin (11154). 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.



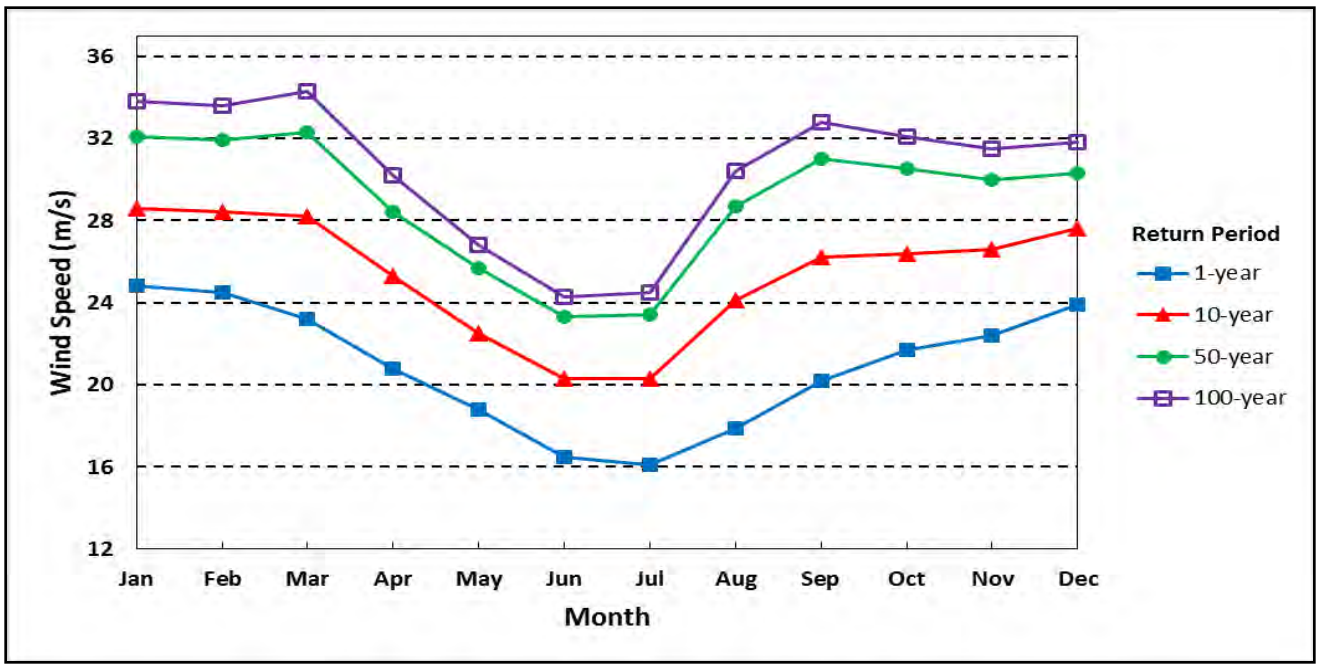
Source: C-NLOPB 2014.

Figure 3.2 Extreme 1-hour Wind Speed Estimates for Orphan Basin (17801).



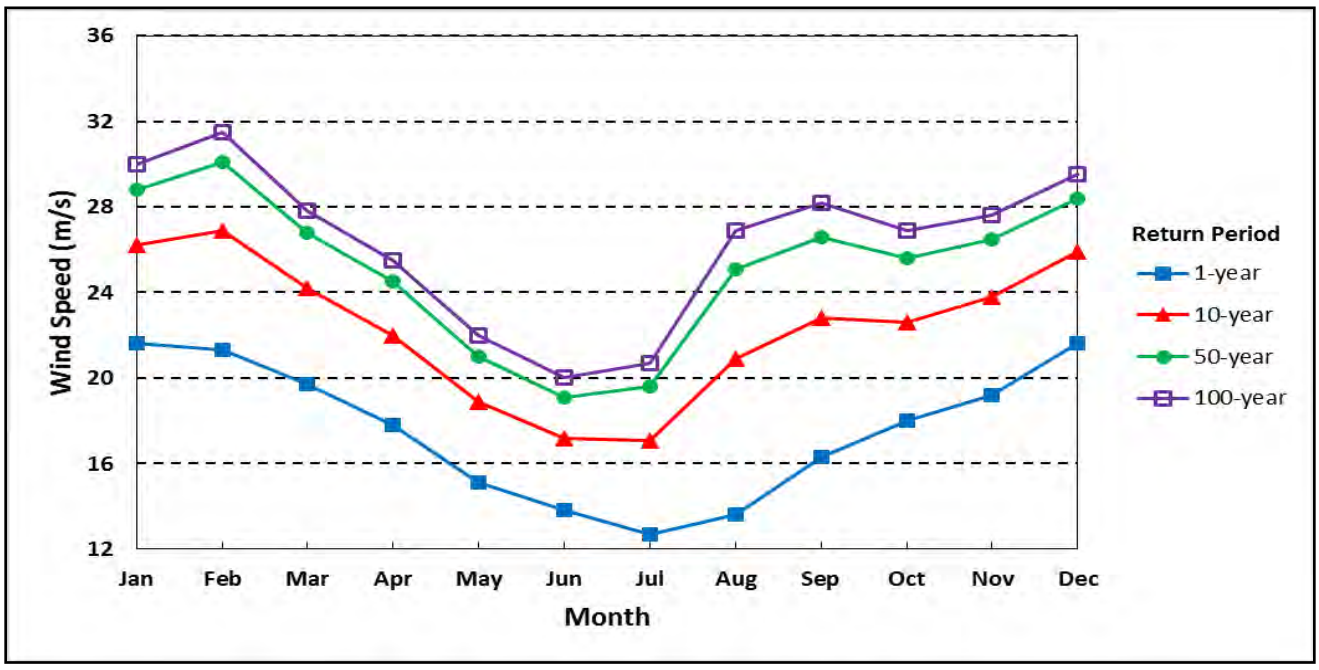
Source: Oceans 2012.

Figure 3.3 Extreme 1-hour Wind Speed Estimates for the Flemish Pass (13912).



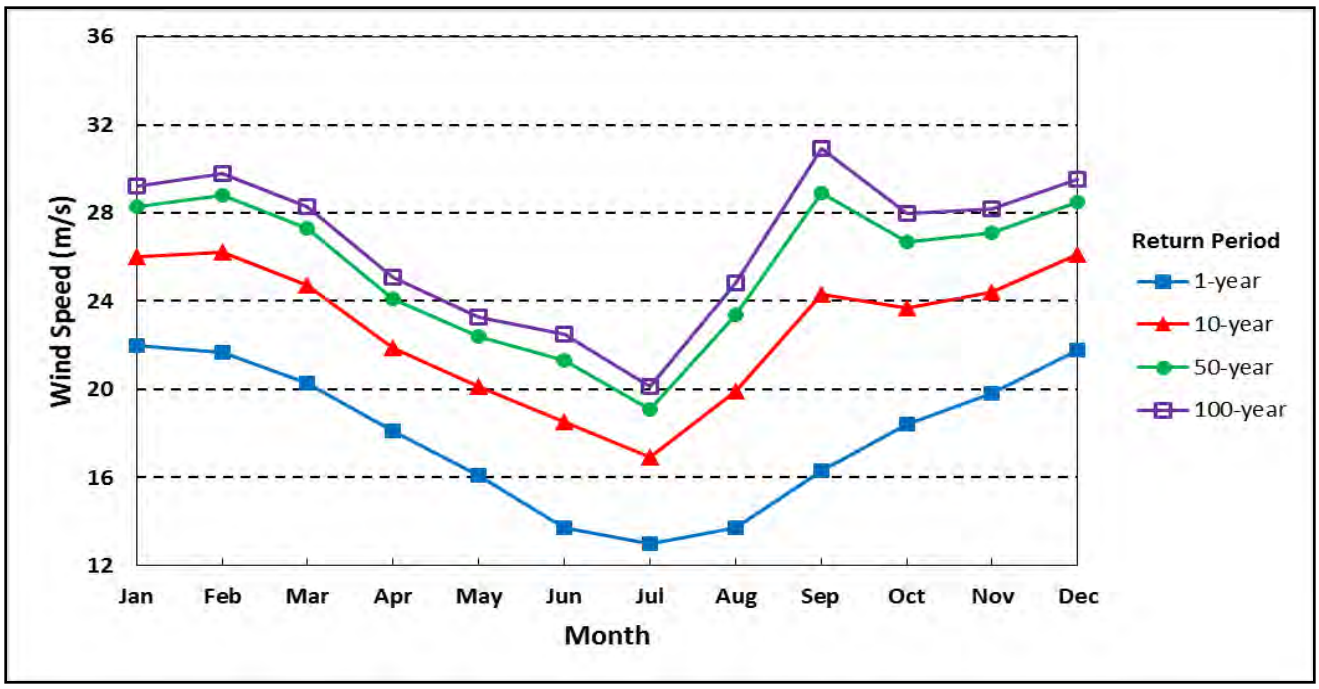
Source: C-NLOPB 2014.

Figure 3.4 Extreme 1-hour Wind Speed Estimates for the Northern Grand Banks (11595).



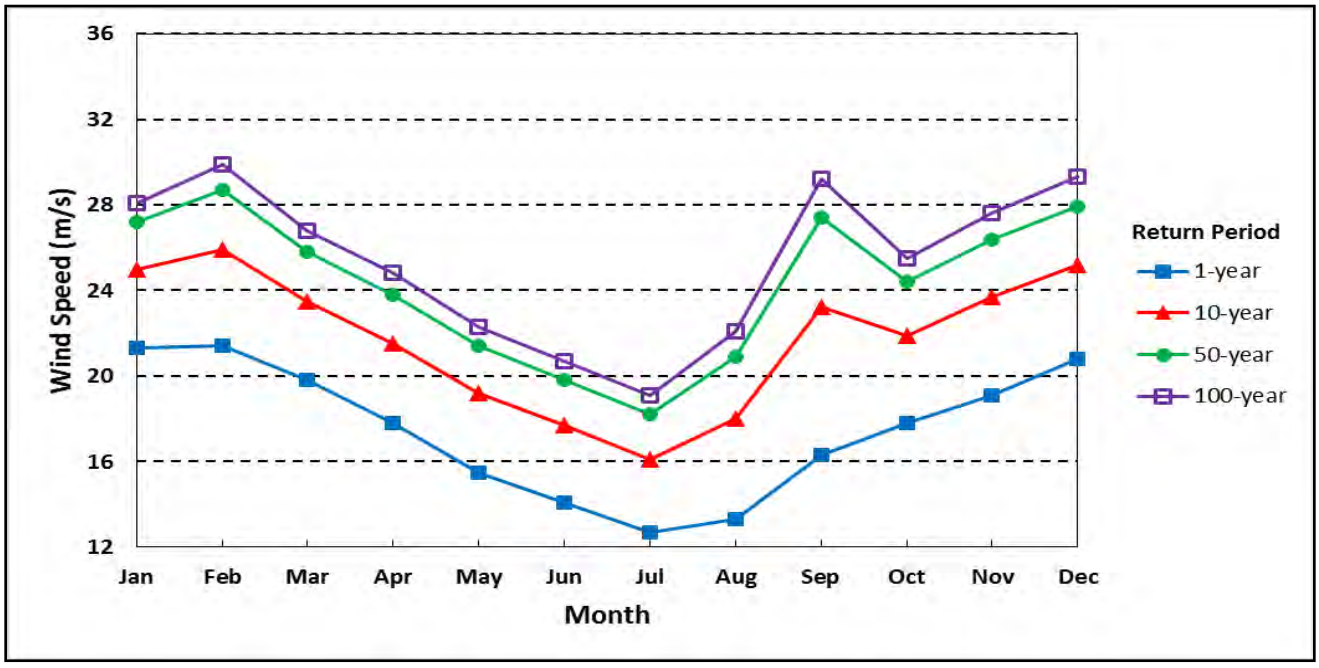
Source: Oceans 2014.

Figure 3.5 Extreme 1-hour Wind Speed Estimates for the Southern Grand Banks (08026).



Source: Oceans 2014.

Figure 3.6 Extreme 1-hour Wind Speed Estimates for the Laurentian Basin (05000).

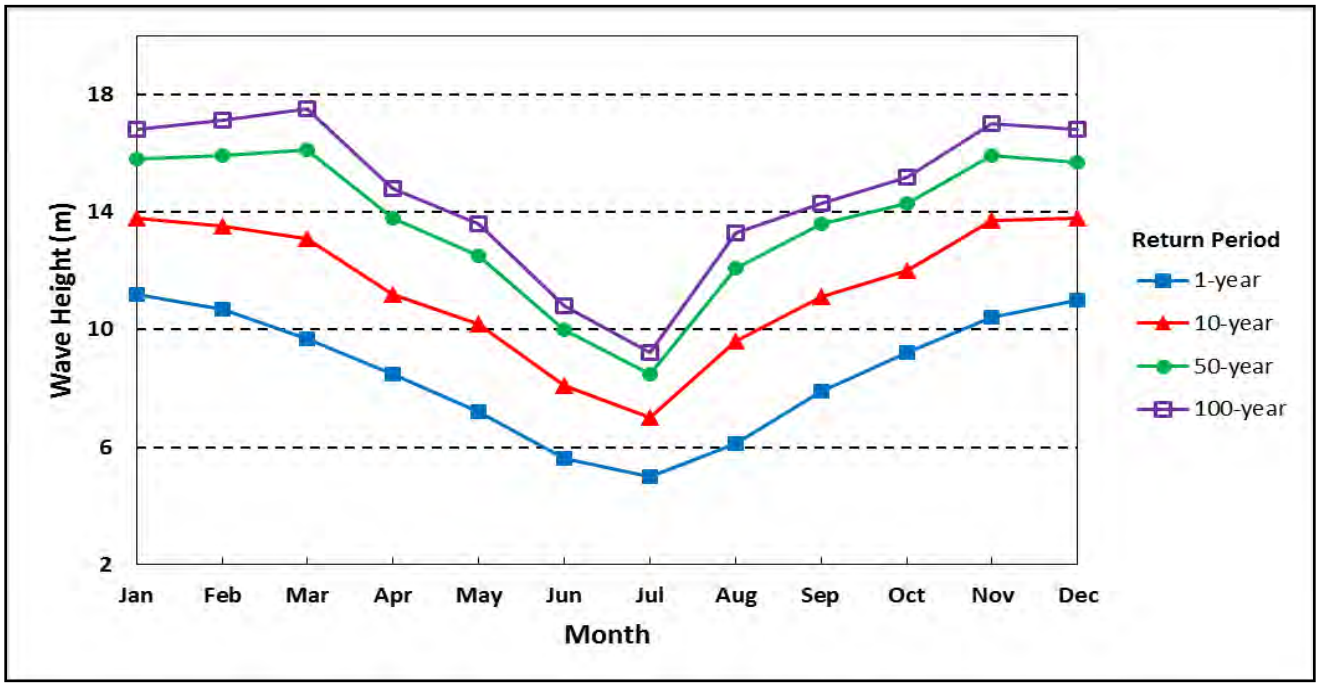


Source: Oceans 2014.

Figure 3.7 Extreme 1-hour Wind Speed Estimates for the Newfoundland Basin (11154).

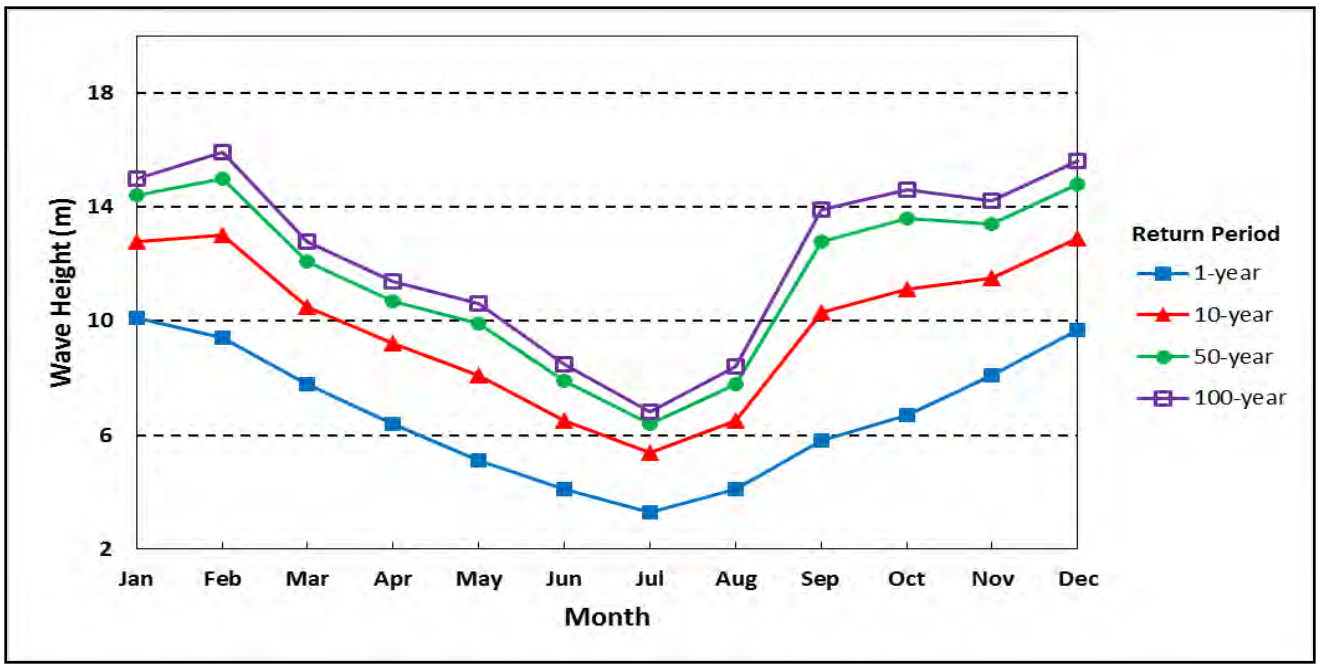
3.2.3.2 Extreme Value Estimates for Waves from a Gumbel Distribution

The monthly extreme value estimates for significant wave height for return periods of 1-year, 10-years, 50-years, and 100-years for grid points within the Study Area are presented in Figures 3.8 to 3.13. 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. The calculated annual 100-year extreme significant wave height ranged from 14.1 to 16.3 m, and was determined to be 16.3 m for Orphan Basin (17801), 16.0 m for the Flemish Pass (13912), 14.3 m for the Northern Grand Banks (11595), 14.1 m for the Southern Grand Banks (08026), 14.6 m for the Laurentian Basin (05000), and 14.8 m for the Newfoundland Basin (11154). 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.



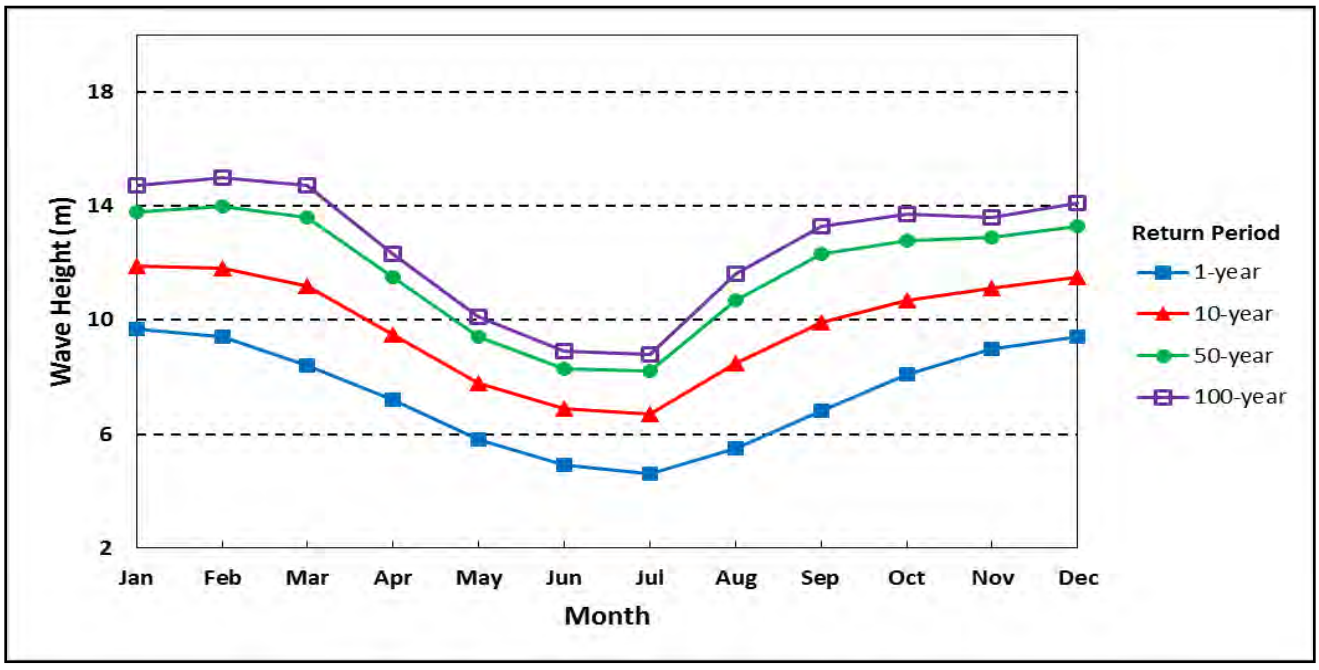
Source: C-NLOPB 2014.

Figure 3.8 Extreme Significant Wave Height Estimates for Orphan Basin (17801).



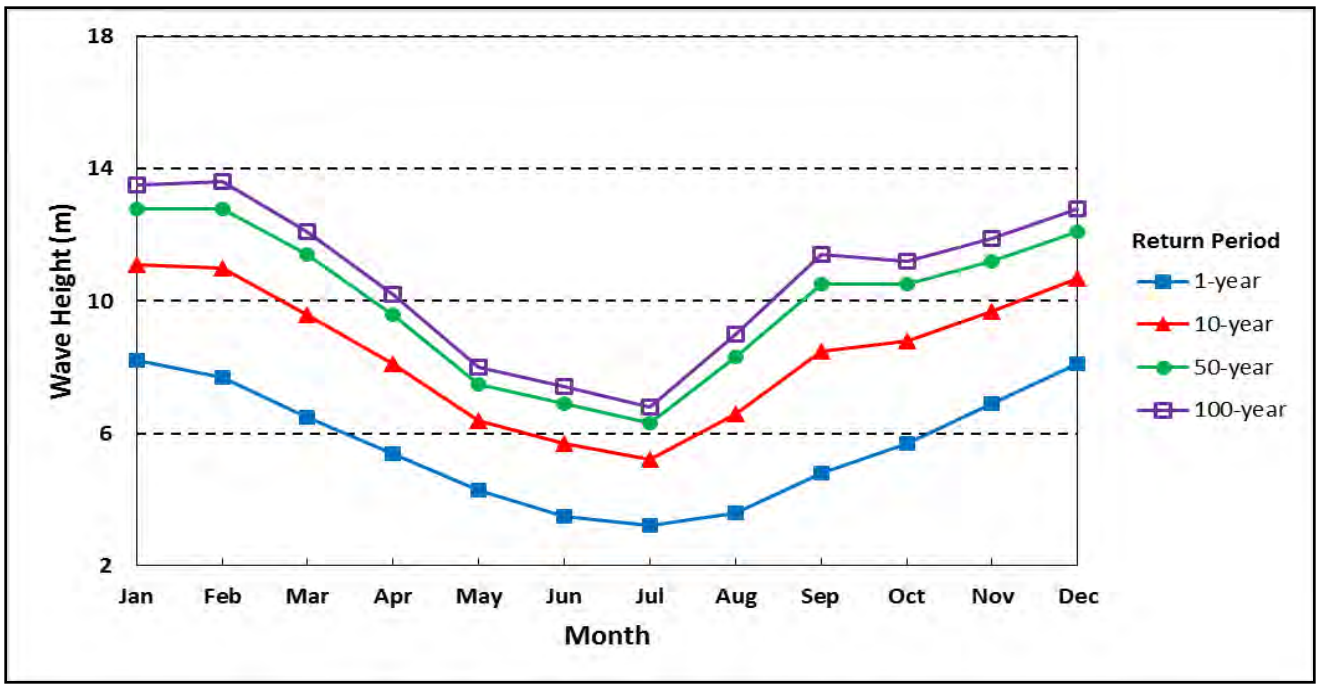
Source: Oceans 2012.

Figure 3.9 Extreme Significant Wave Height Estimates for the Flemish Pass (13912).



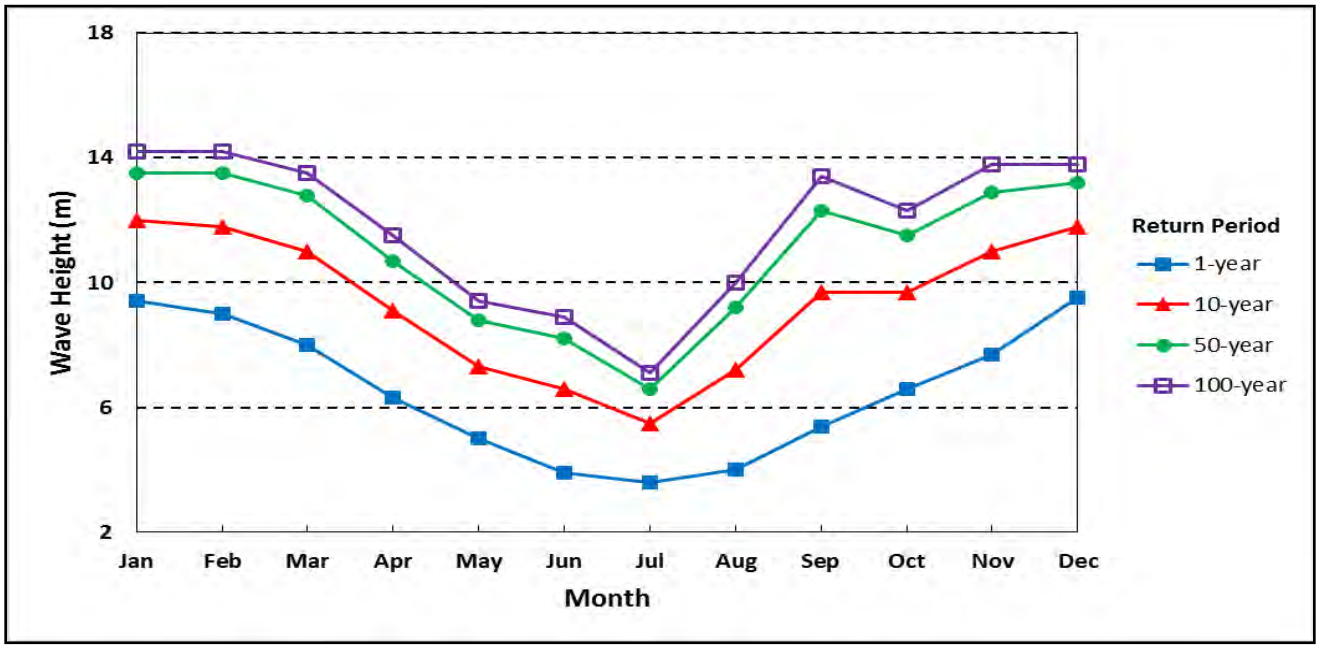
Source: C-NLOPB 2014.

Figure 3.10 Extreme Significant Wave Height Estimates for the Northern Grand Banks (11595).



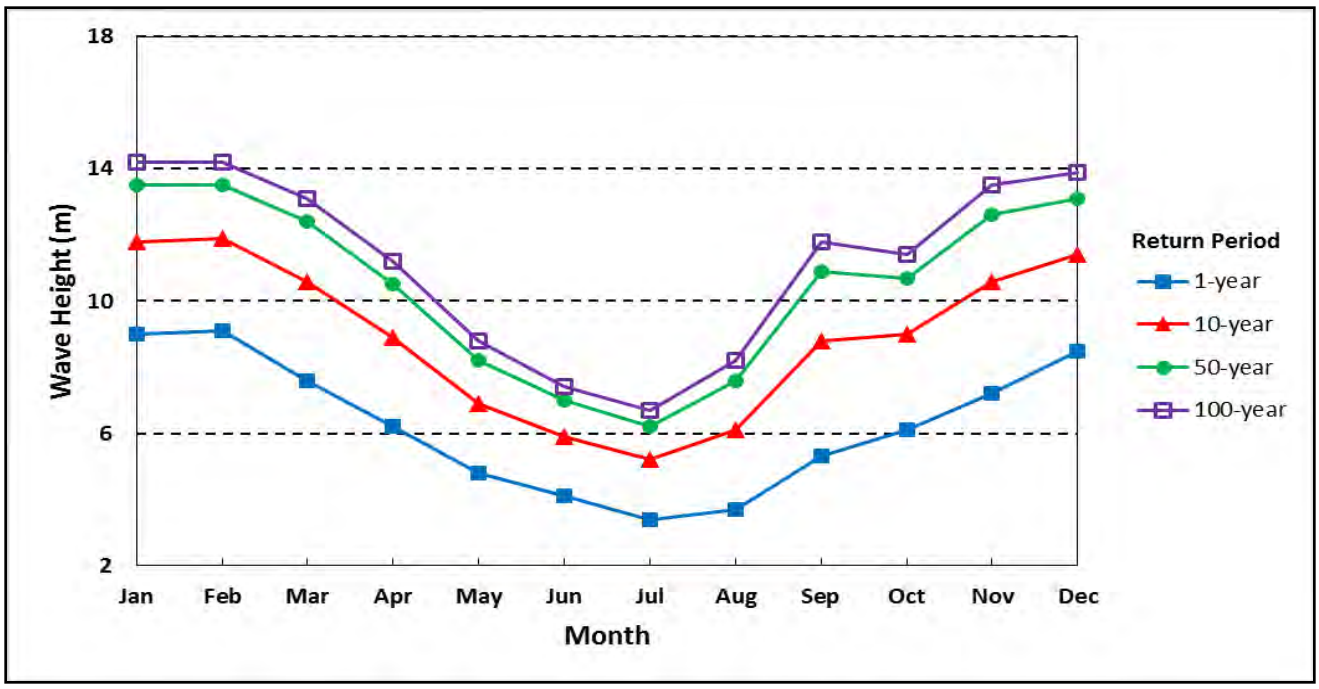
Source: Oceans 2014.

Figure 3.11 Extreme Significant Wave Height Estimates for the Southern Grand Banks (08026).



Source: Oceans 2014.

Figure 3.12 Extreme Significant Wave Height Estimates for the Laurentian Basin (05000).



Source: Oceans 2014.

Figure 3.13 Extreme Significant Wave Height Estimates for the Newfoundland Basin (11154).

3.2.4 Weather Variables

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. Air and sea surface temperatures for each region (see Figure 3.1) were extracted from the ICOADS data set (C-NLOPB 2014; Oceans 2012, 2014). Mean monthly air temperatures and sea surface temperatures for the Study Area are presented in Tables 3.5 and 3.6, 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.

Table 3.5 Mean Monthly Air Temperatures for Offshore Newfoundland.

Month	Air Temperature (°C)					
	Orphan Basin	Flemish Pass	Northern Grand Banks	Southern Grand Banks	Laurentian Basin	Newfoundland Basin
January	-1.4	3.9	0.4	2.3	1.9	6.4
February	-2.9	3.1	-0.1	1.3	0.8	6.0
March	-0.4	3.7	0.7	2.0	1.4	6.8
April	1.3	3.8	2.3	3.9	4.0	9.6
May	3.5	5.2	4.4	6.2	6.9	11.1
June	6.6	6.7	7.6	9.9	10.6	13.6
July	10.1	9.3	12.1	15.4	16.0	17.6
August	11.7	11.5	14.6	17.7	18.3	18.7
September	10.3	11.3	12.8	15.6	16.2	17.1
October	6.6	9.4	9.2	12.5	12.3	14.0
November	3.7	7.4	5.6	8.0	8.6	11.2
December	1.1	5.8	2.5	5.1	4.8	8.5

Sources: C-NLOPB 2014; Oceans 2012, 2014.

Table 3.6 Mean Monthly Sea Surface Temperatures for Offshore Newfoundland.

Month	Sea Surface Temperature (°C)					
	Orphan Basin	Flemish Pass	Northern Grand Banks	Southern Grand Banks	Laurentian Basin	Newfoundland Basin
January	0.9	4.0	0.9	3.6	4.3	11.7
February	0.4	2.9	0.0	2.5	3.2	10.2
March	0.7	3.3	0.1	2.2	2.9	9.9
April	1.2	3.3	0.7	2.8	3.7	9.9
May	2.5	4.7	2.6	5.2	6.1	11.8
June	4.8	6.6	5.5	8.9	10.3	14.0
July	8.4	9.2	10.3	14.5	15.3	17.5
August	11.3	11.8	14.0	17.9	18.3	20.3
September	10.6	11.6	13.5	17.1	17.0	18.8
October	7.7	9.9	10.5	13.0	13.4	16.3
November	4.7	7.2	6.8	8.9	10.0	14.9
December	2.5	5.6	3.5	6.0	7.0	13.2

Sources: C-NLOPB 2014; Oceans 2012, 2014.

3.2.4.2 Precipitation

Precipitation may occur in three forms, classified as liquid, freezing, or frozen. Included in these classifications are:

- Liquid precipitation
  - Drizzle
  - Rain
- Freezing precipitation
  - Freezing drizzle
  - Freezing rain
- Frozen precipitation
  - Snow
  - Snow pellets
  - Snow grains
  - Ice pellets
  - Hail
  - Ice crystals

The migratory high and low pressure systems transiting the middle latitudes of the Northern Hemisphere result in a variety of precipitation types. The frequency of occurrence of each precipitation type was calculated as a percentage of the total monthly and annual weather observations from the ICOADS data set, with each occurrence counting as one event. The frequencies of occurrence of precipitation types for regions within the Study Area are presented in Tables 3.7 to 3.12.

Most of the observed precipitation events are in the form of rain or snow. From May to November, the monthly occurrence of rain events is lowest during July and highest during October and November. The minimum frequency of snow events occurs from May to November, ranging from 0.0 to 4.6%, and is lowest during the summer months. Other types of precipitation, such as freezing rain/drizzle, mixed rain/snow, and hail, occur less frequently than rain or snow. Thunderstorms occur infrequently over the Study Area, although there is a year-round potential of occurrence. In general, thunderstorms are most frequent during the summer months.

Table 3.7 Frequency of Occurrence of Precipitation for Orphan Basin.

Month	Frequency of Occurrence (%)					
	Rain/Drizzle	Freezing Rain/Drizzle	Rain/Snow Mixed	Snow	Hail	Thunder Storm
January	6.7	0.3	1.9	21.5	0.5	0.1
February	4.0	0.3	0.8	18.6	0.3	0.1
March	6.2	0.2	1.2	14.2	0.5	0.3
April	8.0	0.2	0.8	7.2	0.3	0.2
May	9.1	0.1	0.5	2.0	0.3	0.3
June	8.2	0.0	0.1	0.1	1.4	1.4
July	7.3	0.0	0.0	0.1	0.6	0.7
August	8.5	0.0	0.0	0.0	0.3	0.2
September	9.9	0.0	0.1	0.1	0.2	0.2
October	12.6	0.0	0.3	0.9	0.3	0.2
November	11.1	0.1	0.8	4.6	0.4	0.1
December	8.4	0.2	1.5	12.7	0.5	0.1
Annual	8.2	0.1	0.6	7.0	0.5	0.3

Source: C-NLOPB 2014.

Table 3.8 Frequency of Occurrence of Precipitation for the Flemish Pass.

Month	Frequency of Occurrence (%)					
	Rain/Drizzle	Freezing Rain/Drizzle	Rain/Snow Mixed	Snow	Hail	Thunder Storm
January	12.3	0.1	1.7	20.8	0.3	0.1
February	11.6	0.2	1.5	20.5	0.0	0.1
March	11.2	0.1	1.0	14.2	0.0	0.1
April	9.9	0.1	0.4	6.0	0.1	0.0
May	13.5	0.0	0.2	2.2	0.0	0.1
June	14.9	0.0	0.0	0.2	0.0	0.1
July	12.2	0.0	0.0	0.1	0.0	0.4
August	14.5	0.0	0.0	0.1	0.1	0.3
September	21.1	0.0	0.0	0.6	0.0	0.2
October	19.7	0.0	0.0	0.6	0.0	0.2
November	17.9	0.0	1.6	3.6	0.8	0.2
December	14.6	0.0	2.5	11.5	0.4	0.2
Annual	13.4	0.1	0.7	7.3	0.1	0.1

Source: Oceans 2012.

Table 3.9 Frequency of Occurrence of Precipitation for the Northern Grand Banks.

Month	Frequency of Occurrence (%)					
	Rain/Drizzle	Freezing Rain/Drizzle	Rain/Snow Mixed	Snow	Hail	Thunder Storm
January	10.1	0.4	0.7	14.4	0.5	0.1
February	8.2	0.6	0.6	14.8	0.3	0.0
March	8.8	0.7	0.5	9.8	0.3	0.1
April	10.2	0.2	0.3	3.7	0.2	0.1
May	10.0	0.1	0.1	0.8	0.2	0.1
June	9.6	0.0	0.1	0.1	0.2	0.2
July	8.4	0.0	0.1	0.1	0.3	0.4
August	9.6	0.0	0.1	0.1	0.3	0.4
September	10.6	0.0	0.1	0.1	0.1	0.1
October	14.1	0.0	0.1	0.3	0.3	0.3
November	14.2	0.1	0.4	2.8	0.4	0.1
December	12.0	0.1	0.8	8.5	0.4	0.1
Annual	10.4	0.2	0.3	4.4	0.3	0.2

Source: C-NLOPB 2014.

Table 3.10 Frequency of Occurrence of Precipitation for the Southern Grand Banks.

Month	Frequency of Occurrence (%)					
	Rain/Drizzle	Freezing Rain/Drizzle	Rain/Snow Mixed	Snow	Hail	Thunder Storm
January	12.5	0.2	1.4	12.3	0.0	0.2
February	11.6	0.4	1.5	15.4	0.4	0.4
March	12.4	0.4	0.9	10.9	0.2	0.2
April	12.8	0.1	0.4	4.0	0.0	0.1
May	13.5	0.0	0.2	0.9	0.0	0.0
June	11.1	0.0	0.0	0.4	0.0	0.1
July	8.6	0.0	0.0	0.1	0.0	0.3
August	11.9	0.0	0.1	0.4	0.1	0.5
September	16.4	0.0	0.0	0.3	0.0	0.3
October	17.5	0.0	0.1	0.6	0.1	0.4
November	15.7	0.0	0.7	2.5	0.3	0.4
December	16.8	0.0	0.8	8.6	0.2	0.1
Annual	13.3	0.1	0.5	4.3	0.1	0.3

Source: Oceans 2014.

Table 3.11 Frequency of Occurrence of Precipitation for the Laurentian Basin.

Month	Frequency of Occurrence (%)					
	Rain/Drizzle	Freezing Rain/Drizzle	Rain/Snow Mixed	Snow	Hail	Thunder Storm
January	10.9	0.4	1.8	25.2	0.2	0.2
February	9.8	0.7	2.2	23.8	0.1	0.1
March	11.5	0.5	1.0	14.4	0.2	0.2
April	14.0	0.1	0.5	4.7	0.1	0.1
May	11.4	0.0	0.0	0.8	0.0	0.2
June	14.4	0.0	0.0	0.4	0.1	0.3
July	9.5	0.0	0.0	0.3	0.1	0.4
August	13.4	0.0	0.1	0.2	0.1	0.7
September	15.6	0.0	0.1	0.5	0.1	0.3
October	19.7	0.0	0.2	0.7	0.1	0.2
November	20.0	0.0	1.1	4.1	0.6	0.2
December	15.1	0.1	1.8	13.0	0.4	0.3
Annual	13.7	0.2	0.7	6.7	0.2	0.3

Source: Oceans 2014.

Table 3.12 Frequency of Occurrence of Precipitation for the Newfoundland Basin.

Month	Frequency of Occurrence (%)					
	Rain/Drizzle	Freezing Rain/Drizzle	Rain/Snow Mixed	Snow	Hail	Thunder Storm
January	19.6	0.0	1.6	7.9	1.4	0.4
February	19.9	0.2	1.6	9.0	1.0	0.5
March	20.2	0.0	1.0	6.8	0.9	0.3
April	16.7	0.0	0.3	1.9	0.3	0.1
May	15.1	0.0	0.1	0.8	0.0	0.3
June	14.3	0.0	0.1	0.7	0.0	0.2
July	10.5	0.0	0.1	0.3	0.1	0.4
August	14.5	0.0	0.1	0.2	0.1	0.5
September	17.1	0.0	0.1	0.5	0.0	0.4
October	19.7	0.0	0.1	0.4	0.2	0.5
November	21.2	0.0	0.3	1.6	0.8	0.6
December	23.8	0.0	1.1	4.3	1.4	0.7
Annual	17.5	0.0	0.5	2.9	0.5	0.4

Source: Oceans 2014.

3.2.4.3 Visibility

Visibility is defined as the greatest distance at which objects of suitable dimensions can be seen and identified. Horizontal visibility may be reduced by any of the following 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.

The frequency distributions of visibility states from the ICOADS data set for each region within the Study Area are presented in Tables 3.13 to 3.18. The visibility states have been defined as very poor (less than 0.5 km for Orphan Basin and the Northern Grand Banks, and less than 1 km for all other regions), poor (0.5 to 2 km for Orphan Basin and the Northern Grand Banks, and 1 to 2 km for all other regions, fair (2 to 10 km), and good (greater than 10 km). Annually, the Southern Grand Banks has the highest occurrence of reduced visibility, with poor to very poor visibility (less than 2 km) occurring 23.9% of the time, followed by the Northern Grand Banks (23.7%), the Flemish Pass (~23.0%), Orphan Basin (19.5%), the Laurentian Basin (18.5%), and the Newfoundland Basin (10.4%). In all regions, visibility is poorest during July, with poor to very poor visibility occurring ~56.0% of the time in the Flemish Pass, 51.8% on the Northern Grand Banks, 47.7% on the Southern Grand Banks, 41.5% in the Orphan Basin, 36.1% in the Laurentian Basin, and 24.8% in the Newfoundland Basin. There is less seasonal variation in visibility in the Newfoundland Basin and farther south of the Grand Banks.

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.

Table 3.13 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 3.14 Frequency of Occurrence of Visibility States for the Flemish Pass.

Month	Frequency of Occurrence (%)			
	Very Poor (< 1 km)	Poor (1 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	8	4	21	67
February	9	5	22	64
March	12	4	18	66
April	23	3	13	61
May	26	2	13	59
June	28	4	15	53
July	52	4	11	33
August	31	3	14	52
September	13	3	13	71
October	9	2	14	75
November	12	2	16	70
December	7	3	17	73
Annual	20	3	15	62

Source: Oceans 2012.

Table 3.15 Frequency of Occurrence of Visibility States for the Northern 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

Sources: C-NLOPB 2014.

Table 3.16 Frequency of Occurrence of Visibility States for the Southern Grand Banks.

Month	Frequency of Occurrence (%)			
	Very Poor (< 1 km)	Poor (1 – 2 km)	Fair (2 – 10 km)	Good (>10 km)
January	9.0	2.4	17.3	71.3
February	13.0	3.4	18.5	85.1
March	14.2	3.3	14.9	67.6
April	25.7	4.0	14.3	56.0
May	32.6	4.3	13.2	49.8
June	37.4	3.0	12.3	47.3
July	44.4	3.3	13.1	39.2
August	22.2	3.0	12.9	61.9
September	13.6	2.3	12.8	71.3
October	8.5	2.0	11.2	78.3
November	11.4	2.8	12.0	73.8
December	9.1	2.9	16.5	71.5
Annual	20.8	3.1	14.0	62.2

Source: Oceans 2014.

Table 3.17 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 3.18 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.

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. The influence of advection fog is mainly noticed in the Laurentian Sub-Basin and the Southern Grand Banks since the other regions experience a warmer climate.

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.]

During the winter months, an upper level trough tends to lie over central Canada and an upper ridge over the North Atlantic, resulting in three main storm tracks affecting the region: (1) one from the Great Lakes Basin; (2) one from Cape Hatteras, North Carolina; and (3) one from the Gulf of Mexico. These storm tracks, on average, bring eight low pressure systems per month over the area. The intensity of these systems ranges from relatively weak features to major winter storms. With increasing solar radiation during spring, there is a general warming of the atmosphere that is relatively greater at higher latitudes. This decreases the north-south temperature contrast, lowers the kinetic energy of the westerly flow aloft, and decreases the potential energy available for storm development. By summer, the main storm tracks have moved further north than in winter, and storms are less frequent and much weaker. During the summer months, with low pressure systems normally passing to the north of the region, in combination with the northwest sector of the sub-tropical high to the south, the prevailing wind direction across the Grand Banks is from the southwest to south. Wind speed is lower during the summer, and gale or storm force winds are relatively infrequent. There is also a corresponding decrease in significant wave heights.

Frequently, intense low pressure systems become ‘captured’ and slow down or stall off the coast of Newfoundland and Labrador. This may result in an extended period of little change in

conditions that may range, depending on the position, overall intensity, and size of the system, from relatively benign to heavy weather conditions.

Rapidly deepening storms are a problem south of Newfoundland in the vicinity of the warm water of the Gulf Stream. Sometimes explosively deepening oceanic cyclones develop into a "weather bomb"; defined as a storm that undergoes central pressure decreases greater than 24 mb over 24 hours. Typical features of weather bombs include hurricane force winds near the center, the outbreak of convective clouds to the north and east of the center during the explosive stage, and the presence of a clear area near the center in its mature stage. After development, these systems will either move across Newfoundland or near the southeast coast producing gale to storm force winds from the southwest to south.

In addition to extratropical cyclones, tropical cyclones often retain their tropical characteristics as they enter the Study Area. Tropical cyclones account for the strongest sustained surface winds observed anywhere on earth. The hurricane season in the North Atlantic Basin normally extends from June through November, although tropical storm systems occasionally occur outside this period. Once formed, a tropical storm or hurricane will maintain its energy as long as a sufficient supply of warm, moist air is available. These systems typically move east to west over the warm water of the tropics; however, some of these systems turn northward, moving towards Newfoundland and the Orphan Basin. Since the capacity of the air to hold water vapour is dependent on temperature, as the hurricanes move northward over the colder ocean waters, they begin to lose their tropical characteristics. By the time these weakening cyclones reach Newfoundland, they are generally embedded into a mid-latitude low and are classified as post-tropical, either as an extratropical cyclone or a remnant low. Occasionally, conditions are favourable for tropical cyclones to retain their tropical characteristics long enough to reach the Orphan Basin.

A significant number of tropical cyclones that move into the mid-latitudes will undergo transition into extratropical cyclones. On average, 46% of tropical cyclones formed in the Atlantic transform into extratropical cyclones. During this transformation, the system loses tropical characteristics and becomes more extratropical in nature. These systems frequently produce large waves, gale to hurricane force winds, and intense rainfall. The likelihood that a tropical cyclone will undergo transition into an extratropical cyclone increases toward the second half of the tropical season, with October having the highest probability of transition. In the Atlantic, extratropical transition occurs at lower latitudes in the early and late hurricane season and at higher latitudes during the peak of the season.

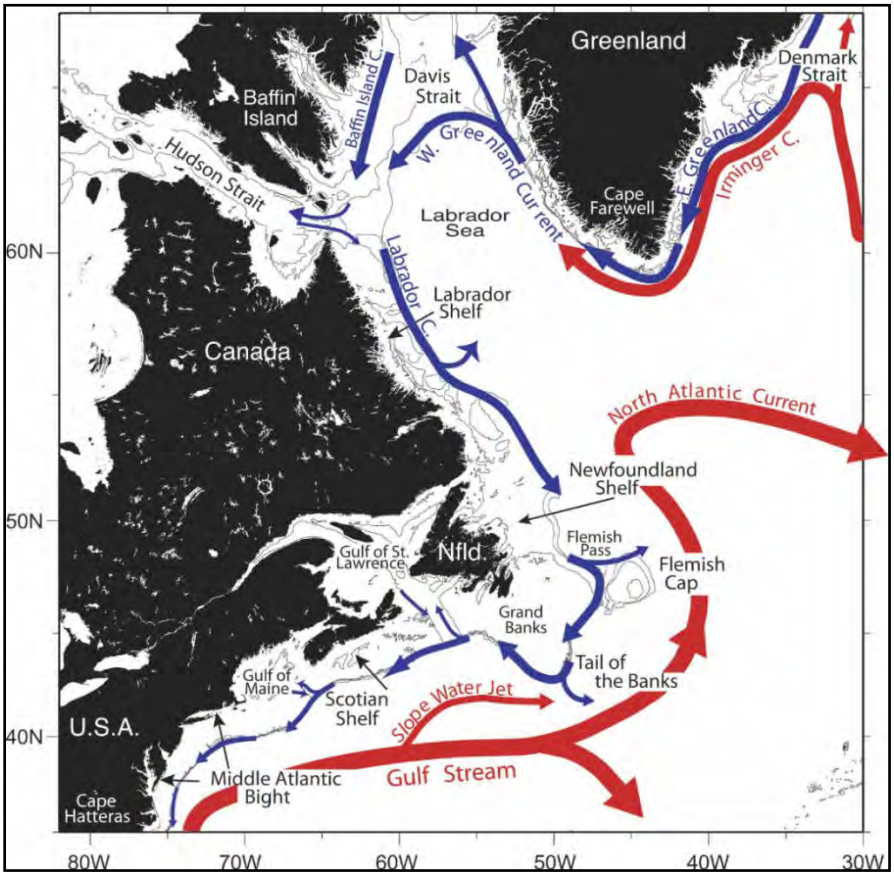
3.3 Physical Oceanography

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 Southern and Eastern Newfoundland SEAs (C-NLOPB 2010, 2014). A

summary of the major currents in the Study Area is provided below, with additional information from project-specific EAs (LGL 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 3.14, with cold shelf break waters shown in blue and warm Gulf Stream waters shown in red.



Source: Fratantoni and Pickart 2007.

Figure 3.14 Major Ocean Currents and Surface Circulation Features in the Northwest Atlantic Ocean.

The Labrador Current is the major current on the Grand Banks and is a continuation of the Baffin Island Current, which transports the cold and relatively low salinity water flowing out of Baffin Bay and a branch of the warmer and more saline waters of the West Greenland Current. The Labrador Current divides into two major branches on the northern Grand Banks. The inshore branch, which is approximately 100 km wide, is steered by the local underwater topography

through the Avalon Channel, and then continues to follow the bathymetry around the Avalon Peninsula and southern Newfoundland. This branch then divides into two parts, one flowing west and around the north side of St. Pierre Bank and the other flowing south in Haddock Channel between Green Bank and Whale Bank.

The stronger offshore branch of the Labrador Current flows along the shelf break over the upper portion of the continental slope. This branch divides east of 48°W, resulting in part of the branch flowing to the east around Flemish Cap and the other part flowing south around the eastern edge of the Grand Banks and through Flemish Pass. Within 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. Northward forming meanders, at certain stages of their development, 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 tides, wind stress, atmospheric pressure changes from the passage of storm systems, volume transport of the Labrador Current, seasonal temperature changes, salinity variations, etc. 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.

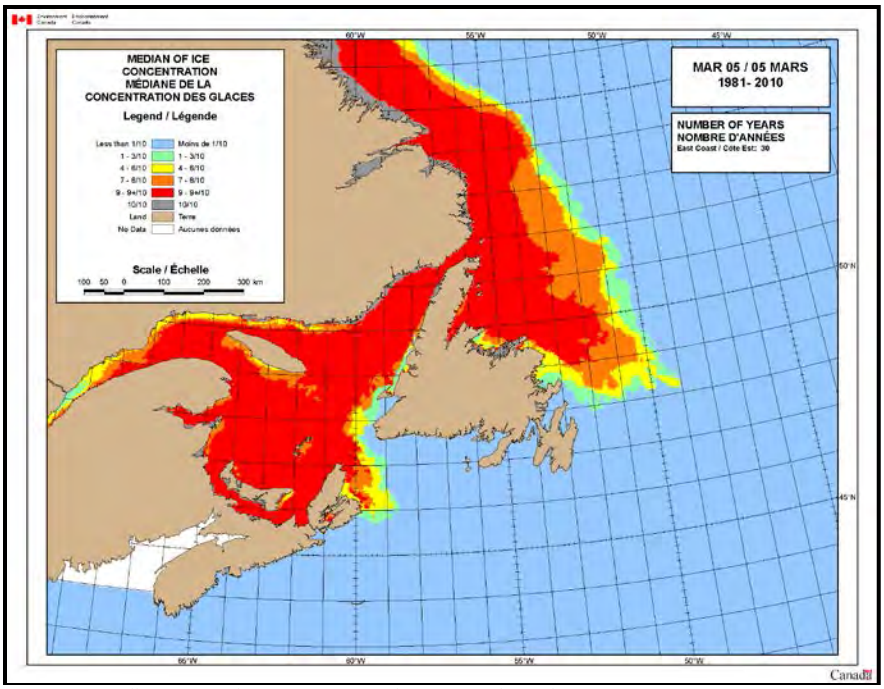
3.4 Ice Conditions

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 Southern and Eastern Newfoundland SEAs (C-NLOPB 2010, 2014). A summary of ice conditions is provided below, with updated information on sea ice extent and iceberg sightings for offshore Newfoundland. The classification of ice commonly found along Canada's eastern seaboard is based on internationally accepted terminology (CIS 2011).

3.4.1 Sea Ice

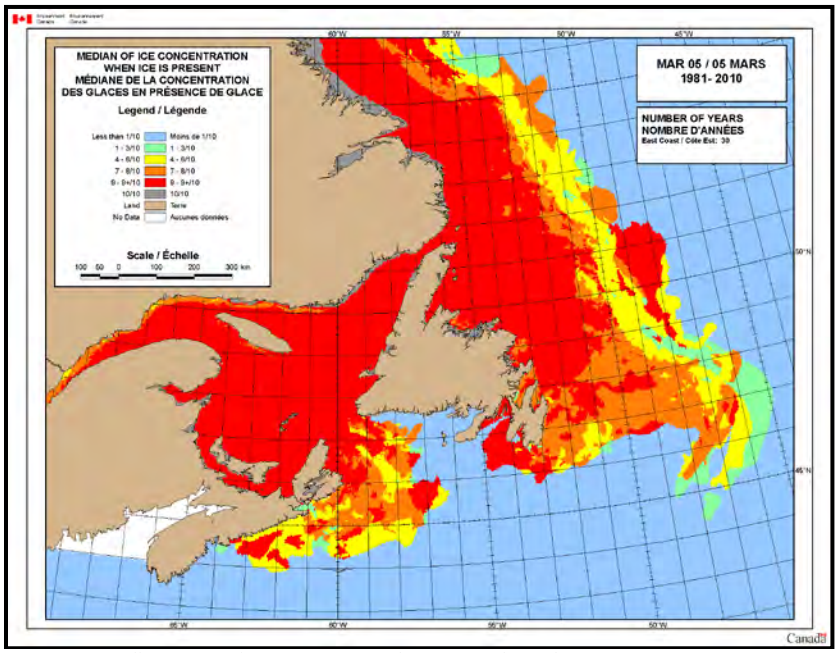
Sea ice begins to form on the coast of southern Labrador in mid-December and spreads south to Newfoundland waters in early January. The 30-year median concentration of sea ice reaches its maximum during the week of 5 March (Figure 3.15). The maximum median sea ice extent reaches to approximately 48°N, 50°W. During median years, only the northwestern portion of the Study Area would have some ice cover (Figure 3.15). During extreme years, sea ice could occur throughout the Study Area (Figure 3.16). A majority of the Study Area will be free of sea ice from mid-April until January, with the exception of the northeastern portion where sea ice may persist until early July.

A weekly analysis of the Canadian Ice Service's 30-Year Frequency of Presence of Sea Ice indicates that the Study Area is first affected by sea ice beginning the week of 1 January and lasting until the week beginning 2 July. Figure 3.17 depicts the week of 12 March, the period when the frequency of presence of sea ice is the greatest over the Study Area. When sea ice is present, the predominant ice type within the Study Area from 1 January until the week of 12 February is a mixture of grey and grey-white. By the week of 19 February, thin first-year ice begins to form and is the predominant ice type until the week of 2 April, with small amounts of grey-white and new ice also present. Medium first-year ice begins to appear by the week of 5 March, and some thick first-year by the week of 26 March. Small amounts of old ice are present within the Study Area by the week of 26 March.



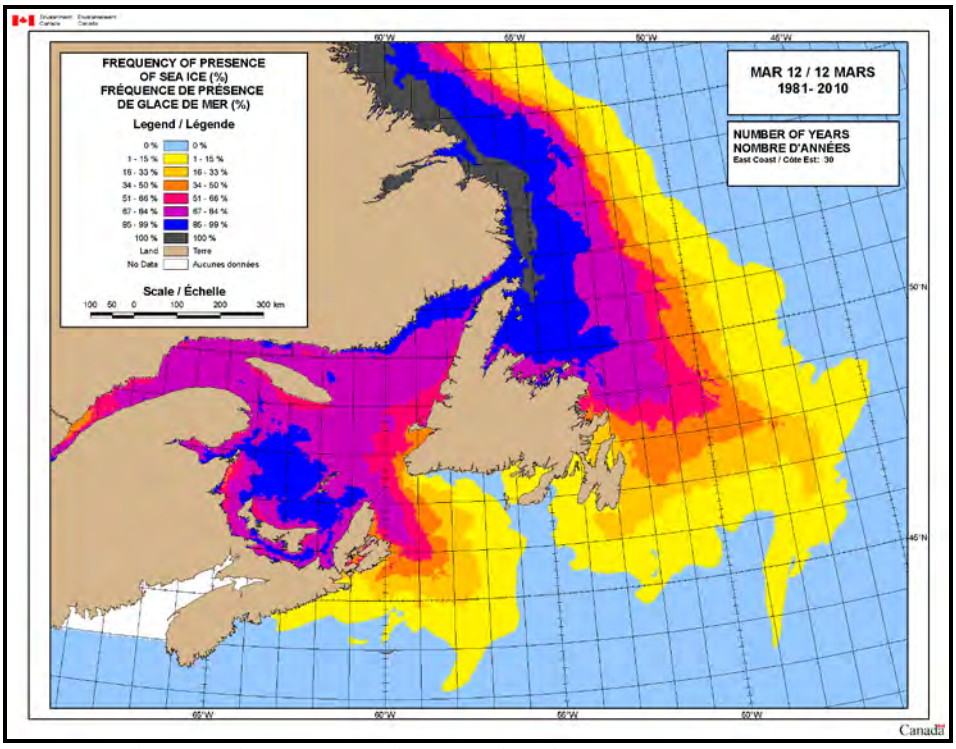
Source: Canadian Ice Service 30-Year Ice Atlas, accessed October 2015.

Figure 3.15 30-Year Median Concentration of Sea Ice, 1981–2010 (5 March).



Source: Canadian Ice Service 30-Year Ice Atlas, accessed October 2015.

Figure 3.16 30-Year Median Concentration of Sea Ice when Ice is Present, 1981–2010 (5 March).



Source: Canadian Ice Service 30-Year Ice Atlas, accessed October 2015.

Figure 3.17 30-Year Frequency of Presence of Sea Ice, 1981–2010 (12 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 influence the number of icebergs that move into the coast or remain offshore. Major iceberg drift patterns branch in the northwest corner of the Study Area, flowing southward along the western border, and through the center from the northwest corner to the southeast. In the Newfoundland offshore area, with the exception of the Flemish Pass, the highest numbers of icebergs are sighted along the northeast coast. Iceberg sightings generally decrease to the east and south.

An analysis was performed to determine the threat posed by icebergs in the Study Area. The International Ice Patrol (IPP) Iceberg Sightings Database was used as the primary data source in this analysis (NSIDC 1995, updated annually). As shown in Table 3.19, during the period from 2001–2014, a total of 15,039 icebergs were observed in the Study Area. Only months with recorded iceberg sightings have been included (January to September). These observed sightings may not include all icebergs passing through the Study Area but indicate the relative abundance by month. Of the 15,039 icebergs sighted, 41.4% were observed during the period from May to November. Most were sighted in May (30.0%), followed by June (9.4%), and July (1.9%).

There were no icebergs observed in October or November. 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 1,712 icebergs observed in the Study Area. During the same time period of 2010 and 2011, there were no icebergs observed.

Table 3.19 Annual and Monthly Iceberg Sightings within the Study Area, 2001–2014.

Year	Month									Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
2001	-	38	21	25	14	23	2	-	-	**123**
2002	-	32	402	730	590	135	11	-	-	**1,900**
2003	-	1	159	928	1,075	178	31	-	-	**2,372**
2004	-	-	1	33	206	133	30	1	-	**404**
2005	-	-	6	6	1	-	-	-	-	**13**
2006	-	-	1	-	1	1	-	-	-	**3**
2007	-	-	-	29	57	186	69	-	-	**341**
2008	-	1	220	1,742	126	65	4	-	-	**2,158**
2009	-	5	109	313	1,195	464	53	-	-	**2,139**
2010	-	-	-	1	-	-	-	-	-	**1**
2011	-	-	-	1	-	-	-	-	-	**1**
2012	-	-	105	491	954	17	-	-	-	**1,567**
2013	-	2	-	4	3	45	9	2	1	**66**
2014	1	239	1,478	1,691	289	167	76	10	-	**3,951**
Total	**1**	**318**	**2,502**	**5,994**	**4,511**	**1,414**	**285**	**13**	**1**	**15,039**
% of Total	0.0	2.1	16.6	39.9	30.0	9.4	1.9	0.1	0.0	

Source: NSIDC 1995, IPP 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, 38.0% of the 15,039 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 Eastern Newfoundland SEA (§ 4.2 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.0 of C-NLOPB 2010), and two site-specific EAs (§ 4.0 of LGL 2015a,b) prepared in 2015. 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 two SEAs (C-NLOPB 2014, 2010) 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 invertebrates, fishes, marine-associated birds, marine mammals and sea turtles, that are important ecologically, economically, and/or socially and with potential to interact with the Project. This is the VEC approach to environmental assessment (§ 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 Eastern Newfoundland SEA (§ 4.2.1 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.1 and § 3.2 of C-NLOPB 2010), and two site-specific EAs (§ 4.2 of LGL 2015a, b). An overview of the fish and fish habitat of the Study Area, based primarily on information from the two SEAs and two 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

For the purposes of this EA, 'fish habitat' includes physical and biological aspects of the marine environment used by macro-invertebrate and fish species. The physical and chemical nature of the water column (e.g., water temperature, depth, salinity) and bottom substrate (i.e., surficial sediment) are critical factors affecting the characterization of associated marine biological communities. Section 3.1 of this EA discusses both the bathymetry and the geology of the Study Area. The biological component of fish habitat refers to bacteria, fungi, phytoplankton, zooplankton, and benthos (i.e., infaunal and epibenthic invertebrates, such as polychaetes and echinoderms, that are 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. Spatial and temporal aspects of ichthyoplankton (fish eggs and larvae) and macroinvertebrate eggs and larvae are presented in § 4.2.2.3. Generally, phytoplankton 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 are in turn ingested by predators (i.e., tertiary production) such as predacious zooplankton (e.g., chaetognaths, jellyfish), all of which may be grazed by higher predators such as fishes, seabirds, marine mammals and sea turtles. This food web also links to the benthic ecosystem through bacterial degradation processes, dissolved and particulate carbon, and direct predation. An understanding of plankton production is important because areas of enhanced production and/or biomass are usually locations where congregations of fishes, seabirds, marine mammals and sea turtles feed.

Phytoplankton distribution, productivity, and growth regulation in high-latitude ecosystems constitute a complex system with light, nutrients, and herbivore grazing being the principal limiting factors (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 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. The spring/summer bloom of phytoplankton is typically is 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.

Section 4.2.1.3 of the Eastern Newfoundland SEA (C-NLOPB 2014), § 3.1.3 of the Southern Newfoundland SEA (C-NLOPB 2010), § 4.2.1.1 of LGL (2015a) and § 4.2.1.3 of LGL (2015b) all provide descriptions of the plankton in the Study Area. Information in those documents is briefly summarized below. Some of the key points concerning the various components of planktonic communities for the eastern and southern Grand Banks 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 temperature 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.
- 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 2015b). The AZMP findings in relation to oceanographic conditions in the Study Area for 2013 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 copepod 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.
- 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 in this EA. 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 § 4.1.2 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 § 4.2.1.5 of the Eastern Newfoundland SEA (C-NLOPB 2014), § 3.1.4 of the Southern Newfoundland SEA (C-NLOPB 2010), § 4.2.1.2 of LGL (2015a), and § 4.2.1.4 of LGL (2015b). Information from these documents that is briefly summarized below 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, Iceland scallops (*Chlamys islandica*), sea scallops (*Placopecten magellanicus*), northern shrimp, 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 (*Chionoecetes opilio*), toad crab (*Hyas* sp.), rock crab (*Cancer* sp.), Iceland scallops (*Chlamys islandica*), sea scallops (*Placopecten magellanicus*), northern shrimp (*Pandalus borealis*), Stimpson's surf clams (*Mactromeris polynyma*), propeller clams (*Cyrtodaria siliqua*), ocean quahogs (*Arctica islandica*) and sea urchins.
- 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 snow crab and echinoderms. Catches of sponges and shrimp in 3L were larger than those in 3NO. 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; 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).

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). Figure 4.72 in the Eastern Newfoundland SEA (C-NLOPB 2014) shows the distribution of various coral groups collected during DFO RV surveys in NAFO Divisions 3LMNO during 2000-2012. 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 Grand Banks, Flemish Pass, and Flemish Cap, 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. 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*, and *Gersemia rubiformis*, and *Nephtheid* spp.). Also noted were scleractinian species (*Flabellum alabastrum, Javania cailleti, Dasmosmilia lymani,* 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. 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 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, Sensitive Areas (NAFO 2015a).

DFO has recently published a report that discusses its coral and sponge conservation strategy for Eastern Canada (DFO 2015a). 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 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 macroinvertebrates 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 Macro-invertebrate and Fish Species Harvested during Commercial Fisheries

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 (see § 4.3). 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 (2015a, b). Subsections 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. 3LNO (offshore) have remained near their highest level, at about 26,000 t, in the past three years (DFO 2015c). Landings in 3K (offshore) have declined by

half since 2009 to 6,100 t in 2014. Long-term recruitment prospects in these NAFO Divisions are considered unfavourable due to a recent warming oceanic regime (DFO 2015c).

In the commercial fishery conducted within the Study Area during May to November 2014, snow crab harvesting was conducted primarily along the southeastern, eastern and northeastern shelf and upper slope of the Grand Banks (see Figure 4.12 *in* § 4.3.3.2). Distributions of fishing effort for snow crab within the Study Area during recent years prior to 2014 are provided in 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 (2015a,b). Subsections 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.

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 Shrimp Fishing Area (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, 2014 was prosecuted primarily along the northeastern slope of the Grand Banks (see Figure 4.9 in § 4.3.3.2). Fishing effort distribution for snow crab within the Study Area during recent years prior to 2014 are provided in Figures 4.17 and 4.18 in § 4.3.3 of LGL (2015a). Catch locations for northern shrimp 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 4.34 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. This 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 (2015a). 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 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 4.18 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 4.29 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 4.35 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 4.2.1.2 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 4.21 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 § 4.2.2.1 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 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 Study Area, the Notre Dame Channel, southern Hamilton Bank and Hawke Channel are located north of the 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 4.21 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 4.26 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 4.2.1.6 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 4.21 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 4.25 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 4.15 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 4.32 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 (*Sebastes* sp.), 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 redfishes.

In the commercial fishery conducted within the Study Area during May to November, 2014, redfish harvesting was conducted primarily along the slope area of the northeastern Grand Bank and the Southern Grand Bank (see Figure 4.21 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 to 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 4.2.1.6 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 WesternGeco's Eastern Newfoundland EA (LGL 2015a) and 4.2.2.1 of WesternGeco's Southeastern Newfoundland EA (LGL 2015b). Section 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 4.30 in § 4.3.7).

Swordfish

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

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
Cusk	Uncertain	May to August	Presumed to be 4 to 16 weeks
Sand Lance	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 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 three SEAs were completed is noted throughout § 4.2.

4.3 Fisheries

The Fisheries VEC of the Study Area has been recently described in the Eastern Newfoundland SEA (§ 4.3.4 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.3 of C-NLOPB 2010), and two site-specific EAs (§ 4.3 of LGL 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 3K, 3L, 3M, 3N, 3O, 3Ps and 4Vs (Figure 4.1).

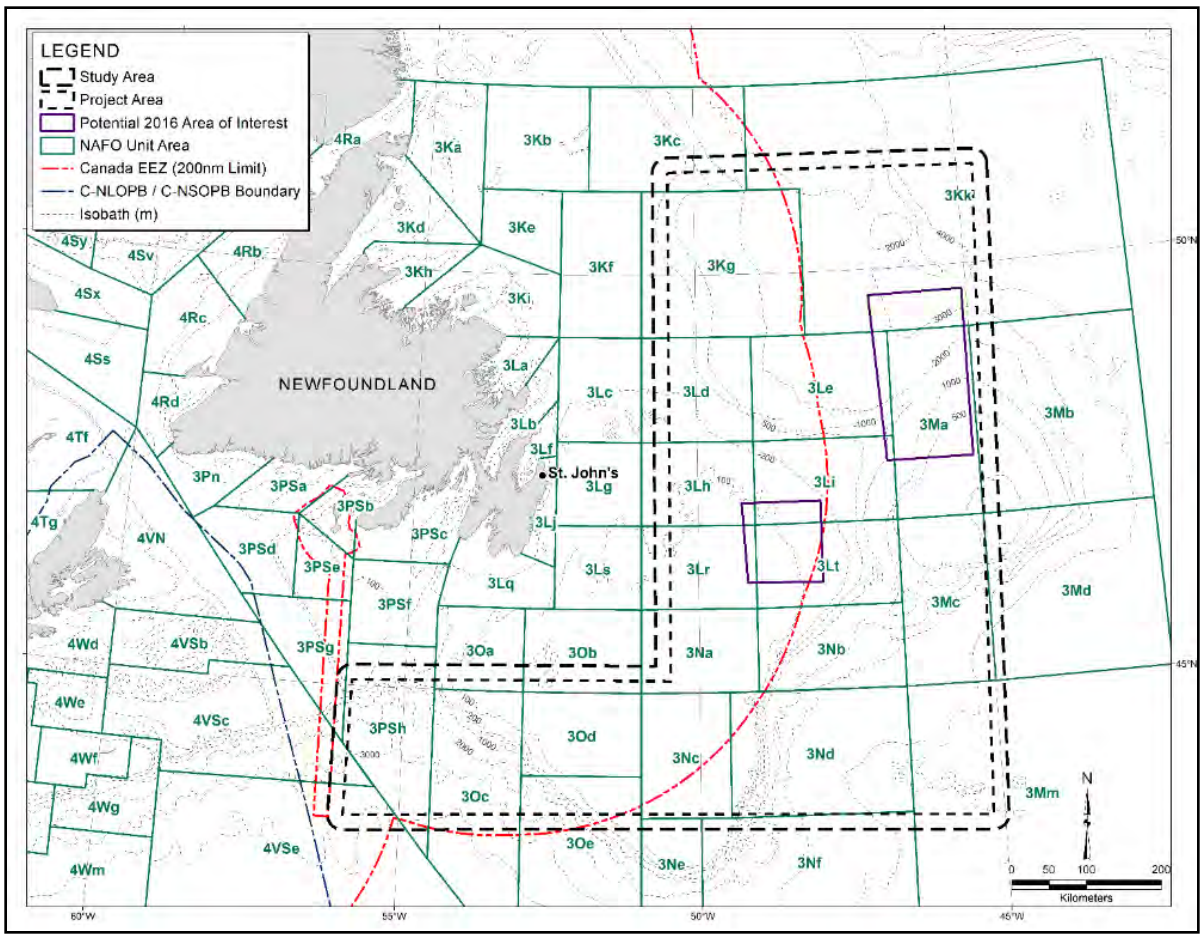


Figure 4.1 Study Area, Project Area and Potential 2016 Areas of Interest in Relation to Regional Fisheries Management Areas (NAFO Divisions and Unit Areas).

This subsection also briefly describes recreational fisheries, traditional fisheries, aquaculture activity, and fisheries research surveys in the Study Area. The biological aspects of the principal macroinvertebrate and fish species included in this subsection 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. The eastern portion 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 analysis in this EA quantifies harvesting for NAFO Divisions 3K, 3L, 3M, 3N, 3O, 3Ps and 4Vs (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 2014. Figure references from the Eastern Newfoundland SEA (C-NLOPB 2014), Southern Newfoundland SEA (C-NLOPB 2010) and site-specific EAs (LGL 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 snow crab (22% of total catch weight; primarily in NAFO Division 3L), northern shrimp (19%; primarily in 3K), surf clam (9%; almost exclusively in 4Vs), Atlantic redfishes (9%; primarily in 3M and 3O), capelin (9%; almost exclusively in 3L and 3K), Atlantic cod (7%; primarily in 3M and 3Ps) and Greenland halibut (5%; primarily in 3L). The highest catch weights during the six year period were reported in NAFO Divisions 3L (28%) and 3K (25%), followed by 4Vs (14%), 3M and 3Ps (10% each), 3N (8%) and 3O (5%). Canadian vessels accounted for 78% of the commercial catch weight reported for this area during 2009–2013. Foreign vessels dominated catches (>99% of total catch weight in these Divisions) in Division 3M only. 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.

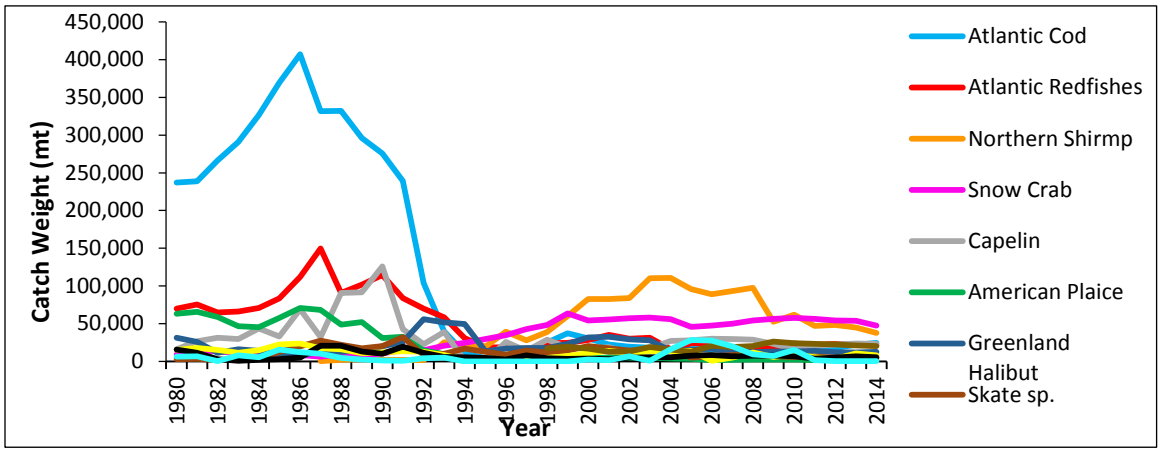
4.3.3 Domestic Fisheries

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 provided 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 3K, 3L, 3M, 3N, 3O, 3Ps and 4Vs largely targeted Atlantic cod, 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).

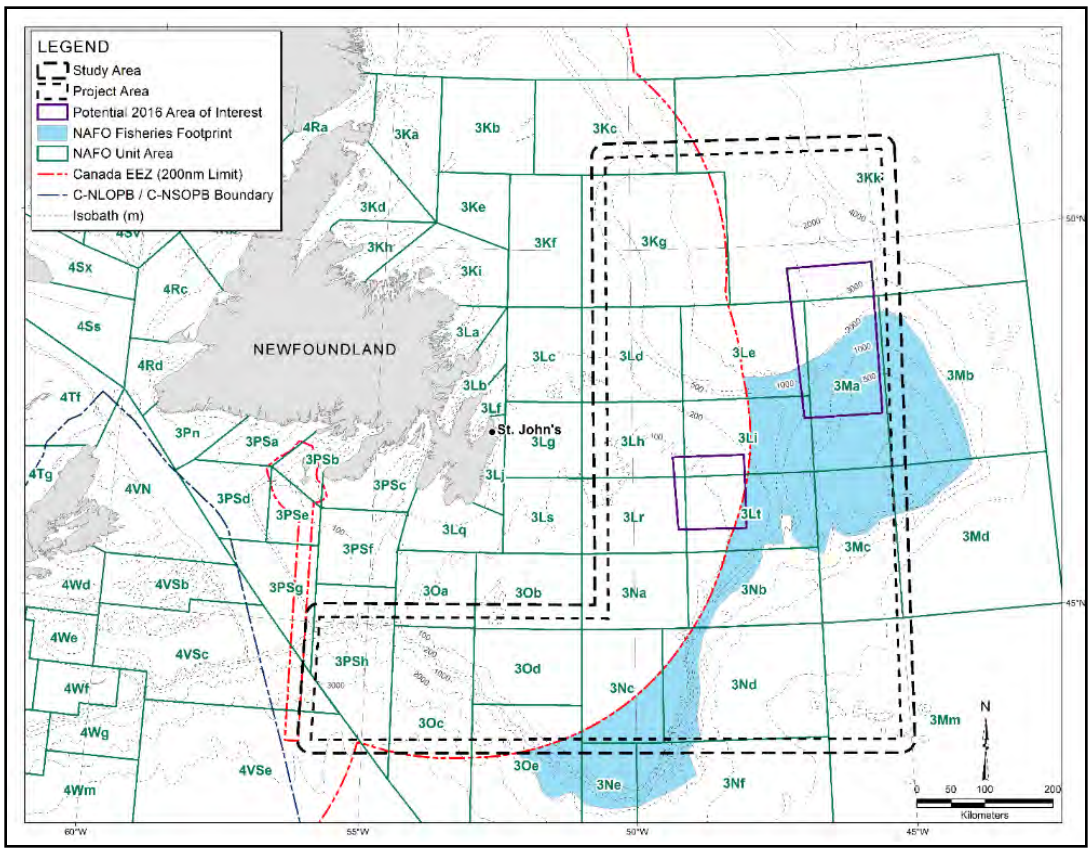


Source: NAFO STATLANT 21A Data Extraction Tool.

Figure 4.2 Historical Catch Weights for Predominant Species in the Commercial Fisheries in NAFO Divisions 3K, 3L, 3M, 3N, 3O, 3Ps and 4Vs, All Countries, 1980–2014.

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 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), in 2016.

NAFO's bottom fishing footprint was described in § 4.3.3.1 of LGL (2015a). The majority of this footprint is within the central and southern portions of the Study Area (Figure 4.3). The fishing footprint includes a small portion of the southeast corner of the southernmost potential 2016 Area of Interest, and the southern half of the northernmost potential 2016 Area of Interest.



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, yellowtail flounder and Greenland halibut, which combined accounted for ~89% of the average annual catch weight in these areas during May–November, 2009–2010. Northern shrimp harvests have decreased in contribution to the overall catch since 2013. Other notable species in commercial fisheries in the Study Area include American plaice, Atlantic halibut, redfish, Atlantic cod, cockle, white hake, monkfish, pollock, Stimpson's surf clam and swordfish. The total annual commercial fisheries catch weights of all species in the Study Area during May–November 2009–2010 remained relatively consistent, between ~31,600–34,400 mt per year. The sum of quartile catch ranges showed some variation during May– November 2011– 2014, ranging between ~7,000–11,000 with greater catches in 2011 and 2013 than 2012 or 2014 (Figure 4.4).

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	12,318	37	15,724,607	28	12,173	40	15,582,405	30
Snow Crab	9,528	29	28,472,000	50	8,779	29	26,237,802	50
Yellowtail Flounder	3,833	12	1,226,277	2	3,567	12	1,154,791	2
Greenland Halibut	3,508	11	7,051,147	12	2,874	9	5,787,226	11
American Plaice	769	2	312,191	1	730	2	298,394	1
Cockle	576	2	766,479	1	576	2	766,479	1
Redfish	515	2	291,039	1	418	1	254,120	0.5
White Hake	470	1	229,769	0.4	343	1	161,622	0.3
Monkfish	221	1	236,549	0.4	209	1	221,526	0.4
Atlantic Cod	186	1	148,311	0.3	140	0.5	101,689	0.2
Atlantic Halibut	185	1	1,493,001	3	168	1	1,358,445	3
Skate sp.	179	1	43,474	0.1	164	1	39,102	0.1
Pollock	172	1	117,460	0.2	55	0.2	35,249	0.1
Witch Flounder	101	0.3	39,647	0.1	97	0.3	37,530	0.1
Atlantic Haddock	84	0.3	62,781	0.1	60	0.2	37,059	0.1
Hagfish	81	0.2	62,569	0.1	20	0.1	15,671	<0.1
Stimpson's Surf Clam	81	0.2	141,484	0.2	81	0.3	141,484	0.3
Swordfish	79	0.2	464,414	1	77	0.3	452,110	1
Roughhead Grenadier	20	0.1	13,488	<0.1	18	0.1	12,087	<0.1
Atlantic Herring	18	0.1	3,491	<0.1	18	0.1	3,491	<0.1
Whelk	11	<0.1	9,408	<0.1	7	<0.1	6,215	<0.1
Capelin	9	<0.1	1,329	<0.1	9	<0.1	1,329	<0.1
Mackerel	9	<0.1	3,576	<0.1	9	<0.1	3,576	<0.1
Porbeagle Shark	4	<0.1	5,214	<0.1	3	<0.1	3,779	<0.1
Cusk	4	<0.1	2,406	<0.1	4	<0.1	2,068	<0.1
Bluefin Tuna	4	<0.1	67,837	0.1	4	<0.1	60,970	0.1
Mako Shark	3	<0.1	8,125	0.01	3	<0.1	7,936	<0.1
Sea Scallop	1	<0.1	1,133	<0.1	0.1	<0.1	310	<0.1
Bigeye Tuna	1	<0.1	8,142	<0.1	1	<0.1	8,142	<0.1
Mahi Mahi (dolphinfish)	0.4	<0.1	2,067	<0.1	0.4	<0.1	2,024	<0.1
Albacore Tuna	0.3	<0.1	719	<0.1	0.3	<0.1	694	<0.1
Roundnose Grenadier	<0.1	<0.1	20	<0.1	<0.1	<0.1	20	<0.1
Flounder sp.	<0.1	<0.1	25	<0.1	<0.1	<0.1	25	<0.1
Atlantic (striped) Wolffish	<0.1	<0.1	8	<0.1	<0.1	<0.1	7	<0.1
Iceland Scallop	<0.1	<0.1	25	<0.1	0	0	0	0
Totals	**32,971**	**100**	**57,010,212**	**100**	**30,605**	**100**	**52,795,380**	**100**

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	
Snow Crab	81	295	449	96	43	221	400	257	**921**
Northern Shrimp	226	174	127	195	279	173	181	89	**722**
Greenland Halibut	100	206	172	54	83	208	175	66	**532**
Redfish sp.	47	99	138	55	80	104	108	47	**339**
Atlantic Halibut	87	109	78	31	81	162	57	5	**305**
Witch Flounder	25	68	103	51	60	74	71	42	**247**
American Plaice	25	59	74	47	78	68	45	14	**205**
Atlantic Cod	45	49	43	30	71	62	31	3	**167**
Yellowtail Flounder	15	46	49	24	61	51	19	3	**134**
Roughhead Grenadier	15	43	53	17	14	39	52	23	**128**
Skate sp.	15	65	39	5	22	66	26	10	**124**
White Hake	30	46	34	10	34	59	27	0	**120**
Atlantic Haddock	20	34	31	29	46	41	25	2	**114**
Monkfish	15	54	35	7	31	58	22	0	**111**
Pollock	5	16	8	13	16	13	13	0	**42**
Swordfish	23	13	1	0	13	20	4	0	**37**
Bluefin Tuna	28	8	1	0	15	19	3	0	**37**
Cusk	10	9	2	0	3	15	3	0	**21**
Mako Shark	10	7	1	0	6	9	3	0	**18**
Hagfish	1	2	9	2	3	9	2	0	**14**
Cockle	1	5	1	3	3	4	0	3	**10**
Stimpson's Surf Clam	0	2	0	3	0	2	0	3	**5**
Roundnose Grenadier	0	3	0	0	0	3	0	0	**3**
Whelk	2	1	0	0	3	0	0	0	**3**
Porbeagle Shark	3	0	0	0	2	1	0	0	**3**
Atlantic (striped) Wolffish	3	0	0	0	2	1	0	0	**3**
Shark sp.	1	0	0	1	1	0	1	0	**2**
Bigeye Tuna	1	1	0	0	0	2	0	0	**2**
Sea Scallop	2	0	0	0	2	0	0	0	**2**
Capelin	0	1	0	0	1	0	0	0	**1**
Winter Flounder	1	0	0	0	1	0	0	0	**1**
Albacore Tuna	0	0	1	0	0	0	1	0	**1**
Yellowfin Tuna	1	0	0	0	0	1	0	0	**1**
White Marlin	1	0	0	0	1	0	0	0	**1**
Total	**839**	**1,415**	**1,449**	**673**	**1,055**	**1,485**	**1,269**	**567**	**4,376**

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

Notes:

[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	
Snow Crab	86	267	340	82	69	193	326	187	775
Northern Shrimp	131	140	139	59	177	134	125	33	469
Greenland Halibut	108	175	145	14	105	174	150	13	442
Atlantic Halibut	108	114	78	11	107	138	62	4	311
Redfish sp.	44	85	106	15	60	80	101	9	250
Atlantic Cod	48	39	45	9	73	49	19	0	141
White Hake	33	62	43	0	42	66	30	0	138
Skate sp.	21	59	44	0	29	53	40	2	124
American Plaice	35	32	46	6	70	34	13	2	119
Monkfish	21	58	30	0	35	55	19	0	109
Witch Flounder	15	22	55	10	27	24	44	7	102
Yellowtail Flounder	34	28	31	5	67	28	3	0	98
Roughhead Grenadier	16	24	32	8	16	32	29	3	80
Atlantic Haddock	17	19	15	3	27	19	8	0	54
Swordfish	17	33	4	0	6	32	16	0	54
Bluefin Tuna	34	6	4	0	29	10	5	0	44
Pollock	3	19	18	0	16	12	12	0	40
Cusk	13	10	10	0	8	17	8	0	33
Mako Shark	10	21	2	0	4	16	13	0	33
Porbeagle Shark	17	3	0	0	7	11	2	0	20
Hagfish	1	5	9	0	4	6	5	0	15
Albacore Tuna	7	4	0	0	4	6	1	0	11
Bigeye Tuna	6	4	0	0	4	4	2	0	10
Mahi Mahi (dolphinfish)	3	5	0	0	2	3	3	0	8
Roundnose Grenadier	5	2	0	0	5	1	1	0	7
White Marlin	0	4	0	0	0	1	3	0	4
Capelin	0	0	4	0	4	0	0	0	4
Yellowfin Tuna	3	0	0	0	2	1	0	0	3
Iceland Scallop	1	1	0	0	1	1	0	0	2
Sea Scallop	1	0	0	0	1	0	0	0	1
Atlantic (striped) Wolffish	0	1	0	0	0	0	1	0	1
Flounder sp.	0	0	1	0	0	0	1	0	1
Total	**838**	**1,242**	**1,201**	**222**	**1,001**	**1,200**	**1,042**	**260**	**3,503**

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

Notes:

[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	
Snow Crab	83	256	360	127	61	183	317	265	826
Greenland Halibut	114	202	159	30	130	186	159	30	505
Atlantic Halibut	151	146	126	37	144	159	135	22	460
Atlantic Cod	68	140	127	41	101	137	118	20	376
American Plaice	40	141	109	43	114	111	88	20	333
Witch Flounder	55	93	111	34	90	85	96	22	293
Redfish sp.	63	92	106	24	86	81	99	19	285
Yellowtail Flounder	37	120	86	37	102	94	69	15	280
Northern Shrimp	90	82	72	5	122	59	53	15	249
White Hake	46	49	17	1	60	44	8	1	113
Atlantic Haddock	22	47	29	11	43	39	23	4	109
Roughhead Grenadier	33	30	29	5	36	31	23	7	97
Skate sp.	21	28	16	3	35	13	16	4	68
Monkfish	12	19	11	1	25	15	3	0	43
Cusk	27	9	1	0	17	19	1	0	37
Pollock	8	20	6	0	24	10	0	0	34
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
Dogfish sp.	2	3	0	0	2	0	2	1	5
Roundnose Grenadier	2	3	0	0	2	0	2	1	5
Sculpin sp.	4	1	0	0	4	1	0	0	5
Bluefin Tuna	2	1	0	0	1	2	0	0	3
Capelin	0	1	1	0	2	0	0	0	2
Whelk	1	0	0	0	1	0	0	0	1
Cockle	0	0	1	0	0	1	0	0	1
Albacore Tuna	0	1	0	0	0	0	1	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
Stimpson's Surf Clam	0	0	1	0	0	1	0	0	1
Total	**897**	**1,501**	**1,375**	**399**	**1,209**	**1,298**	**1,219**	**446**	**4,172**

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

Notes:

[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	63	205	300	89	41	162	284	170	657
Atlantic Halibut	143	125	89	43	126	145	97	32	400
Greenland Halibut	60	107	119	39	65	116	105	39	325
Atlantic Cod	75	106	77	41	89	121	79	10	299
American Plaice	39	61	64	27	72	66	49	4	191
Yellowtail Flounder	36	66	61	26	74	65	46	4	189
White Hake	70	49	31	8	79	65	14	0	158
Redfish sp.	38	47	36	28	51	47	32	19	149
Northern Shrimp	42	34	33	4	53	36	23	1	113
Atlantic Haddock	22	35	35	13	38	37	26	4	105
Skate sp.	41	14	8	4	42	17	6	2	67
Witch Founder	13	15	19	17	18	17	15	14	64
Swordfish	28	19	7	0	17	19	16	2	54
Pollock	6	20	23	4	27	22	4	0	53
Atlantic (striped)	2	15	18	10	8	20	15	2	45
Mako Shark	18	16	7	0	11	15	13	2	41
Cusk	22	10	2	0	14	18	2	0	34
Roughhead Grenadier	2	13	10	8	2	16	11	4	33
Monkfish	5	9	6	4	12	8	4	0	24
Argentine	2	10	4	4	3	12	4	1	20
Porbeagle Shark	14	2	0	0	6	10	0	0	16
Bluefin Tuna	6	3	6	0	3	7	5	0	15
Mahi Mahi	6	6	2	0	3	5	5	1	14
White Marlin	3	4	1	0	2	1	4	1	8
Albacore Tuna	1	3	1	0	0	1	3	1	5
Groundfish sp.	0	4	0	0	0	1	3	0	4
Bigeye Tuna	2	1	0	0	1	1	1	0	3
Mackerel	0	0	1	0	0	1	0	0	1
Whelk	1	0	0	0	1	0	0	0	1
Total	**760**	**999**	**960**	**369**	**858**	**1,051**	**866**	**313**	**3,088**

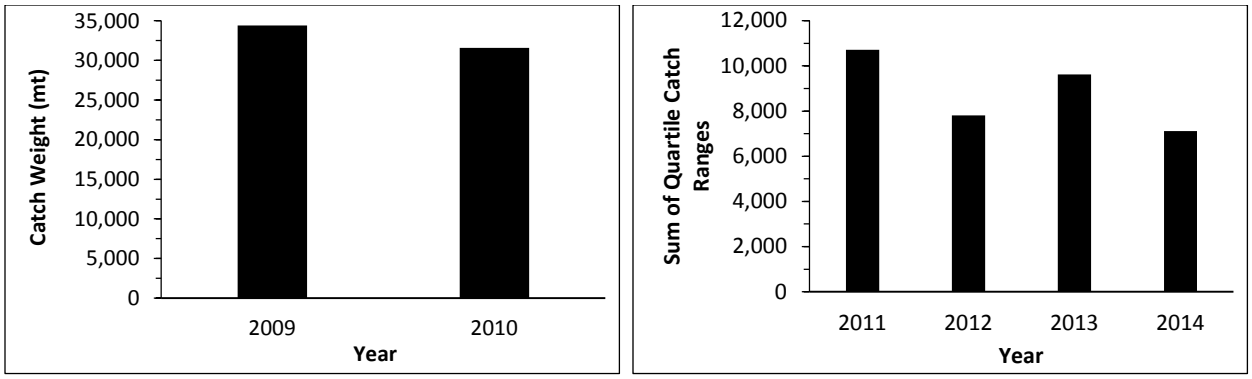
Source: DFO commercial landings database, All Atlantic Regions (2014).

Notes:

[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.

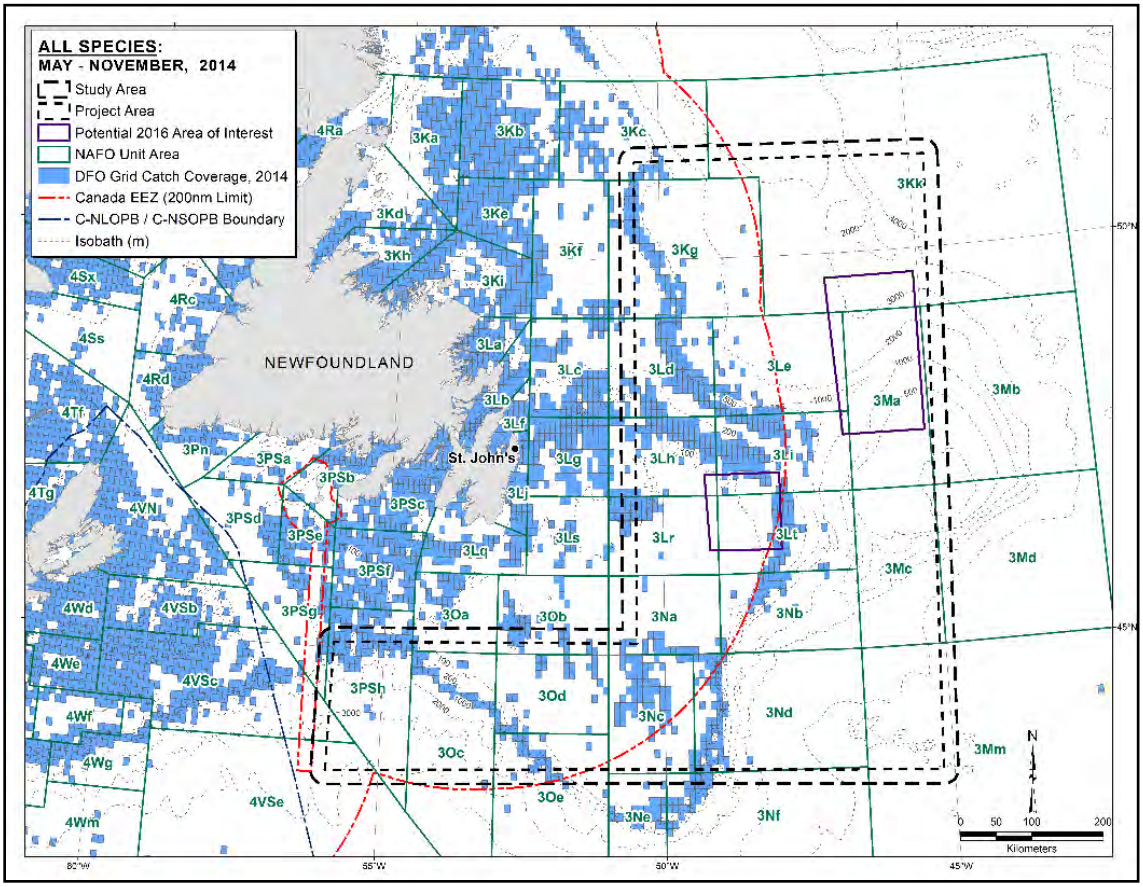
Figure 4.4 Annual Total Catch Weight, May–November, 2009–2010 (left), and Annual Total Catch Weight Quartile Codes, May–November, 2011–2014 (right) (all species within the Study Area).

Commercial Harvest Locations in the Study Area

Georeferenced harvest locations for all species, May–November, 2005–2010 for eastern and southeastern offshore Newfoundland are shown in Figures 4.5 of LGL (2015a,b). Harvest locations in 6' x 6' cells during May–November, 2011–2013 for eastern and southeastern offshore Newfoundland are shown in Figures 4.6–4.8 of LGL (2015a,b). Year-round harvest locations are indicated in Figure 3.18 of the Southern Newfoundland SEA (C-NLOPB 2010) and Figures 4.123 and 4.124 of the Eastern Newfoundland SEA C-NLOPB 2014). Figure 4.5 shows harvest locations in 6' x 6' cells in relation to the Study and Project Areas for all species, May– November, 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.

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 shrimp, yellowtail flounder, Greenland halibut, American plaice, redfishes, white hake, monkfish, Atlantic cod, Atlantic halibut), pots (snow crab), gillnets (yellowtail flounder, Greenland halibut, American plaice, redfishes, white hake, monkfish, Atlantic cod, Atlantic halibut, swordfish), and longlines (Greenland halibut, American plaice, redfishes, white hake, monkfish, Atlantic cod, Atlantic halibut, swordfish) (Tables 4.7 and 4.8). Atlantic cod were also taken using pots and hand lines (baited). Cockle and Stimpson's surf clam were captured using dredges. Shrimp trawls (mobile gear) accounted for about 37% of the average total catch weight of all species in the Study Area between May–November, 2009–2010. Pots (fixed gear) accounted for about 29% of the average total catch weight during this period. Overall, mobile and fixed gears each accounted for ~59% and 41%, respectively (Table 4.7).



Source: DFO commercial landings database, 2014.

Figure 4.5 Distribution of Harvest Locations, All Species Combined, May-November, 2014.

Fishing gears and harvest locations by gear type typically used in the Study Area are provided in Table 4.119 and Figure 4.137 of 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 in eastern and southeastern offshore Newfoundland for all species, May-November, 2005–2013 are shown in Figures 4.9–4.12 of LGL (2015a,b). Figure 4.6 shows locations of mobile and fixed gear harvest locations during 2014.

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	12,318	37.4
Snow Crab	9,528	28.9	0	0.0
Yellowtail Flounder	0	0.0	3,833	11.6
Greenland Halibut	2,421	7.3	1,087	3.3
American Plaice	2	0.0	768	2.3
Cockle	0	0.0	576	1.7
Redfish	33	0.1	481	1.5
White Hake	467	1.4	3	0.0
Monkfish	221	0.7	0	0.0
Atlantic Cod	33	0.1	153	0.5
Atlantic Halibut	180	0.5	5	0.0
Skate sp.	177	0.5	1	0.0
Pollock	168	0.5	4	0.0
Witch Flounder	4	0.0	98	0.3
Atlantic Haddock	59	0.2	25	0.1
Hagfish	81	0.2	0	0.0
Stimpson's Surf Clam	0	0.0	81	0.2
Swordfish	79	0.2	0	0.0
Roughhead Grenadier	20	0.1	0	0.0
Atlantic Herring	0	0.0	18	0.1
Whelk	11	0.0	0	0.0
Capelin	0	0.0	9	0.0
Mackerel	0	0.0	9	0.0
Porbeagle Shark	4	0.0	1	0.0
Cusk	4	0.0	0	0.0
Bluefin Tuna	3	0.0	1	0.0
Mako Shark	3	0.0	0	0.0
Sea Scallop	0	0.0	1	0.0
Bigeye Tuna	1	0.0	0	0.0
Mahi Mahi	0	0.0	0	0.0
Albacore Tuna	0	0.0	0	0.0
Roundnose Grenadier	0	0.0	0	0.0
Flounder sp.	0	0.0	0	0.0
Iceland Scallop	0	0.0	0	0.0
Atlantic (striped)	0	0.0	0	0.0
Subtotal	**13,500**	**41**	**19,471**	**59**
Grand Total (mt)	**32,971**			

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.

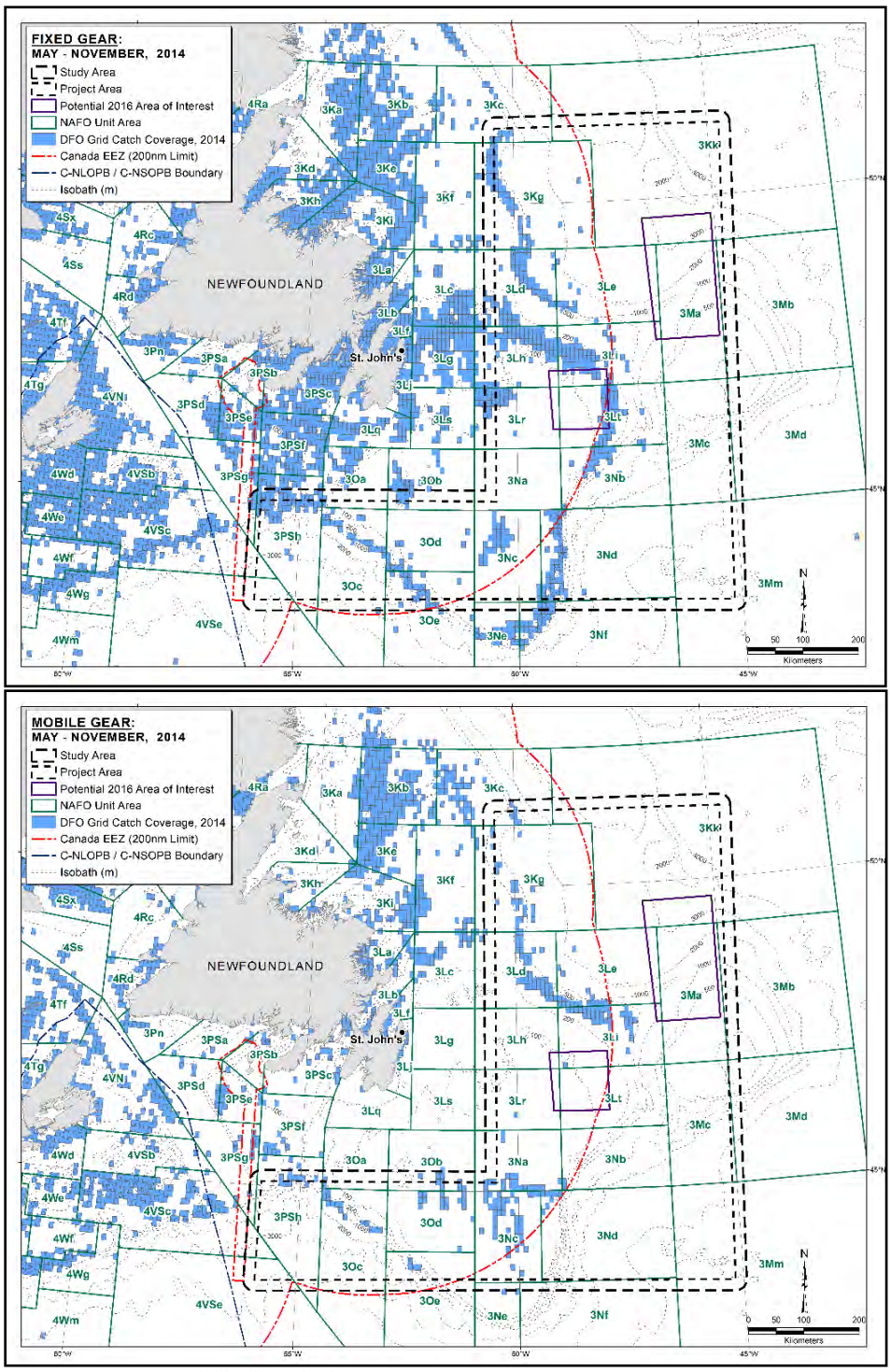
Species	Month Caught					Gear Type	
	2009–2010	2011	2012	2013	2014	Fixed	Mobile
Northern Shrimp	May–Nov	May–Nov	May–Nov	May–Oct	Jun–Sep	-	Trawl
Snow Crab	May–Aug; Oct–Nov	May–Aug	May–Aug	May–Aug	May–Aug	Pot	Trawl
Yellowtail Flounder	May–Jun; Aug–Nov	May–Jul; Oct	May–Jun; Nov	May–Jul; Sep–Nov	May–Jul; Oct–Nov	Gillnet; Longline	Trawl
Greenland Halibut	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
American Plaice	May–Nov	May–Aug; Oct–Nov	May–Jul; Nov	May–Nov	May–Aug; Oct–Nov	Gillnet; Longline	Trawl
Cockle	Jul; Oct–Nov	Oct	-	Nov	-	-	Dredge
Redfish	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
White Hake	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
Monkfish	May–Nov	Jun–Nov	Jun–Oct	May–Aug; Oct	May–Jul; Nov	Gillnet; Longline	Trawl
Atlantic Cod	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline; Pot	Trawl; Hand Line (baited)
Atlantic Halibut	May–Nov	May–Nov	May–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
Skate sp.	May–Nov	Jun–Sep	Jun–Sep	Jun–Aug; Oct–Nov	May–Aug	Gillnet; Longline	Trawl
Pollock	May–Nov	Jun–Nov	Jun–Oct	May–Aug; Oct–Nov	May–Nov	Gillnet; Longline	Trawl
Witch Flounder	May–Nov	May–Sep; Nov	May–Aug: Oct–Nov	May–Nov	May–Nov	Gillnet	Trawl
Atlantic Haddock	May–Nov	May–Nov	Jun–Nov	May–Nov	May–Nov	Gillnet; Longline	Trawl
Hagfish	Sep–Nov	Sep–Oct	Sep–Nov	Jun; Aug–Oct	-	Hagfish Barrel; Trap Net	-
Stimpson's Surf Clam	Jul; Oct–Nov	Oct	-	Nov	-	-	Dredge
Swordfish	Jul–Nov	Jul–Oct	Jul–Nov	Jul–Aug; Oct	Aug–Oct	Gillnet; Longline	-
Roughhead Grenadier	Jun–Nov	Jun–Aug; Nov	May–Oct	May–Nov	Jun–Aug	Gillnet; Longline	Trawl
Atlantic Herring	Nov	-	-	May	-	-	Seine
Whelk	May–Jul	Jun–Jul	-	Jun	Jun	Pot	-
Capelin	May–Nov	Jul	Jul	Jul	-	-	Trawl; Seine
Mackerel	Sep	-	-	-	Oct	-	Seine

Species	Month Caught					Gear Type	
	2009–2010	2011	2012	2013	2014	Fixed	Mobile
Porbeagle Shark	May–Jun; Aug; Oct–Nov	Jul–Aug; Nov	May–Jun; Nov	-	May–Jul	Gillnet; Longline	Trawl
Cusk	Jun–Nov	May–Jul; Sep; Nov	May–Jul; Sep–Nov	May; Jul–Aug; Oct–Nov	May–Jul; Nov	Gillnet; Longline	Trawl
Bluefin Tuna	Jul–Sep; Nov	Jul–Oct	Jul–Nov	Jul; Sep	Aug–Oct	Longline	Troller Lines; Rod and Reel; Electric Harpoon
Mako Shark	Jun–Oct	Aug–Oct	Jul–Nov	Jul–Aug	Jun; Aug–Oct	Gillnet; Longline	-
Sea Scallop	Aug–Sep; Nov	May	Nov	-	-	-	Dredge
Bigeye Tuna	Jul–Sep	Aug–Sep	Jul–Sep; Nov	-	Sep	Longline	-
Mahi Mahi (dolphinfish)	Jul–Sep	-	Jul–Aug; Oct	Jul–Aug	Aug–Sep	Longline	-
Albacore Tuna	Jul–Sep	Sep	Jul–Sep; Nov	Jul	Aug–Sep	Longline	-
Roundnose Grenadier	Sep	Jul	Jun	Nov	-	Longline	-
Flounder sp.	Nov	-	Sep	-	-	Gillnet	Trawl
Iceland Scallop	Sep	-	Aug	-	-	-	Dredge
Atlantic (striped) Wolffish	May; Jul	Jun–Jul	Jun	Jul	May–Jul	Gillnet; Longline	Trawl
Shark sp.	-	Oct	-	-	-	Gillnet	-
Winter Flounder	-	Sep	-	-	-	Gillnet	-
Yellowfin Tuna	-	Oct	Aug–Sep	-	-	Longline	-
White Marlin	-	Jul	Aug	-	Aug	Longline	-
Dogfish sp.	-	-	-	Nov	-	Longline	-
Sculpin sp.	-	-	-	Oct	-	-	Trawl
Argentine	-	-	-	-	Aug	-	Trawl
Groundfish sp.	-	-	-	-	Nov	Longline	-

Source: DFO commercial landings database, 2009–2014.

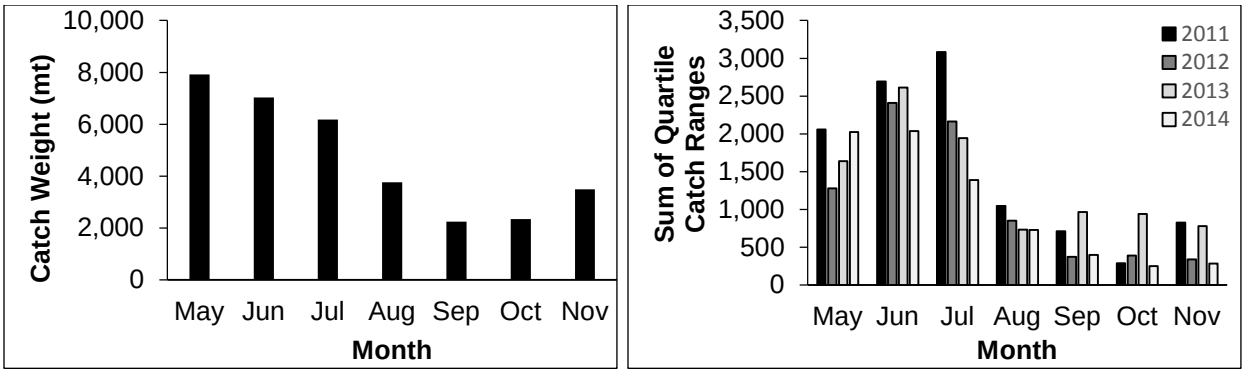
Harvest Timing in the Study Area

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 4.7. Monthly catch weight was highest during the May–July 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.



Source: DFO commercial landings database, 2014.

Figure 4.6 Fixed (top) and Mobile (bottom) 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 4.7 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.

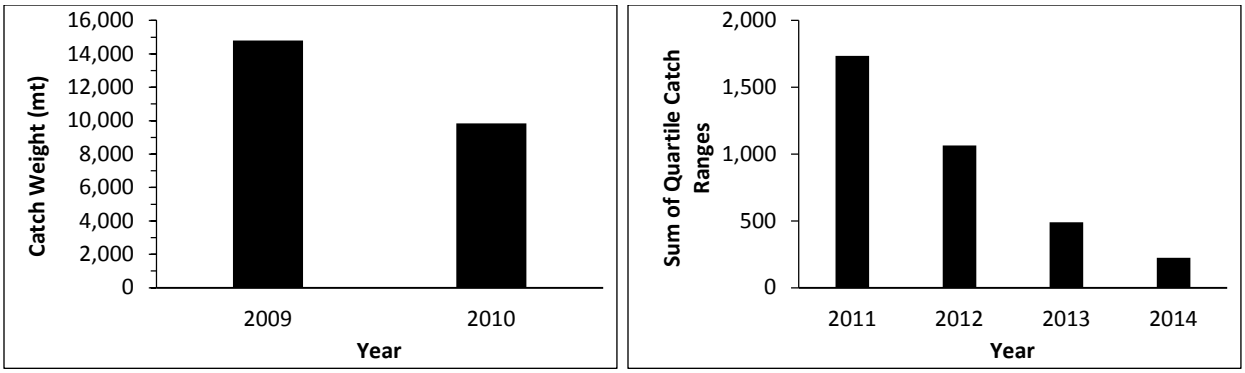
Principal Species in the Study Area

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

Northern Shrimp

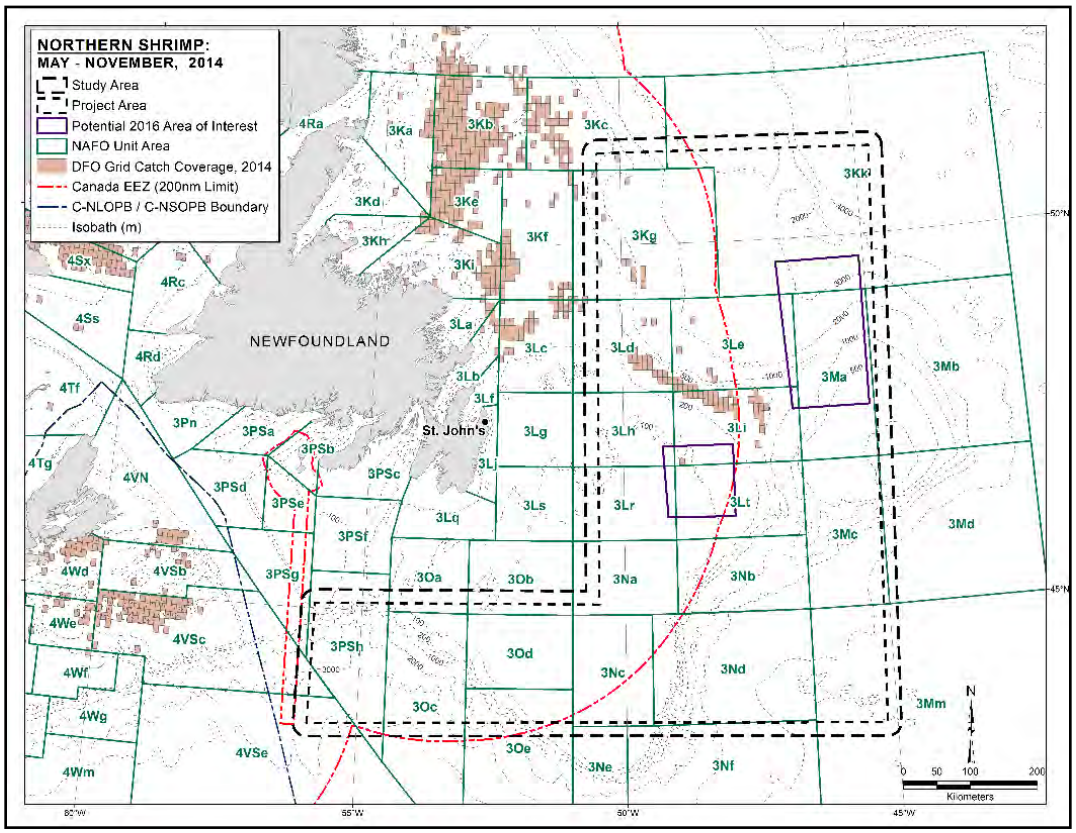
Overall, based on both quantity and value, northern shrimp was the most important commercial species in the Study Area during May-November, 2009–2010 and the second most important in 2011–2012. However, its importance decreased considerably by 2013, likely in relation to substantial decreases in Total Allowable Catch in NAFO Division 3L since the 2012/2013 fishing season (DFO 2012; NAFO 2015e). 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 4.8. Figures 4.15–4.18 of LGL (2015a) show the northern shrimp harvest locations in eastern offshore Newfoundland during May–November, 2005–2013. Fishing locations for northern shrimp by season in 2012 are shown in the Eastern Newfoundland SEA (Figure 4.141 of C-NLOPB 2014).

Figure 4.9 shows harvest location distributions in relation to the Study and Project areas for 2014. Most of the northern shrimp were harvested in the central and northwest portions of the Study and Project Areas, in areas where depth ranged between 200 and 500 m. One catch location cell was within the southernmost potential 2016 Area of Interest during 2014, and none were within the northernmost 2016 Area of Interest. 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 4.10. Most of the northern shrimp was caught during June–August.



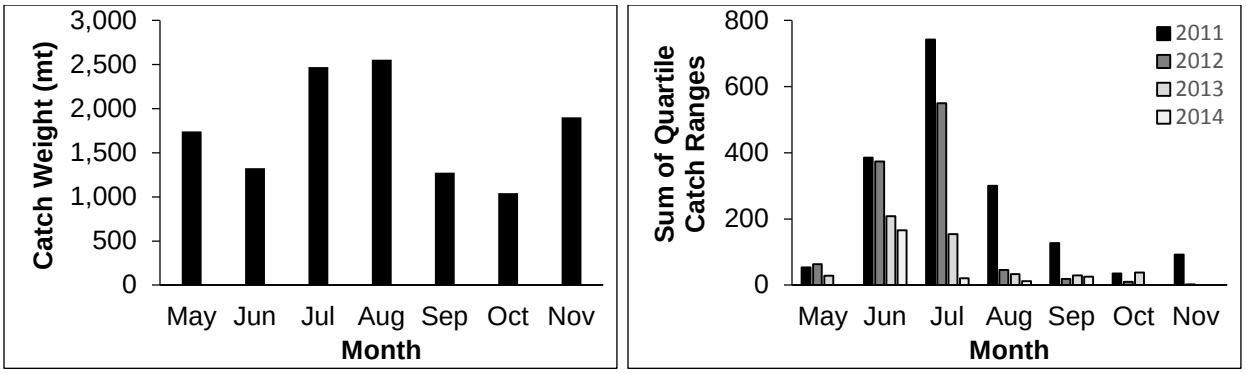
Source: DFO commercial landings database, 2009–2014.
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.8 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, 2014.

Figure 4.9 Distribution of Harvest Locations for Northern Shrimp, May–November, 2014.



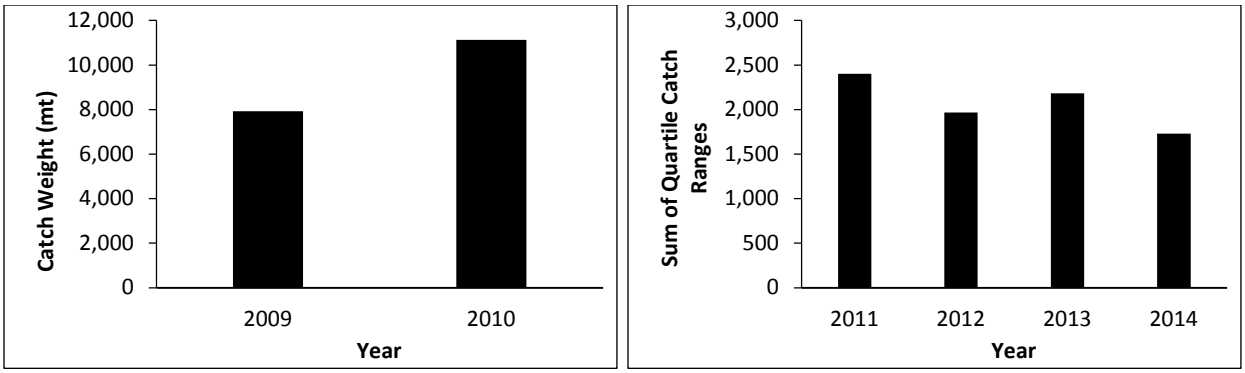
Source: DFO commercial landings database, 2009–2014.
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given month.

Figure 4.10 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

Snow crab was the second most important commercial species in the Study Area during 2009–2010, and the most important during 2011–2014. The 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 4.11. Snow crab harvesting locations for May–November, 2005–2013 in eastern and southeastern offshore Newfoundland are shown in Figures 4.21–4.24 of LGL (2015a) and Figures 4.15–4.18 of LGL (2015b), respectively. Annual harvest locations for snow crab in 2012 are shown in Figure 4.140 of the Eastern Newfoundland SEA (C-NLOPB 2014), and for 2006 and 2007 in Figure 3.57 of the South Newfoundland SEA (C-NLOPB 2010). Figure 4.12 shows the snow crab harvesting locations for May–November, 2014 in relation to the Study and Project Areas. The majority of snow crab was harvested in the central and south-central portions of the Study and Project Areas, in water depths <200 m. Multiple catch locations were within the northern and eastern portions of the southernmost potential 2016 Area of Interest during 2014, while none were within the northernmost 2016 Area of Interest.

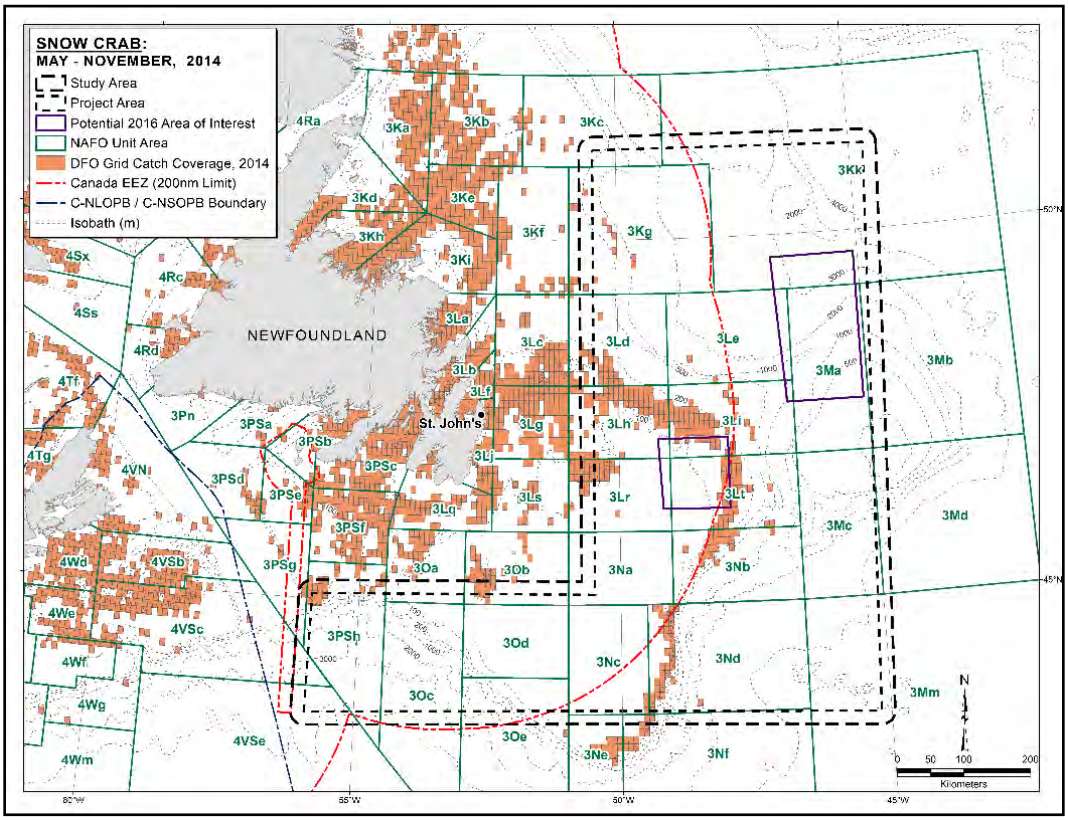
The average and total monthly snow crab harvests in the Study Area during the May–November, 2009–2010 and 2011–2014 periods, respectively, are shown in Figure 4.13. Snow crab were caught between May and August in the Study Area, with the majority of catch taken during May and June.



Source: DFO commercial landings database, 2009–2014.

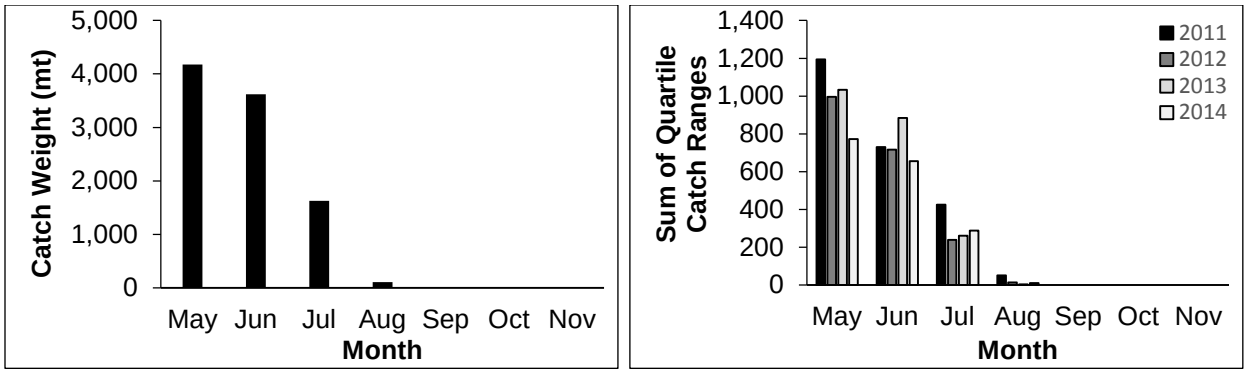
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.11 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, 2014.

Figure 4.12 Distribution of Harvest Locations for Snow Crab, May–November, 2014.



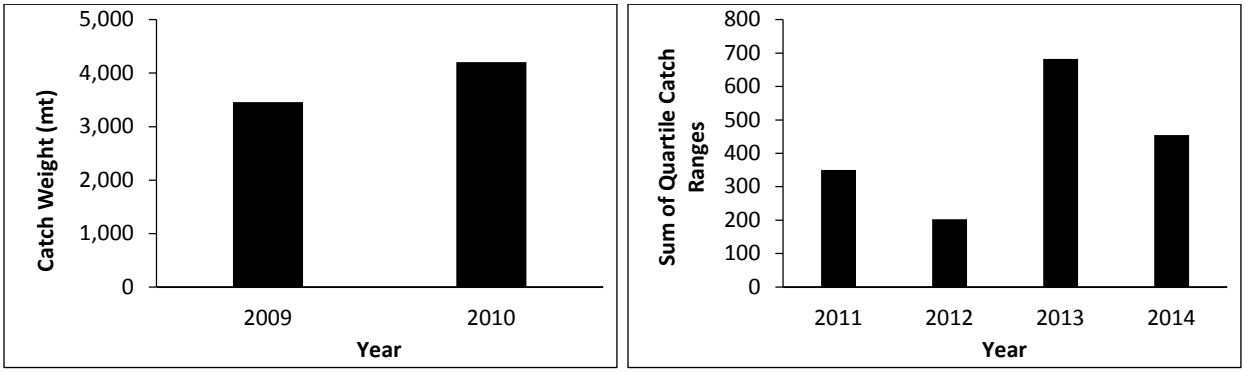
Source: DFO commercial landings database, 2009–2014.

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 4.13 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.

Yellowtail Flounder

Yellowtail Flounder accounted for the largest proportion of groundfish catches and was the third most important commercial species in the Study Area during 2009–2010. This species was also among the predominant groundfish harvested in the Study Area between 2011–2014. Total annual catch weights (2009–2010) and the total sum of catch weight quartile codes (2011–2014) for yellowtail flounder in the Study Area between May and November are indicated in Figure 4.14. Yellowtail flounder harvest locations during May–November, 2005–2013 in southeastern offshore Newfoundland are shown in Figures 4.21–4.24 of LGL (2015b).

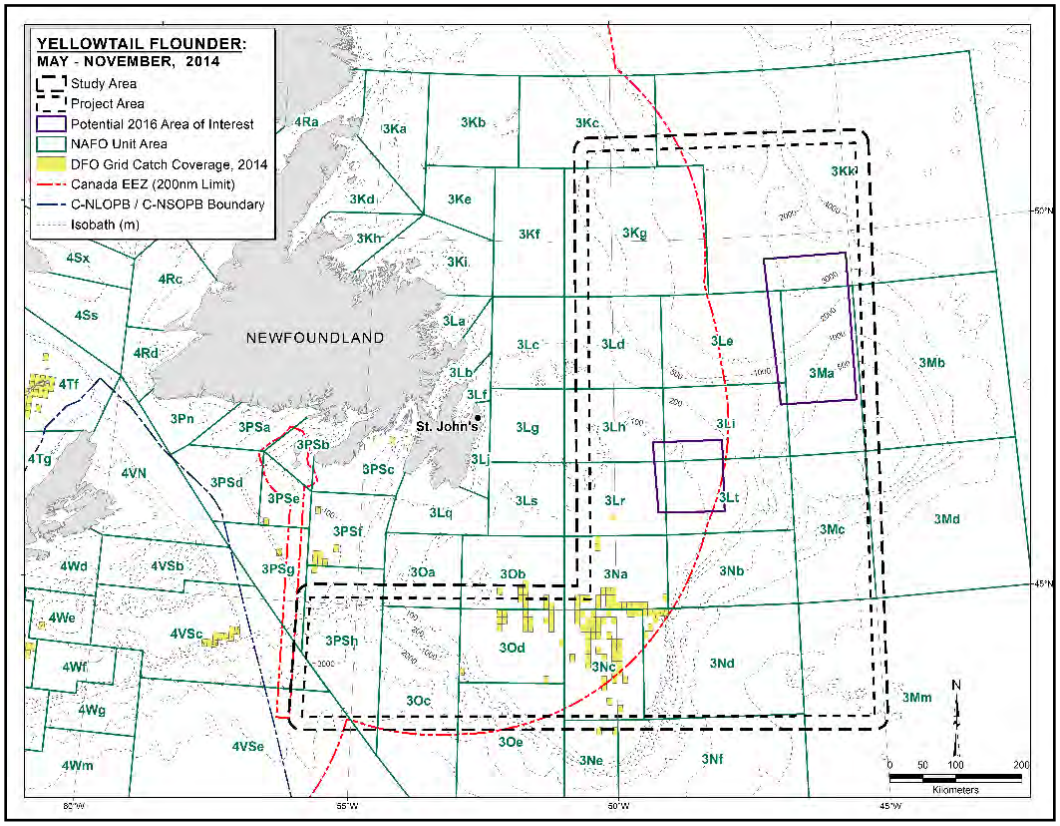


Source: DFO commercial landings database, 2009–2014.

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 4.14 Total Annual Catch Weights, May–November, 2009–2010 (left), and Total Annual Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Yellowtail Flounder in the Study Area.

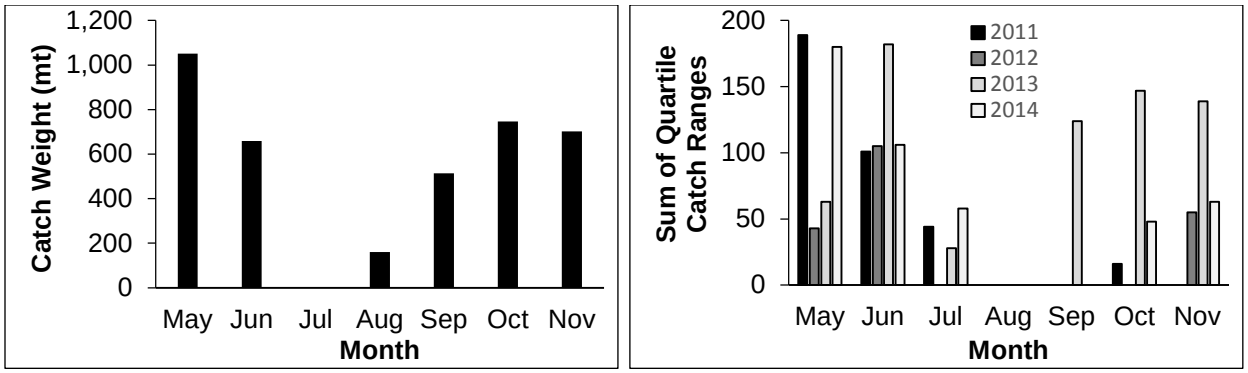
Annual harvest locations for this species are shown for 2012 in the Eastern Newfoundland SEA (Figure 4.143 of C-NLOPB 2014) and for 2006 and 2007 in the Southern Newfoundland SEA (Figure 3.30 of LGL 2010). Figure 4.15 shows yellowtail flounder harvest locations for 2014 in relation to the Study and Project Areas. The majority of yellowtail flounder were caught in the south-central portion of the Project and Study Areas, in areas with depths <100 m. There were no catch locations reported within either the southernmost or northernmost potential 2016 Areas of Interest during 2014.



Source: DFO commercial landings database, 2014.

Figure 4.15 Distribution of Harvest Locations for Yellowtail Flounder, May–November, 2014.

The average and total monthly yellowtail flounder harvests in the Study Area during the May–November, 2009–2010 and 2011–2014 periods are shown in Figure 4.16. Yellowtail flounder were primarily harvested during the spring and fall in the Study Area, with the lowest catches during July and August.



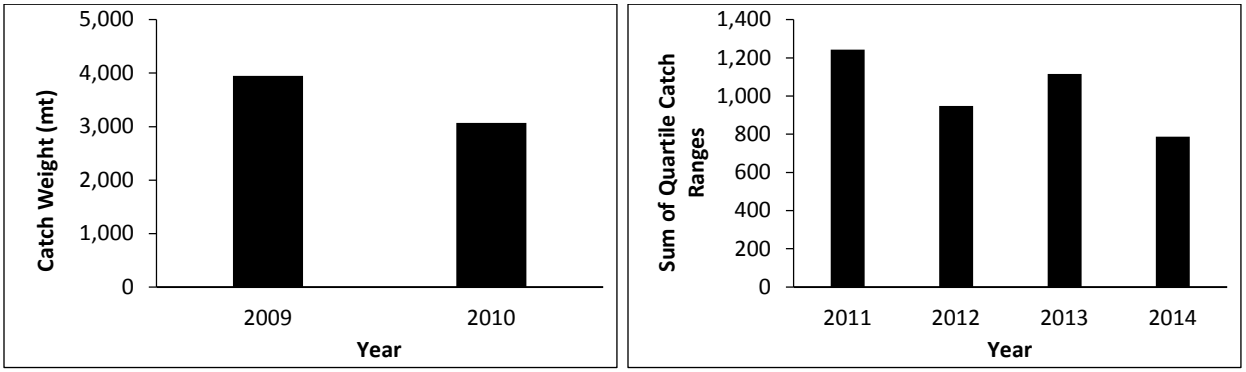
Source: DFO commercial landings database, 2009–2014.

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 month.

Figure 4.16 Average Monthly Catch Weights, May–November, 2009–2010 (left), and Total Monthly Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Yellowtail Flounder in the Study Area.

Greenland Halibut

Greenland halibut was nearly equivalent to yellowtail flounder in terms of catch weight in the Study Area during 2009–2010. However, it was considerably more important than yellowtail flounder in terms of catch value during this period. Greenland halibut accounted for the largest portion of groundfish catches and was among the most important commercial species in the Study Area during 2011–2014. 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 4.17.

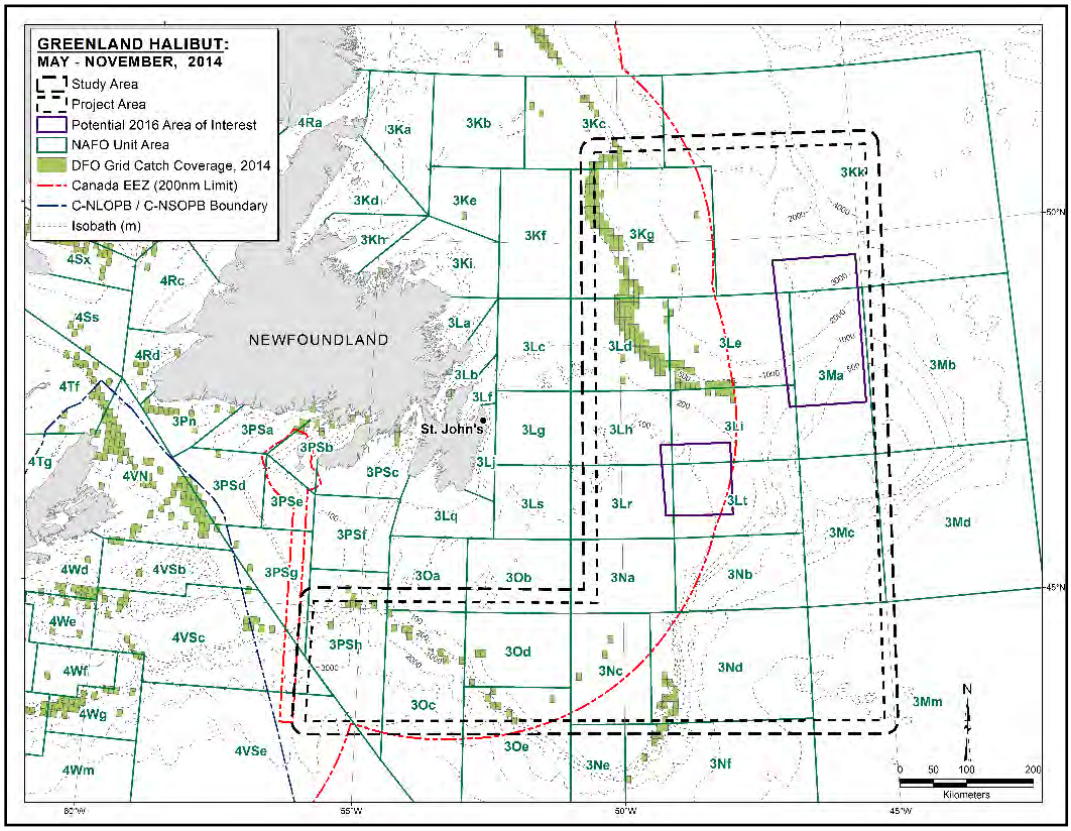


Source: DFO commercial landings database, 2009–2014.

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.

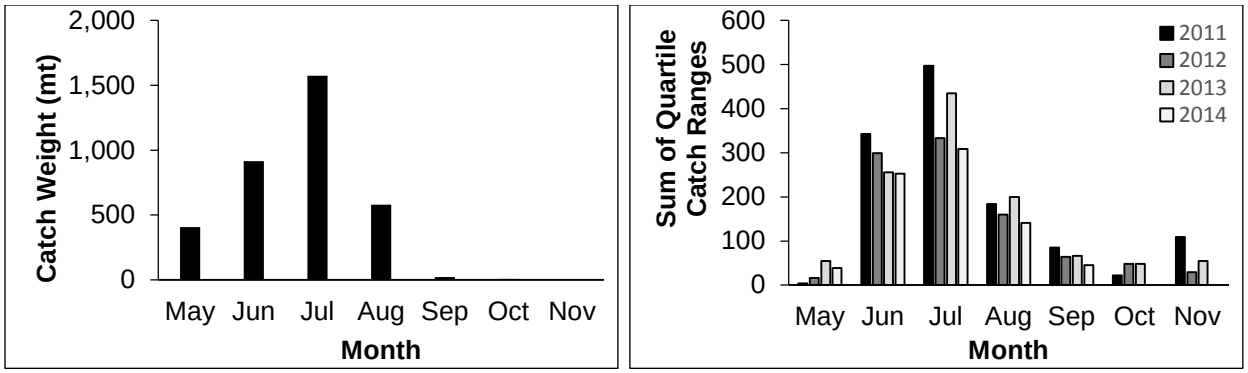
Figure 4.17 Total Annual Catch Weights, May–November, 2009–2010 (left), and Total Annual Catch Weight Quartile Codes, May–November, 2011–2014 (right) for Greenland Halibut in the Study Area.

Greenland halibut harvest locations for May–November, 2005–2013 for eastern offshore Newfoundland are shown in Figures 4.27–4.30 in LGL (2015a). Annual harvest locations for this species for 2012 are shown in Figure 4.142 of the Eastern Newfoundland SEA (C-NLOPB 2014), and for 2006 and 2007 in Figure 3.51 of the Southern Newfoundland SEA (C-NLOPB 2010). Figure 4.18 shows Greenland halibut harvest locations for May–November 2014 in relation to the Study and Project Areas. Greenland halibut were caught in the northwest, central, south-central and southwest portions of the Study and Project Areas, predominantly between the 200 and 1,000 m isobaths. There were no catch locations reported within the potential 2016 Areas of Interest during 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 4.19. Greenland halibut were primarily harvested during the June–August period in the Study Area.



Source: DFO commercial landings database, 2014.

Figure 4.18 Distribution of Harvest Locations for Greenland Halibut, May–November, 2014.



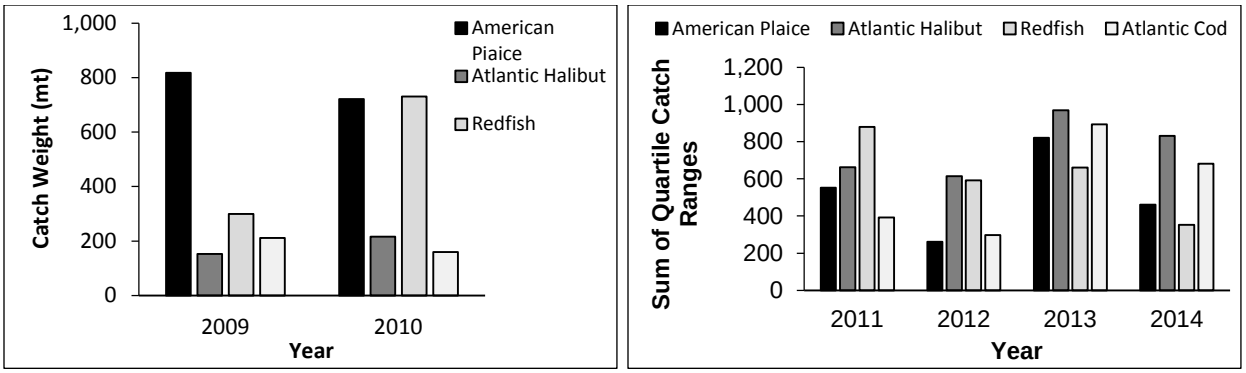
Source: DFO commercial landings database, 2009–2014.

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 4.19 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: American Plaice, Atlantic Halibut, Redfish and Atlantic Cod

In addition to the four species above, American plaice, Atlantic halibut, redfish and Atlantic cod have also been identified as important commercial species within the Study Area (see Tables 4.2–4.6 in § 4.3.3.1). Total annual catch weights (2009–2010) and the total sum of catch weight quartile ranges (2011–2014) for these species in the Study Area between May and November are indicated in Figure 4.20. Harvest locations for redfish, Atlantic cod and Atlantic halibut during May–November, 2005–2013 for southeastern offshore Newfoundland are shown in Figures 4.37–4.51 in LGL (2015b). Annual harvest locations for American plaice and redfish during 2012 are shown in Figures 4.144–4.145 of the Eastern Newfoundland SEA (C-NLOPB 2014), and during 2006 and 2007 for Atlantic cod, redfish, Atlantic halibut and American plaice in Figures 3.24, 3.27, 3.36 and 3.45, respectively, of the Southern Newfoundland SEA (C-NLOPB 2010). Figure 4.21 shows harvest locations for May–November 2014 in relation to the Study and Project areas. The majority of these species were caught in the southern and central portions of the Study and Project Areas, in areas with depths <1,000 m. There were no catch locations reported within the potential 2016 Areas of Interest during 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 made during the May–July period in the Study Area for these four species, with occasional secondary peaks in the fall for American plaice and Atlantic cod.

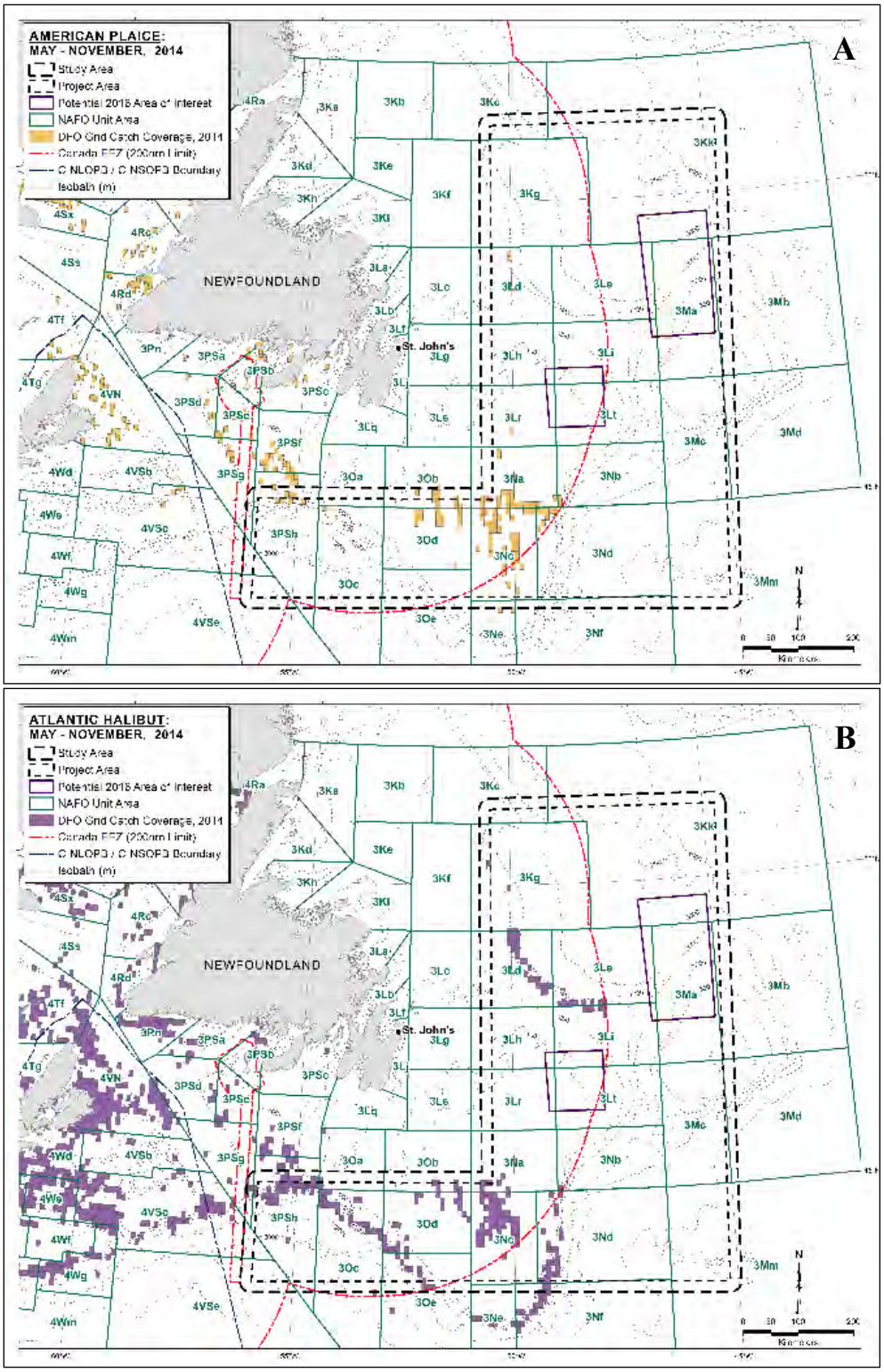


Source: DFO commercial landings database, 2009–2014.
Note: Sum of quartile catch ranges is the summation of catch weight quartile ranges (i.e., 1–4) for all catch records for all species; the greater the sum of quartile range counts, the greater the catch weight for a given year.

Figure 4.20 Total Annual Catch Weights, May–November, 2009–2010 (left), and Total Annual Catch Weight Quartile Codes, May–November, 2011–2014 (right) for American Plaice, Atlantic Halibut, Redfish and Atlantic Cod 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 [2J is north of the Study Area). 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, DFO, Resource Management and Aboriginal Affairs, pers. comm. December 2015; 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).



Source: DFO commercial landings database, 2014.

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

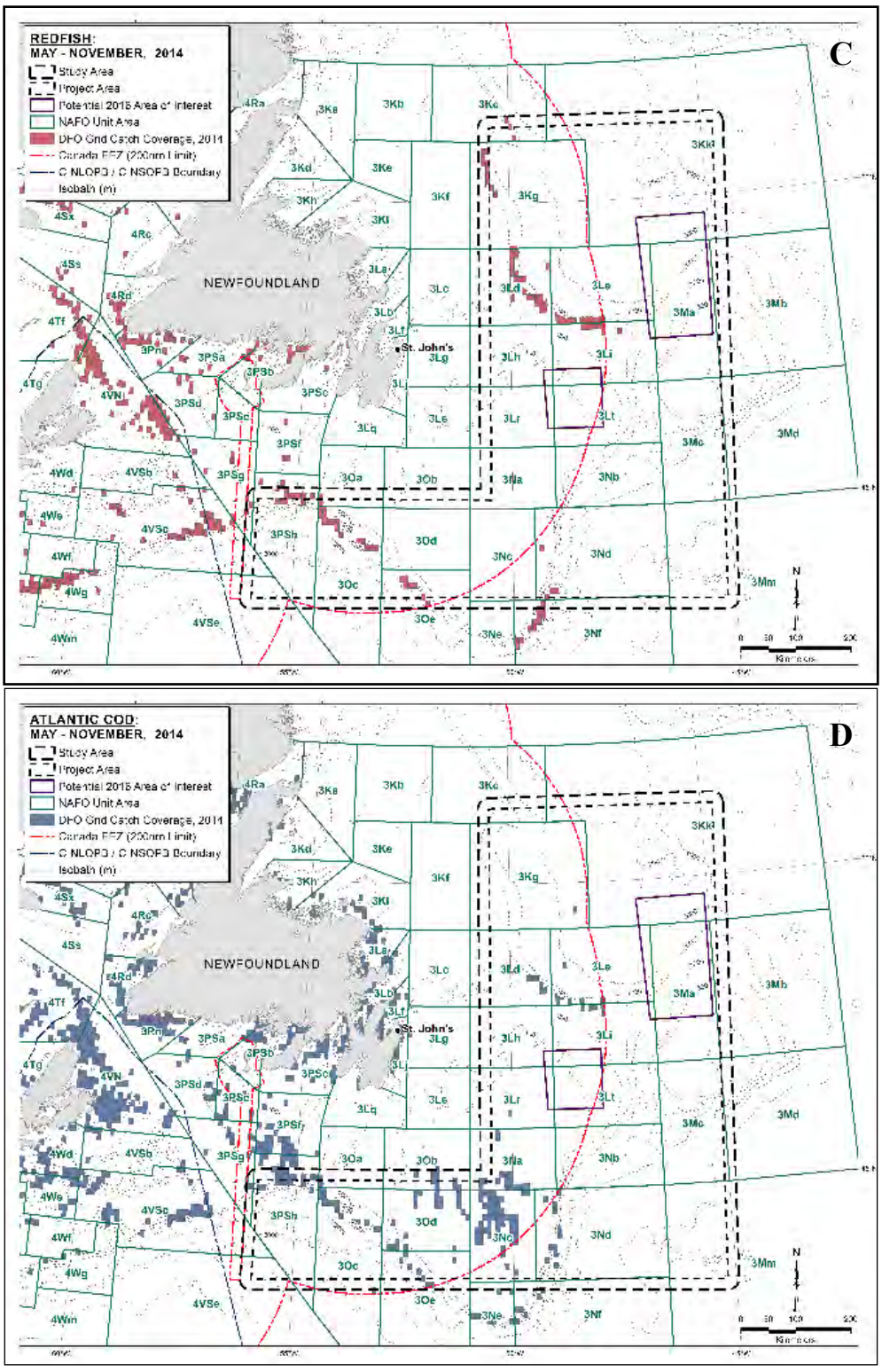
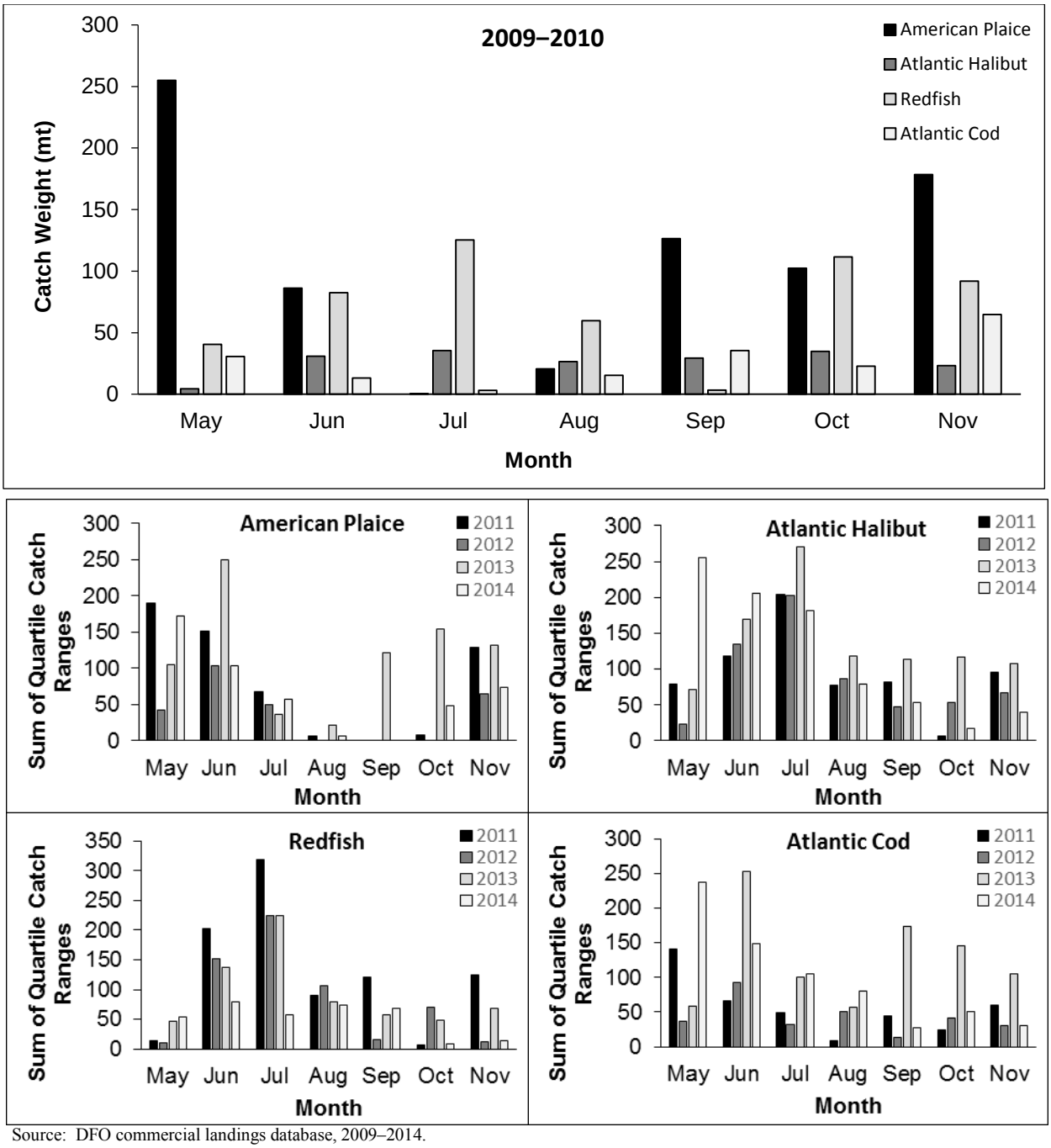


Figure 4.21 (continued) **Distribution of Harvest Locations for A) American Plaice, B) Atlantic Halibut, C) Redfish and D) Atlantic Cod, May–November, 2014.**



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

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). The Nunatsiavut Government holds a Communal Snow Crab licence and allocation within NAFO Divisions 2GHJ, north of 54º40' N, which is beyond and to the north of the Study Area (DFO 2010). The Innu Nation of Labrador communal fixed gear groundfish licence also permits activity within 2GHJ, north of the Study Area (D. Ball and D. Tobin, DFO, Resource Management and Aboriginal Affairs, pers. comm. December 2015).

Otherwise, according to the Eastern Newfoundland SEA (C-NLOPB 2014), there are no other known Aboriginal fisheries that occur within the Study Area.

4.3.5 Recreational Fisheries

Recreational fisheries in Newfoundland and Labrador are briefly described in § 4.3.4.4 of the Eastern Newfoundland SEA (C-NLOPB 2014). 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, portions of 3KL and 3Ps are within the Study Area. This fishery is described in further detail in § 4.3.5 of LGL (2015a).

Given the distance from shore, it is possible but unlikely that recreational fisheries will be conducted within the 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 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 2009–2013 spring (May–June) and fall (September–November) DFO RV surveys in the Study Area was 634 mt. 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, 2009–2013.

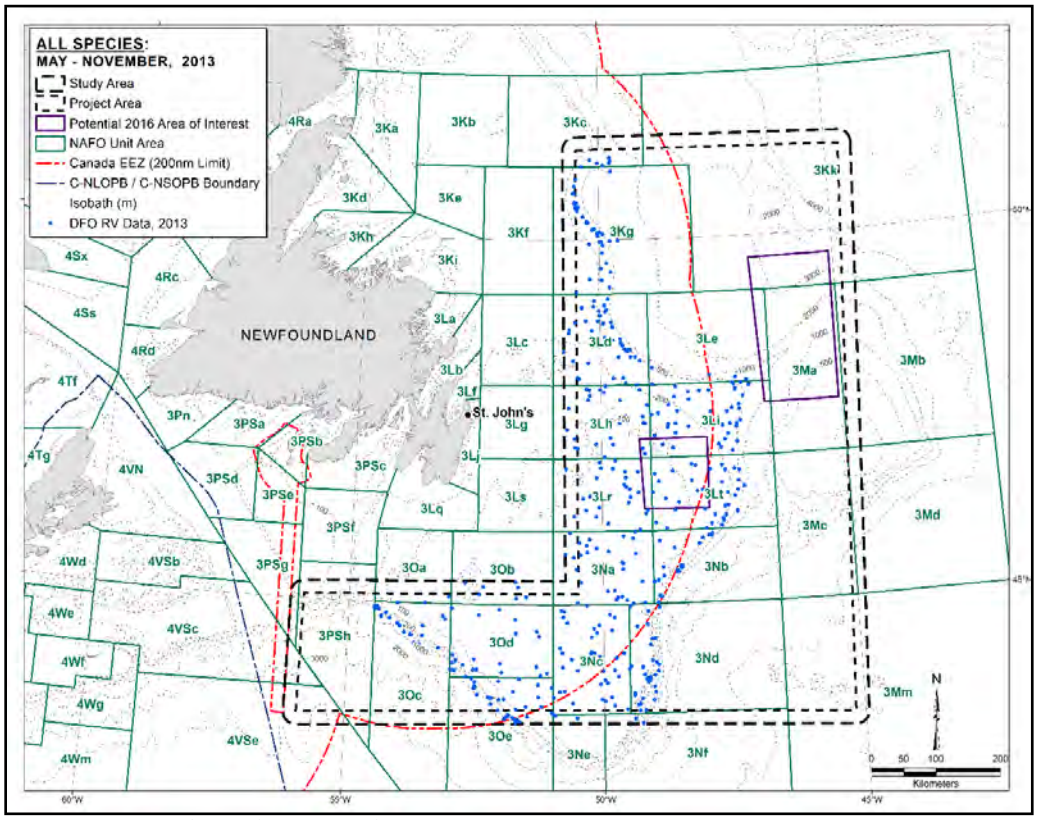
Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Deepwater Redfish	331	2,296,251	384	301
Yellowtail Flounder	72	251,957	70	75
American Plaice	42	219,505	187	148
Atlantic Cod	36	55,363	170	128
Thorny Skate	29	16,967	248	192
Capelin	14	978,765	127	142
Northern Shrimp	12	2,439,269	300	256
Sand Lance (offshore)	9	795,770	93	88
Sea Cucumber (*Cucumaria frondosa*)	7	26,530	107	103
Greenland Halibut	6	21,483	428	427
Roughhead Grenadier	6	13,509	525	530
Silver Hake	6	47,972	243	231
Witch Flounder	5	15,851	381	290
Snow Crab	4	16,415	186	216
Atlantic (striped) Wolffish	3	3,199	215	171
Longfin Hake	3	34,718	438	414
White Hake	3	3,730	298	247
Atlantic Haddock	3	3,260	104	121
Basket Star (*Gorgonocephalus arcticus*)	3	53	181	197
Sea Anemone (Actinaria)	3	16,628	324	291
Comb Jelly (Ctenophora)	2	630	72	73
Sea Cucumber (Holothuroidea)	2	10,669	112	146
Jellyfishes (Scyphozoa)	2	360	528	470
Atlantic Halibut	1	111	327	339
Blue Hake	1	12,593	637	718
Marlin Spike	1	23,544	462	495
Sponges	1	46	324	265
Black Dogfish Shark	1	2,055	660	795
Monkfish	1	281	207	343
Longnose Eel	1	19,760	537	605
Northern Wolffish	1	407	615	538
Basket Star (Gorgonocephalus)	1	120	261	202
Striped Shrimp	1	303,158	104	113
Shrimp (Natantia)	1	48	652	259

Species	Catch Weight (mt)	Catch Number	Mean Catch Depth (m)	
			Spring	Fall
Longhorn Sculpin	1	3,565	66	66
Sand Dollar (*Echinarachnius parma*)	1	31,393	131	141
Brittle Star (Ophiuroidea)	1	20,684	175	248
Green Sea Urchin	1	45,697	108	94
Roundnose Grenadier	1	4,786	654	725
Sea Urchin (*Echinoidea*)	1	23,363	252	177
Spotted Wolffish	1	308	375	277
Atlantic Argentine	1	3,146	334	310
Sea Raven	1	445	68	63
Shrimp (*Argis dentata*)	1	113,980	127	109
Corals	n/d	7,710	308	421
Polar Sea Star	1	5,691	89	90
Spinytail Skate	0.5	78	644	602
Arctic Eelpout	0.5	2,577	172	151
Toad Crab (*Hyas* sp.)	0.5	46,218	98	102
Sea Urchin (*Strongylocentrotus* sp.)	0.5	27,916	92	165
Moustache Sculpin	0.4	36,545	101	111
Shrimp (*Sergestes arcticus*)	0.4	381,772	541	506
Pollock	0.4	123	157	237
Eelpout (*Lycodes* sp.)	0.4	2,908	353	250
Vahl's Eelpout	0.4	2,976	429	408
Sand Dollar (Clypeasteroida)	0.3	17,304	169	131
Cusk	0.005	2	615	256
Wolffishes	0.001	2	635	-
Total	**626**	**8,410,166**	**242**	**232**

Source: DFO RV Survey Data, 2009–2013.
Note: n/d denotes data unavailable.

Deepwater redfish accounted for 52% of the total 2009–2013 catch weight, followed by yellowtail flounder (11%), American plaice (7%), Atlantic cod (6%), thorny skate (5%), capelin and northern shrimp (2% each), and sand lance (offshore), sea cucumber (*Cucumaria frondosa*) and Greenland halibut (1% each). All other species/groups accounted for less than 1% of the total 2009–2013 catch weight in the Study Area. Principal species captured during the 2009–2013 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 eastern and southeastern offshore Newfoundland regions include maps indicating the 2008–2012 DFO RV survey catch locations for all species (see 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 on the shelf and slope Grand Banks regions of the Study Area during the 2009–2013 DFO RV surveys between May and November, predominantly in water depths <1,000 m. Across all

species caught during the 2009–2013 DFO RV surveys in the Study Area, total catch weight ranged from 101–154 mt per year.



Source: DFO Research Vessel Survey Database, 2013.

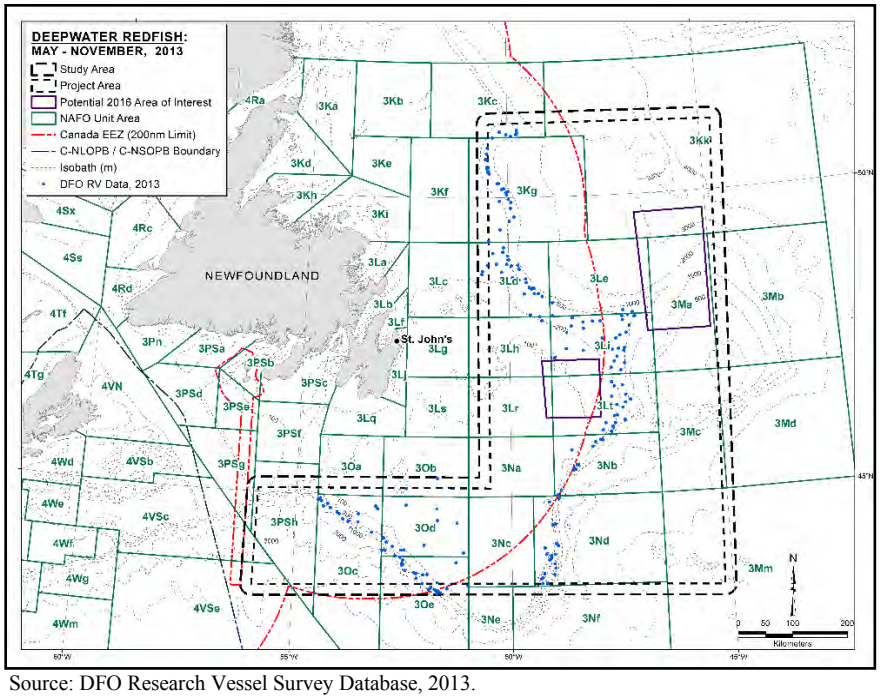
Figure 4.23 Distribution of DFO RV Survey Catch Locations within the Study Area, May–November, 2013.

Spring and fall RV surveys each accounted for 50% of the total catch weight. The average mean depths of catch during spring and fall surveys from 2009–2013 were 242 m (min: 37 m; max: 1,084 m) and 232 m (min: 38 m; max: 1,454 m), respectively.

In descending order, the top five species/groups in terms of catch weight during the 2009–2013 spring and fall surveys were deepwater redfish, yellowtail flounder, Atlantic cod, American plaice and thorny skate. Species/groups that were caught predominantly during the spring RV surveys included wolffishes, cusk, basket star (*Gorgonocephalus arcticus*), capelin, shrimp (*Sergestes arcticus*), pollock, sand dollar (*Echinarachnius parma*) and Atlantic argentine. Species/groups that were caught in essentially equal amounts during both surveys included white hake, spotted wolffish, monkfish, thorny skate, striped shrimp, green sea urchin and Greenland halibut. Species/groups that were caught predominantly during the fall RV surveys included moustache sculpin, black dogfish shark, eelpout (*Lycodes* sp.), roundnose grenadier and shrimp (Natantia). The slight survey depth differences between spring and fall surveys likely account for some of the seasonal differences.

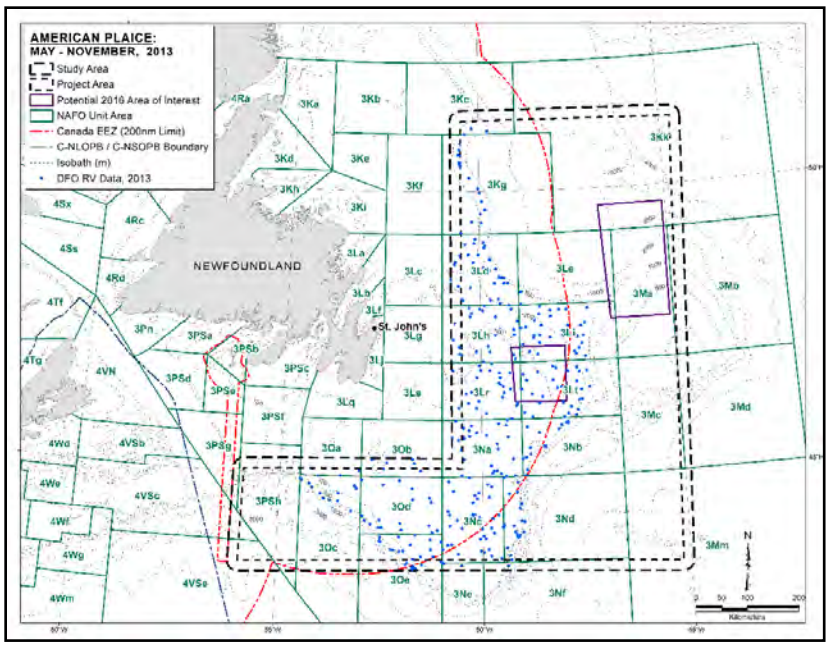
Figures 4.33–4.41 and Figures 4.54–4.61 in LGL (2015a,b) show 2008–2012 DFO RV survey catch locations in eastern and southeastern offshore Newfoundland, respectively, for deepwater redfish, American plaice, Atlantic cod, sponges, corals and wolffishes. Figures 4.24–4.31 show catch locations for these species during the 2013 DFO RV surveys in relation to the Study and Project Areas. Figures 4.32–4.35 show 2009–2013 DFO RV survey catch locations in relation to the Study and Project Areas for yellowtail flounder, thorny skate, northern shrimp and Greenland halibut.

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 2009–2013 period. Northern shrimp, yellowtail flounder and Greenland halibut (predominant commercial species, mainly targeted using mobile gear) were caught primarily at depths ranging from 200–300 m, <100 m and 400–500 m, respectively.



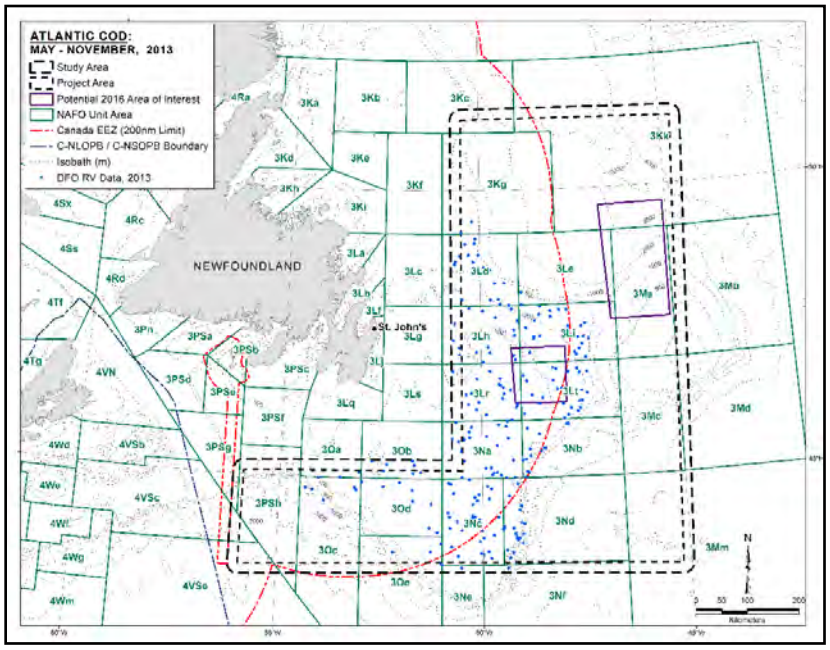
Source: DFO Research Vessel Survey Database, 2013.

Figure 4.24 Distribution of DFO RV Survey Deepwater Redfish Catch Locations in the Study Area, May–November, 2013.



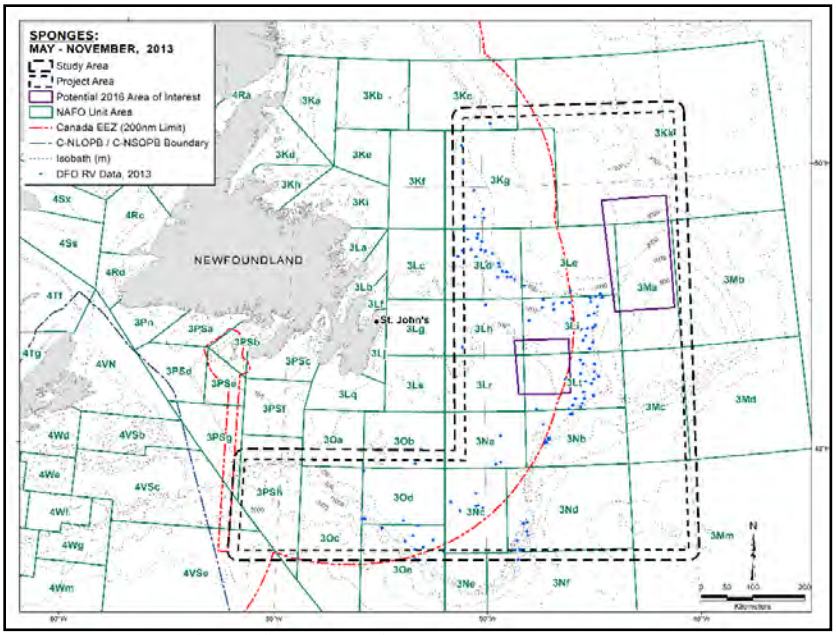
Source: DFO Research Vessel Survey Database, 2013.

Figure 4.25 Distribution of DFO RV Survey American Plaice Catch Locations in the Study Area, May–November, 2013.



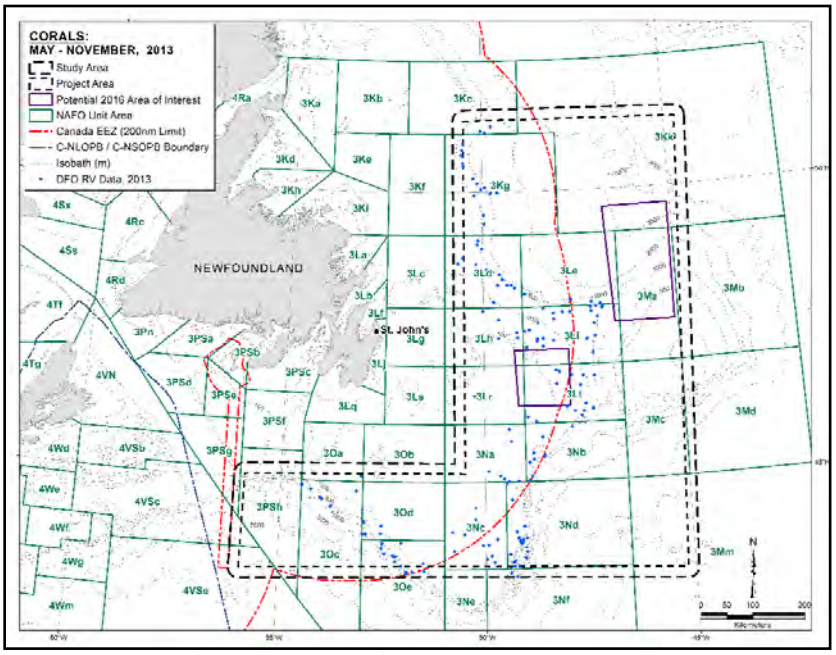
Source: DFO Research Vessel Survey Database, 2013.

Figure 4.26 Distribution of DFO RV Survey Atlantic Cod Catch Locations in the Study Area, May–November, 2013.



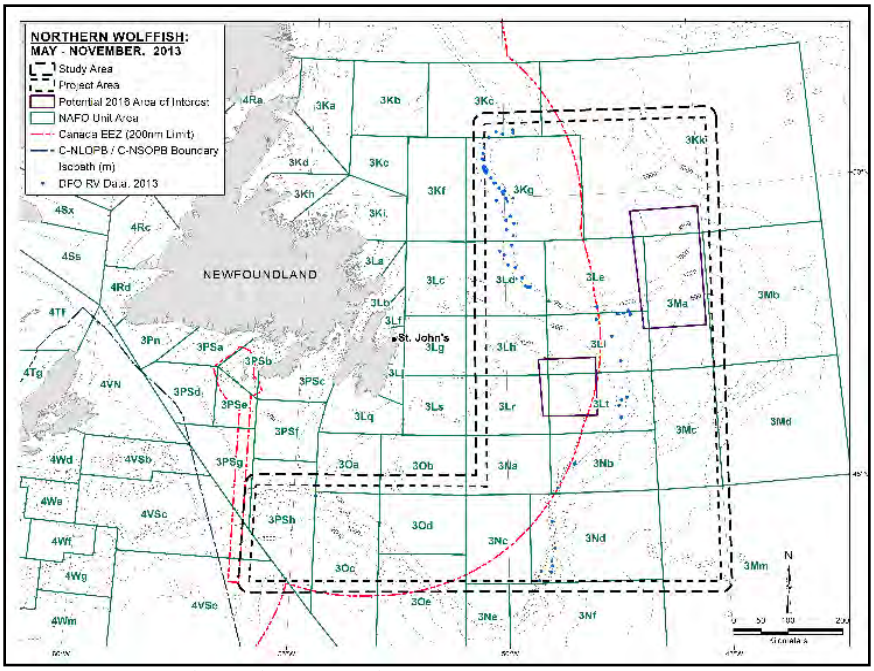
Source: DFO Research Vessel Survey Database, 2013.

Figure 4.27 Distribution of DFO RV Survey Sponge Catch Locations in the Study Area, May–November, 2013.



Source: DFO Research Vessel Survey Database, 2013.

Figure 4.28 Distribution of DFO RV Survey Coral Catch Locations in the Study Area, May–November, 2013.



Source: DFO Research Vessel Survey Database, 2013.

Figure 4.29 Distributions of DFO RV Survey Northern Wolffish Catch Locations within the Study Area, May–November, 2013.

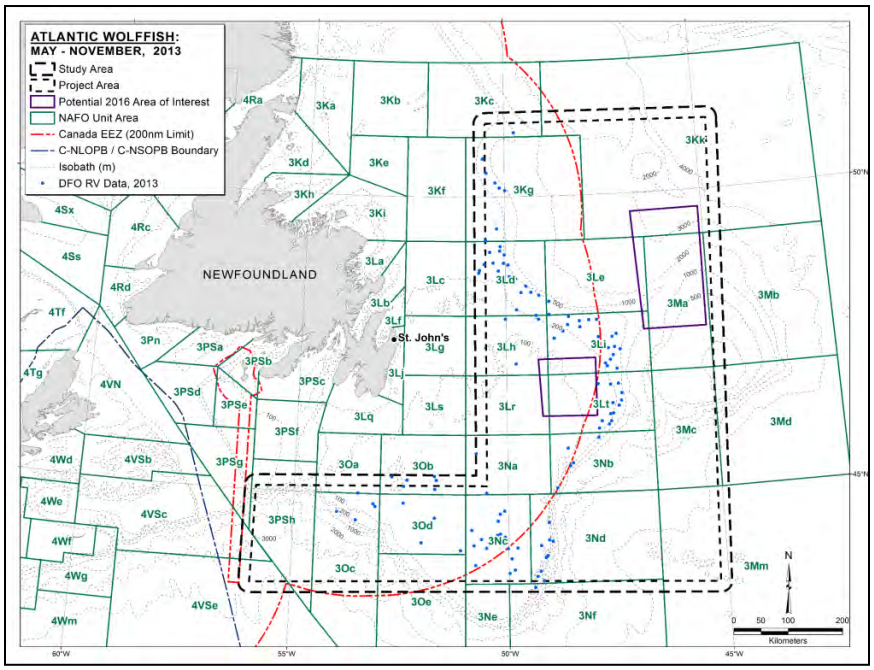
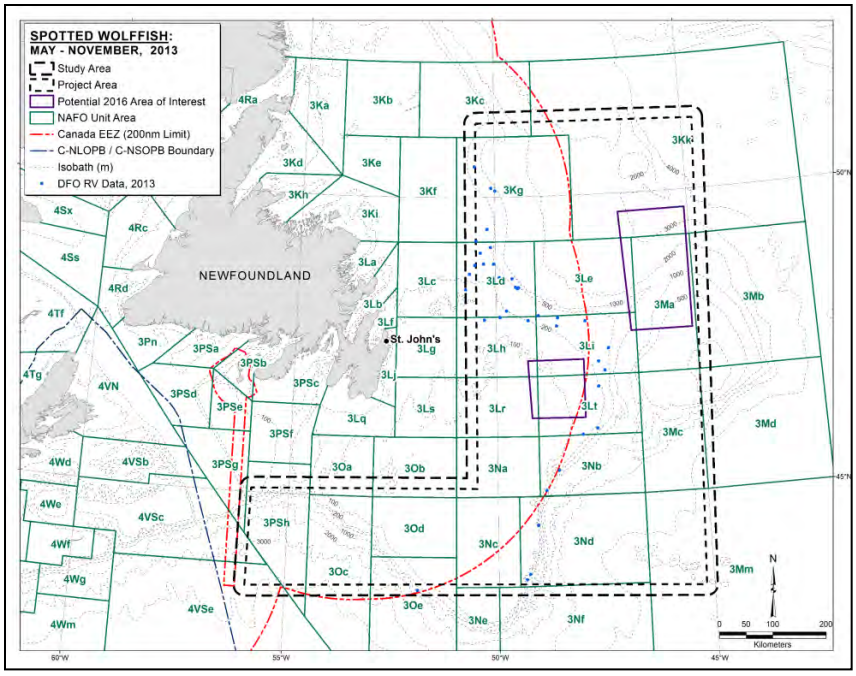
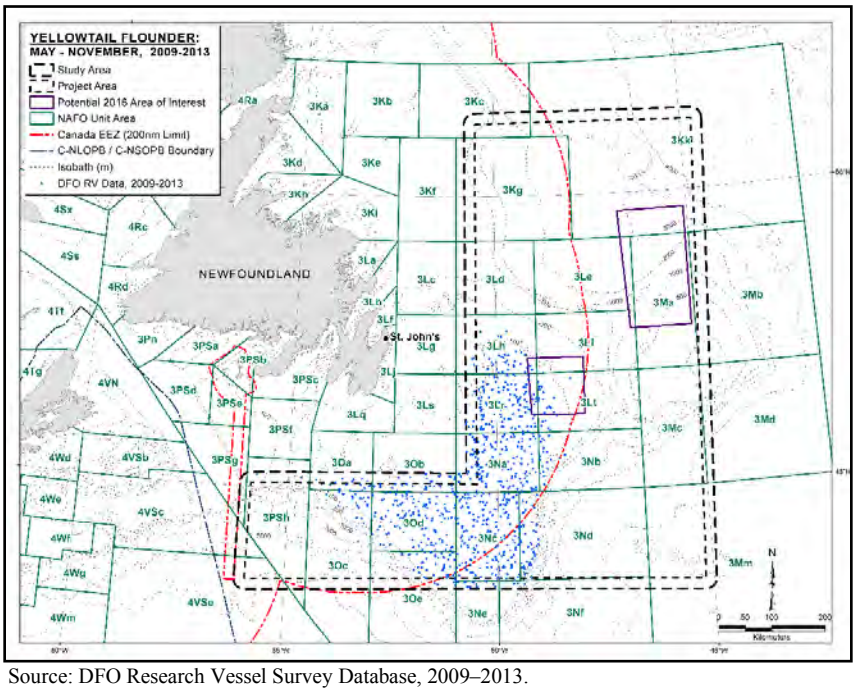


Figure 4.30 Distributions of DFO RV Survey Atlantic Wolffish Catch Locations within the Study Area, May–November, 2013.



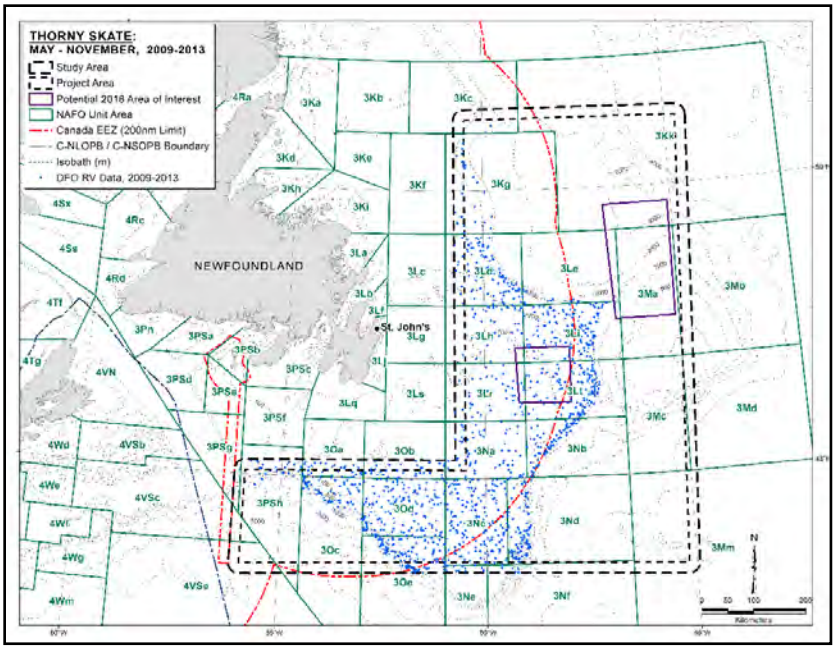
Source: DFO Research Vessel Survey Database, 2013.

Figure 4.31 Distribution of DFO RV Survey Spotted Wolffish Catch Locations within the Study Area, May–November, 2013.



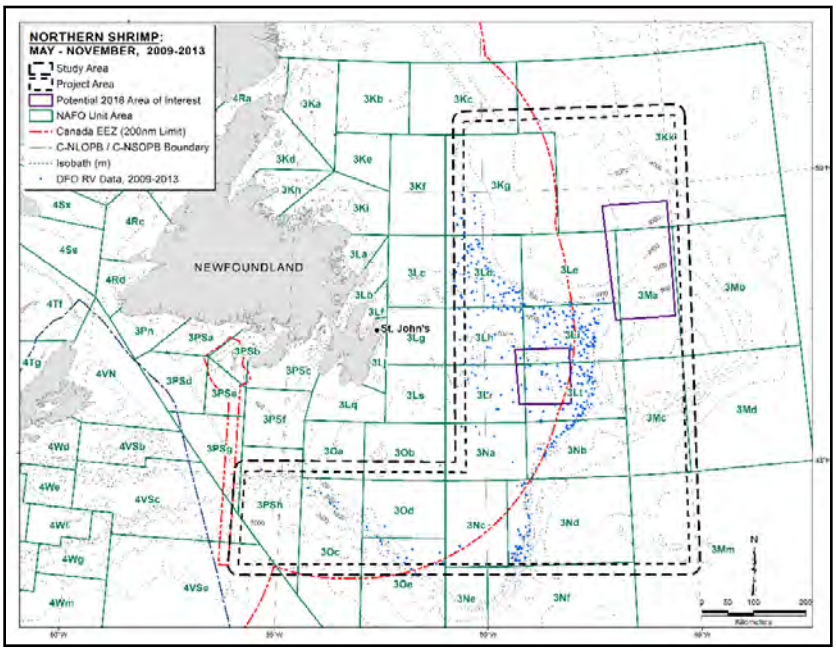
Source: DFO Research Vessel Survey Database, 2009–2013.

Figure 4.32 Distribution of DFO RV Survey Yellowtail Flounder Catch Locations in the Study Area, May–November, 2009–2013.



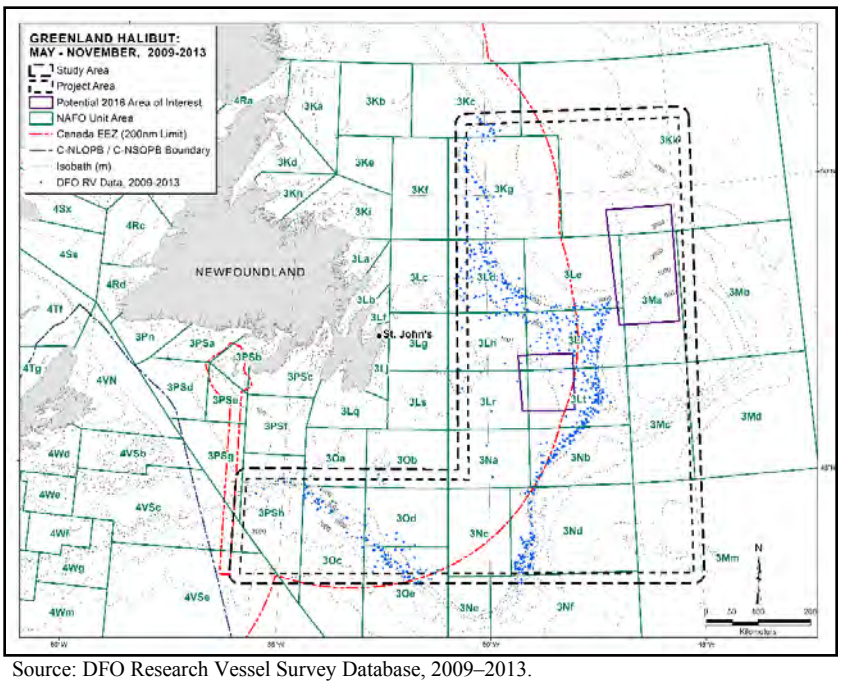
Source: DFO Research Vessel Survey Database, 2009–2013.

Figure 4.33 Distribution of DFO RV Survey Thorny Skate Catch Locations in the Study Area, May–November, 2009–2013.



Source: DFO Research Vessel Survey Database, 2009–2013.

Figure 4.34 Distribution of DFO RV Survey Northern Shrimp Catch Locations in the Study Area, May–November, 2009–2013.



Source: DFO Research Vessel Survey Database, 2009–2013.

Figure 4.35 Distributions of DFO RV Greenland Halibut Catch Locations within the Study Area, May–November, 2009–2013.

Table 4.10 Total Catch Weights and Predominant Species Caught at Various Mean Catch Depth Ranges, DFO RV Surveys, 2009–2013.

Mean Catch Depth Range (m)	Total Catch Weight (mt)	Predominant Species (% of Total Catch Weight)
<100	92	Yellowtail Flounder (79%) Sand Lance (offshore; 9%)
≥100 – <200	111	American Plaice (38%) Atlantic cod (32%) Capelin (12%)
≥200 – <300	56	Thorny Skate (52%) Northern Shrimp (22%)
≥300 – <400	343	Deepwater Redfish (96%)
≥ 400 – <500	11	Greenland Halibut (55%) Longfin Hake (30%)
≥500 – <600	10	Roughhead Grenadier (59%) Jellyfishes (Scyphozoa; 18%)
≥600 – <700	2	Blue Hake (73%) Spinytail Skate (27%)
≥700 – <800	1	Roundnose Grenadier (100%)
≥800 – <900	1	Black Dogfish Shark (100%)
≥900 – <1,000	0	-
≥1,000	0	-

Source: DFO Research Vessel Survey Database, 2009–2013.

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 3L and 3O.

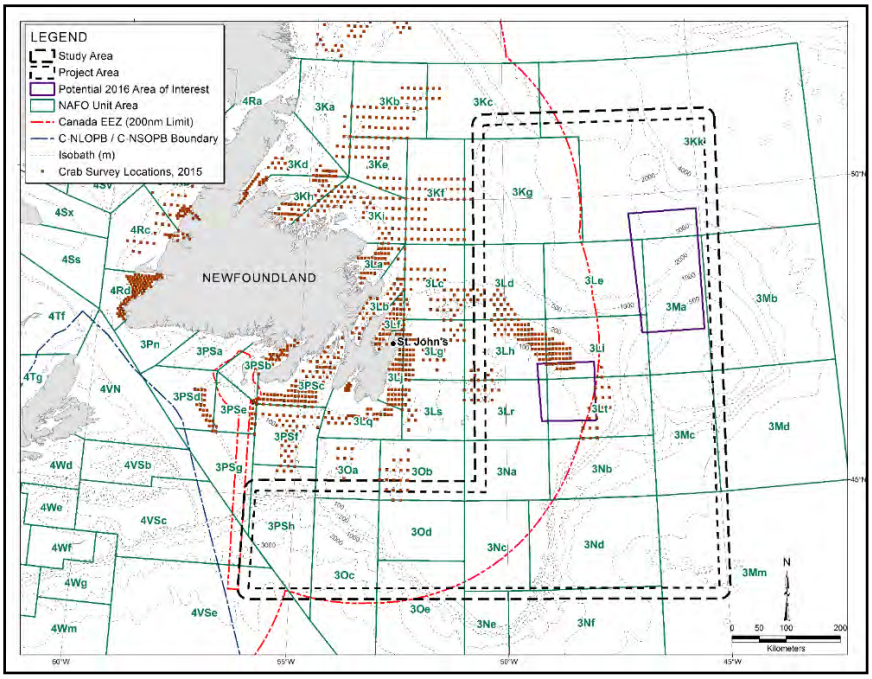
The tentative schedule of DFO RV surveys in the Study Area in 2016 is indicated in Table 4.11. Spring surveys are currently set to begin at the end of March and continue into mid-June, with surveys occurring within the Study Area between the end of May and mid-June. DFO fall research surveys will occur in the Study Area from mid-October 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*
3P	12 Apr	26 Apr	*Needler*
3L	26 Apr	2 May	*Vladykov*
3P + 3O	27 Apr	10 May	*Needler*
3O + 3N	10 May	21 May	*Needler*
3L + 3N	24 May	10 Jun	*Needler*
3K	6 Jul	18 Jul	*Vladykov*
3K	20 Jul	24 Jul	*Vladykov*
3O	14 Sep	27 Sep	*Needler*
3O + 3N	27 Sep	8 Oct	*Needler*
2H	04 Oct	8 Oct	*Teleost*
2H + 2J	11 Oct	25 Oct	*Teleost*
3N + 3L	11 Oct	25 Oct	*Needler*
3L	17 Oct	26 Oct	*Vladykov*
2J + 3K	25 Oct	8 Nov	*Teleost*
3L	25 Oct	8 Nov	*Needler*
3K	9 Nov	22 Nov	*Teleost*
3K + 3L	9 Nov	19 Nov	*Needler*
3K + 3L Deep	22 Nov	6 Dec	*Teleost*

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 central portion of the Study Area in NAFO Division 3L, and several stations are within or immediately adjacent to the Study Area in 3O. Several stations are also immediately adjacent to

the northwestern portion of the Study Area, in 3K. The survey station locations in relation to the Study Area and Project Area are shown in Figure 4.36.



Source: DFO 2015e.

Figure 4.36 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 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 Eastern Newfoundland SEA (§ 4.2.2 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.4 of C-NLOPB 2010), and two site-specific EAs (§ 4.4 of LGL 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 two SEAs are reviewed in terms of current status.

Seabird surveys in the Study Area and surrounding areas have been conducted by the CWS and through oil industry-related seabird monitoring. Prior to 2000, few seabird surveys had been conducted on the Orphan Basin, northern Grand Banks and Flemish Cap. Original baseline information has been collected by the CWS through PIROP (Programme intégré de recherches sur les oiseaux pélagiques). These data have been published for 1969-1983 (Brown 1986) and 1984-1992 (Lock et al. 1994). Since the late 1990s, additional 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 involved in geophysical surveys within the Study Area during 2004-2008 as part of marine bird monitoring programs required by the C-NLOPB (Moulton et al. 2005, 2006; Lang et al. 2006; Lang 2007; Lang and Moulton 2008; Abgrall et al. 2008a,b, 2009). In addition, the CWS initiated a program called Eastern Canadian Seabirds at Sea (ECSAS). The Environmental Studies Research Funds (ESRF) collaborated with CWS to fund a multi-year project focused on improving the knowledge of seabirds at sea on the northern Grand Banks and other areas of oil industry activity in eastern Canada (Fifield et al. 2009). Monthly surveys were conducted within the Study Area from 2006 to 2009. Survey data collected during 2010-2015 were not available at the time of preparation of this EA.

The Study Area encompasses some highly productive marine areas. 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 upwelling of cold water brings mineral nutrients to the surface, resulting in high phytoplankton productivity which forms the basis for increased productivity at higher trophic levels (e.g., seabirds). A mixing of currents in the Orphan Basin creates more upwellings and productive conditions for the growth of plankton, the base of a rich oceanic environment. Several hundred kilometres of continental shelf edge along the southern Grand Banks occur in the Study Area. The major flow of the Labrador Current flows south along the outer edge of the Grand Bank. Some mixing of cold Labrador Current and warm Gulf Stream water occurs in the Study Area on the southern Grand Banks. Seabirds also concentrate at fish spawning areas such as the inshore waters of Newfoundland and the Southeast Shoal, areas where capelin spawn in great numbers.

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). Northern Fulmar and gulls were found in the highest concentrations in the Newfoundland and Labrador shelves region 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, gulls (spring only) and murres. The Grand Banks were determined to be important for a variety of seabirds throughout the year.

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. Table 4.12 summarizes the predicted abundance status for each species 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).

4.4.2 Breeding Seabirds in Eastern Newfoundland and Southeastern Newfoundland

Just over four million pairs of seabirds nest on the east and southeast coasts of Newfoundland. This includes 2.5 million pairs of Leach's Storm-Petrels and 760,000 pairs of Common Murres (Table 4.13). 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 (Table 4.13). This includes the largest Atlantic Canadian colonies of Leach's Storm-petrel (2,022,000 pairs on Baccalieu Island), Common Murre (470,000 pairs on Funk Island), Black-legged Kittiwake (13,950 pairs on Witless Bay Islands), Thick-billed Murre (1,000 pairs at Cape St. Mary's), and Atlantic Puffin (324,650 pairs on Witless Bay Islands). The larger seabird colonies are recognized as Important Bird Areas (IBAs) (see Figures 4.110 in C-NLOPB 2014 and 3.69 in C-NLOPB 2010). 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. 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 Project's Study Area.

In addition to local breeding birds, there are many non-breeding seabirds that occur within the Study Area during all seasons of the year. A significant portion of the world's population of Great Shearwater migrates to the Grand Banks and eastern Newfoundland to moult and feed during the summer months after nesting in the Southern Hemisphere (Lock et al. 1994). Depending on the species, seabirds require two to four years to become sexually mature. Many non-breeding sub-adult seabirds, notably Northern Fulmars and Black-legged Kittiwakes, are present on the Grand Banks and Flemish Cap year-round. Large numbers of Arctic-breeding Thick-billed Murre, Dovekie, Northern Fulmar, and Black-legged Kittiwake migrate to eastern Newfoundland, including the Grand Banks and Flemish Cap, to spend the winter.

The following subsections address the distribution and abundance of various species of seven seabird families that breed in eastern Newfoundland.

4.4.2.1 Procellariidae (Fulmars and Shearwaters)

Northern Fulmar

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

Subsections 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 in the Study Area during June to October, uncommon in May and scarce in November (Table 4.12).

Subsections 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.

Table 4.12 Predicted Monthly Abundances of Seabird Species Occurring in the Study Area.

Common Name	Scientific Name	Monthly Abundance											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Procellariidae													
Northern Fulmar	*Fulmarus glacialis*	C	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		
Hydrobatidae													
Leach's Storm-Petrel	*Oceanodroma leucorhoa*				U-C	C	C	C	C	C	C	S	
Wilson's Storm-Petrel	*Oceanites oceanicus*						S	S	S	S			
Sulidae													
Northern Gannet	*Morus bassanus*				U	U	U	U	U	U	U		
Phalaropodinae													
Red Phalarope	*Phalaropus fulicarius*					S	S	S	S	S	S		
Red-necked Phalarope	*Phalaropus lobatus*					S	S	S	S	S			
Laridae													
Herring Gull	*Larus argentatus*	U	U	U	U	U	S	S	S	S	S	S	S
Iceland Gull	*Larus glaucoides*	S	S	S	S						S	S	S
Lesser Black-backed Gull	*Larus fuscus*					R	R	R	R	R	R	R	R
Glaucous Gull	*Larus hyperboreus*	S	S	S	S						S	S	S
Great Black-backed Gull	*Larus marinus*	U	U	U	U	U	S	S	U	U	U	U	U
Ivory Gull	*Pagophila eburnea*	R	R	R	R								
Black-legged Kittiwake	*Rissa tridactyla*	C	C	C	C	C	S	S	S	C	C	C	C
Arctic Tern	*Sterna paradisaea*					S	S	S	S	S			
Stercorariidae													
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			
Alcidae													
Dovekie	*Alle alle*	C	C	C	C	U	R	R	R	S	C	C	C
Common Murre	*Uria aalge*	U	U	U	U	C	C	C	C	C	C	C	U
Thick-billed Murre	*Uria lomvia*	C	C	C	C	C	S	S	S	U	C	C	C
Razorbill	*Alca torda*				S	S	S	S	S	S	S	S	
Atlantic Puffin	*Fratercula arctica*	S	S	S	U	U	S	S	C	C	C	C	S

Notes: C = Common
U = Uncommon
S = Scarce
R = Rare

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)

Table 4.13 Numbers of Pairs of Seabirds Nesting at Colonies in Eastern Newfoundland.

Species	Wadham Islands	Funk Island	Cape Freels and Cabot Island	Baccalieu Island	Witless Bay Islands	Mistaken Point	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island	Grand Colobier Island	Miquelon Cape
Northern Fulmar	-	13[a]	-	-	13[a]	-	Present[a]	-	-	-		
Manx Shearwater	-	-	-	-	-	-	-	7[c]	-	-		
Leach's Storm-Petrel	6000[a]	-	250[b]	2,022,000[b]	314,020[a]	-	-	13,879[d]	100,000[b]	103,833[b]	363,787[e]	
Northern Gannet		6,075[a]		2,564[a]	-	-	14,789[a]	-	-	-		
Herring Gull	-	150[a]	-	46[a]	2,045[a]	-	Present[b]	20[b]	5,000[b]	Present[b]	60[f]	265[d]
Great Black-backed Gull	Present[b]	75[a]	-	2[a]	15[a] [65]	-	Present[b]	6[b]	25[b]	-	10[f]	
Black-legged Kittiwake	-	100[a]	-	5,096[a]	13,950[a]	4,750[a]	10,000[b]	-	50[b]	-	196[f]	2,415[d]
Arctic and Common Terns	376[b]	-	250[b]	-	-	-	-	-	-	Present[b]		
Common Murre	-	470,000[a]	2,600[b]	1,440[a]	268,660[a]	100[b]	15,484[a]	-	-	-	3[f]	
Thick-billed Murre		250[a]	-	73[a]	240[a]	-	1,000[b]	-	-	-		
Razorbill	30[a]	200[a]	25[b]	406[a]	846[a]	Present[b]	100[b]	-	-	-	50[f]	
Black Guillemot	25[a]	1[b]	-	113[a]	20[a]	Present[b]	Present[b]	-	-	-	46[f]	Present[d]
Atlantic Puffin	7,140[a]	2,000[a]	20[b]	45,300[a]	324,650[a]	40[b]	-	-	-	-	9,543[f]	
TOTALS	**13,571**	**478,864**	**3,145**	**2,077,040**	**924,459**	**4,890**	**41.373**	**13,912**	**105,075**	**103,833**	**373,695**	**2,680**

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

Other Shearwaters

Other shearwaters (i.e., Cory's Shearwater, Sooty Shearwater and Manx Shearwater) are expected to be either uncommon or scarce in the Study Area during May to November (see Table 4.12).

Subsections 4.4.4.1 of LGL (2015a) and 4.4.3.3 of LGL (2015b) provide more information on the occurrence and abundance of other shearwaters in the Study Area.

4.4.2.2 Hydrobatidae (Storm-petrels)

Leach's Storm-Petrel

Leach's Storm-Petrel are expected to be common in the Study Area during May to October, and become scarcer in November (see Table 4.12). Numbers of breeding pairs and their breeding locations are indicated in Table 4.13.

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 4.4.4.2 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 Study Area during June to September (see Table 4.12).

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.

4.4.2.3 Sulidae (Gannets)

Northern Gannet

Northern Gannet are expected to be uncommon in the Study Area during May to November (see Table 4.12). Numbers of breeding pairs and their breeding locations are indicated in Table 4.13.

Subsections 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.

4.4.2.4 Phalaropodinae (Phalaropes)

Red and Red-necked Phalarope

Phalaropes are expected to be scarce in the Study Area during May to October (see Table 4.12).

Subsection 4.4.4.4 of LGL (2015a) provides more information on Red and Red-necked Phalarope occurrence and abundance in the Study Area.

4.4.2.5 Laridae (Gulls and Terns)

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

These gulls are expected to be either rare, scarce or uncommon in the Study Area during May-November (see Table 4.12). Numbers of breeding pairs of Herring and Great Black-backed Gulls and their breeding locations are indicated in Table 4.13.

Subsections 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 and September to November in the Study Area, but scarce during the June to August period (see Table 4.12). Numbers of breeding pairs of Black-legged Kittiwake and their breeding locations are indicated in Table 4.13.

Subsections 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 (see Table 4.12).

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 Tern

Arctic Tern are expected to be scarce during May to September, and absent during October to November in the Study Area (see Table 4.12). Numbers of breeding pairs of Arctic Tern and their breeding locations are indicated in Table 4.13.

Subsections 4.4.4.5 of LGL (2015a) and 4.4.3.6 of LGL (2015b) provide more information on Arctic Tern occurrence and abundance in the Study Area.

4.4.2.6 Stercorariidae (Skuas and Jaegers)

Great Skua and South Polar Skua

Great Skua and South Polar Skua are expected to be scarce in the Study Area during May to November (see Table 4.12).

Subsection 4.4.4.6 of LGL (2015a) provides more information on skua occurrence and abundance in the Study Area.

Pomarine Jaeger, Parasitic Jaeger and Long-tailed Jaeger

These three jaeger species are expected to be scarce in the Study Area during May to November (see Table 4.12).

Subsection 4.4.4.6 of LGL (2015a) provides more information on jaeger occurrence and abundance in the Study Area.

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

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 Table 4.13). 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 rare or uncommon within the Study Area.

Dovekie

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

Subsections 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 Study Area during May to November, but Thick-billed Murre are expected to be common in May, scarce during June to August, uncommon in September and common during October to November (see Table 4.12). Numbers of breeding pairs for each species and their breeding locations are indicated in Table 4.13.

Subsections 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.

Other Alcids (Atlantic Puffin, Razorbill and Black Guillemot)

Atlantic Puffin

Atlantic Puffin are expected to be uncommon in the Study Area during May, scarce during June to July, and common during August to November (see Table 4.12). Numbers of breeding pairs for each species and their breeding locations are indicated in Table 4.13.

Subsection 4.4.4.7 of LGL (2015a) provides more information on Atlantic Puffin occurrence and abundance in the Study Area.

Razorbill

Razorbill are expected to be scarce in the Study Area during May to November (see Table 4.12). Numbers of breeding pairs for each species and their breeding locations are indicated in Table 4.13.

Subsection 4.4.4.7 of LGL (2015a) provides more information on Razorbill occurrence and abundance in the Study Area.

Black Guillemot

Black Guillemot is common nearshore in Newfoundland and Labrador but would not be expected as far offshore as the Study Area (see Table 4.12). Numbers of breeding pairs for each species and their breeding locations are indicated in Table 4.13.

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 4.14). The estimated head submergence time and diving depth of various seabirds are also provided in Table 4.14.

More details regarding prey and foraging habits of seabirds likely to occur in the Study Area are provided in § 4.4.5 of LGL (2015a) and § 4.4.4 of LGL (2015b).

4.4.4 Marine-associated Bird Data Gaps Identified in Relevant SEA

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 4.14 Prey, Foraging Strategy, Head Submergence Time, and Dive Depth of Seabirds in the Study Area.

Species	Prey	Foraging Strategy	Head Submergence Time	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

4.5 Marine Mammals and Sea Turtles

The Marine Mammal and Sea Turtle VEC of the Study Area has been recently described in 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 two site-specific EAs (§ 4.5 of LGL 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. Newly available information since publication of 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 two SEAs are also discussed in terms of current status.

4.5.1 Marine Mammals

Twenty-five marine mammal species are known to occur near or within the Study Area, including 19 species of cetaceans (whales, dolphins, and porpoises) and six species of phocids (true seals). Only 21 of these species (Table 4.15) are expected to regularly occur in the Study Area. 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 cetacean and phocid species that could occur in or near the Study Area is presented in Table 4.15. Four of the marine mammals that have been recorded near or within the Study Area are unlikely to occur there (beluga whale, harbour seal, ringed seal, and bearded seal). These four species were described in § 4.5.1 of LGL (2015a,b).

Table 4.15 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*) Western North Atlantic population	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

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Fin Whale (*Balaenoptera physalus*) Atlantic population	Common	Year-round, but mostly summer	Shelf breaks, banks & pelagic	Schedule 1: Special Concern	SC
Blue Whale (*Balaenoptera musculus*) Atlantic population	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*) Scotian Shelf population	Uncommon	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
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*) NW Atlantic/Eastern Arctic population	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*) NW Atlantic population	Uncommon	Year-round, but mostly spring–fall	Shelf, coastal & pelagic	Schedule 2: Threatened	SC
True Seals (Phocids)					
Harp Seal (*Pagophilus groenlandicus*)	Uncommon	Year-round, but mostly winter–spring	Pack ice & pelagic	NS	NC; HPC
Hooded Seal (*Cystophora cristata*)	Uncommon	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

Notes: ? denotes uncertainty.

[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.

4.5.1.1 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 are without any 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 (2015a,b).

Cetacean sightings in the Study Area compiled from the DFO sightings database (1947-2008) are summarized in Table 4.16. Sightings include baleen whales, large toothed whales, dolphins and porpoises.

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 4.15). Given that the Atlantic population of blue whales 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 (2,863 individuals). While humpback sightings occur year-round (Table 4.16; Figure 4.37), they are predominant during June to August. Humpback whales are expected to be common throughout the Study Area.

Minke Whale

The minke whale is the third most commonly recorded mysticete in the Study Area in the DFO sightings database (358 individuals), with most sightings recorded during June to September (Table 4.16; Figure 4.36). Minke whales were commonly recorded in Jeanne d'Arc Basin during a 2008 seismic monitoring program (Abgrall et al. 2009),). Minke whales are considered common throughout the Study Area.

Table 4.16 Cetacean Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

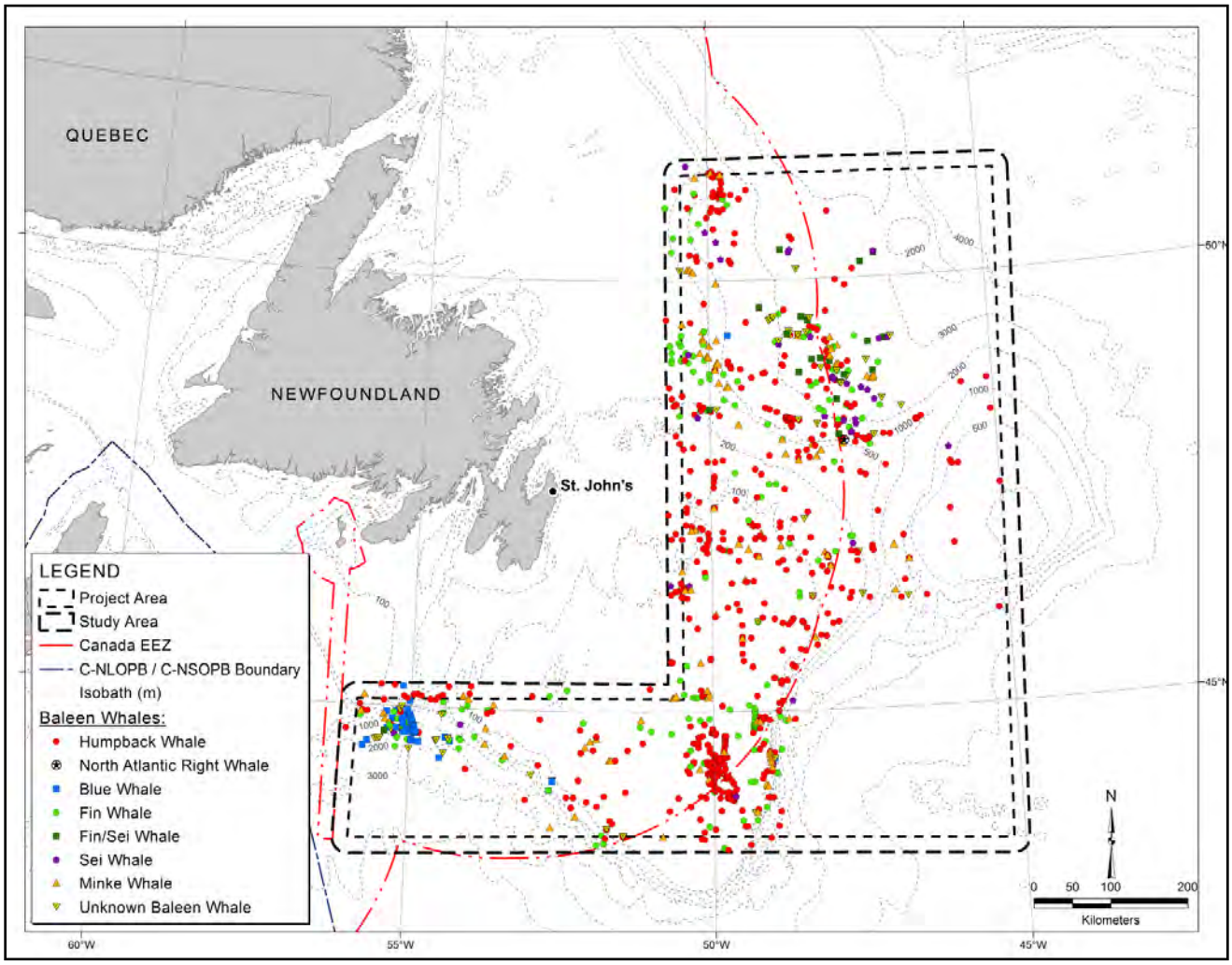
Species	Number of Sightings	Number of Individuals	Months Sighted
Mysticetes			
North Atlantic Right Whale	1	2	June
Humpback Whale	899	2,863	Jan–Dec
Minke Whale	179	358	Jan, Apr–Dec
Sei Whale	44	74	Feb, May–Sept
Fin Whale	239	420	Mar–Oct
Sei/Fin Whale	20	27	June–Sept
Blue Whale	47	49	Apr, June–Sept
Unidentified Baleen Whale	59	86	May–Oct
Odontocetes			
Sperm Whale	171	357	Jan–Dec
Pygmy Sperm Whale	1	2	June
Northern Bottlenose Whale	41	174	Mar–Oct
Sowerby's Beaked Whale	1	4	Sept
Beluga	1	1	July
Striped Dolphin	7	181	Aug, Sept
Common Dolphin	164	2,145	Jan, Mar–Apr, Jun–Dec
White-beaked Dolphin	59	417	Feb–Mar, May–Aug
Atlantic White-sided Dolphin	171	2,371	Feb, May–Oct
Bottlenose Dolphin	1	15	Sept
Risso's Dolphin	5	41	June, July
False Killer Whale	1	2	June
Killer Whale	46	203	Jan, Apr–Nov
Long-finned Pilot Whale	456	6,832	Jan–Dec
Harbour Porpoise	76	704	Feb, Mar, May–Nov
Unidentified Dolphin	438	6,835	Jan–Dec
Unidentified Toothed Whale	7	27	July–Sept
Other			
Unidentified Cetacean	648	2,353	Jan–Dec

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

Sei Whale

Sei whales are expected to be uncommon in the Study Area. There are 44 sightings of sei whales (74 individuals) recorded in the Study Area in the DFO sightings database; most of these sightings were recorded during June to September (see Table 4.16; Figure 4.37). Sei whales have been sighted in small numbers during seismic monitoring programs in the Orphan Basin (Moulton et al. 2005, 2006a) and Jeanne d'Arc Basin (Abgrall et al. 2009). During a 2007 aerial survey conducted by DFO, one sei whale was observed off southern Newfoundland (Lawson and

Gosselin 2009). One of the sei whales tagged during the Prieto et al. (2010, 2014) study remained near the middle of the Study Area for about 96 h on route to the Labrador Sea.



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

Figure 4.37 Baleen Whale Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

Fin Whale

The current estimate for the western North Atlantic stock of fin whale 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 (420 individuals) with most sightings recorded during June to August (Table 4.16; Figure 4.37). Fin whales were commonly observed in Orphan Basin during the 2004 and 2005 seismic monitoring programs (Moulton et al. 2005, 2006a). This species was also sighted during the seismic monitoring programs in Jeanne d'Arc Basin in 2008 (Abgrall et al. 2009). 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)

Twelve species of toothed whales are likely to occur in the Study Area (see Table 4.15), 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 (Lang et al. 2006; Lang and Moulton 2008; Abgrall et al. 2008a, 2009). During aerial surveys conducted in summer 2007, sperm whales were observed in small numbers (11 sightings of 11 individuals) in the waters off eastern and southern Newfoundland (Lawson and Gosselin 2009). There are 171 sightings (357 individuals) of sperm whales in the Study Area in the DFO sightings database. These sightings occurred year-round but primarily during March to October (see Table 4.16; Figure 4.38). Sperm whales are expected to be common in deep waters of the Study Area.

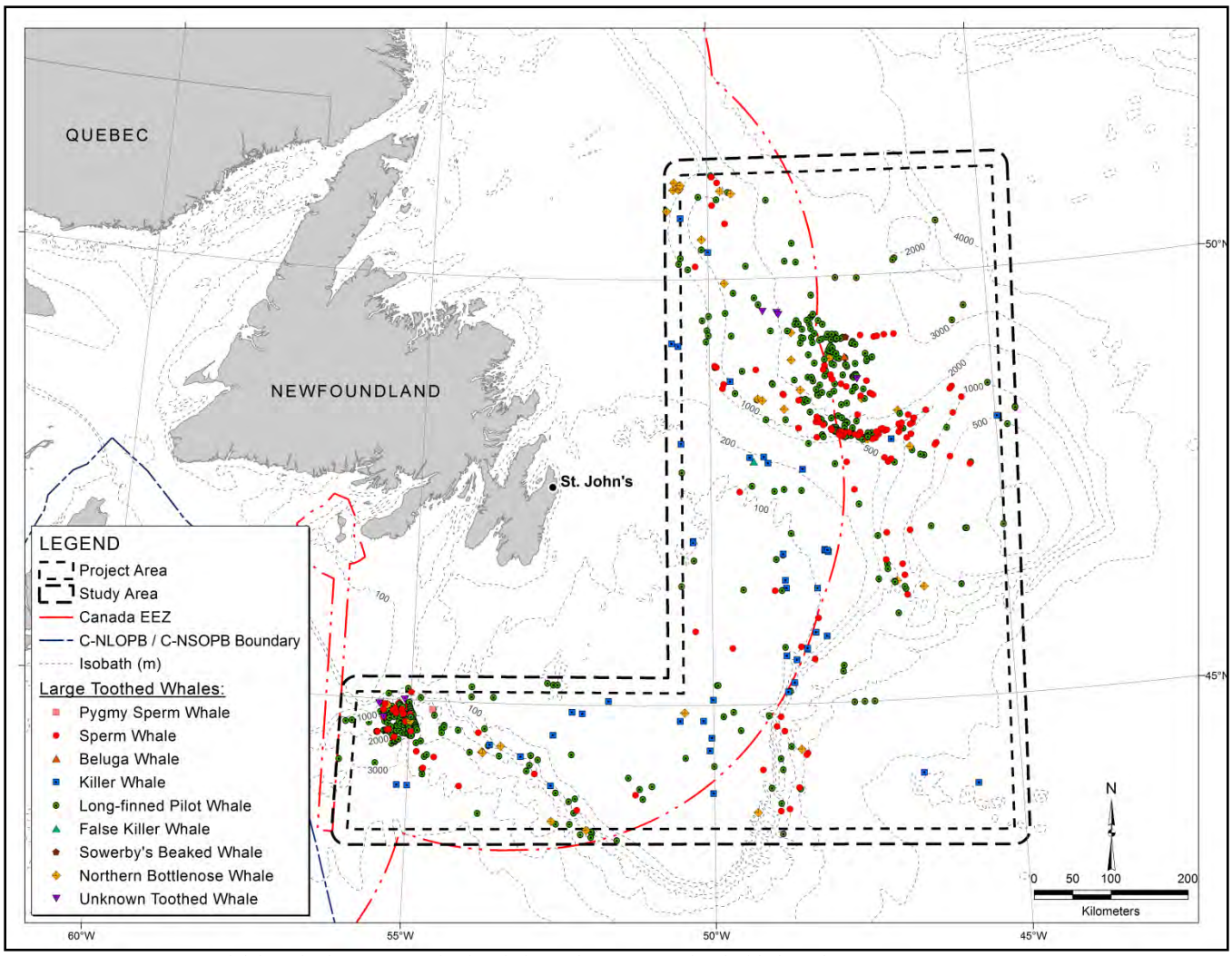
Sowerby's Beaked Whale

There is one sighting of four Sowerby's beaked whales in the Study Area in the DFO sightings database (see Table 4.16; Figure 4.38). 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).

Striped Dolphin

There are seven sightings (181 individuals) of striped dolphins in the Study Area in the DFO sightings database. All sightings occurred in August and September (see Table 4.16; Figure 4.39). Striped dolphins are considered rare in the Study Area.

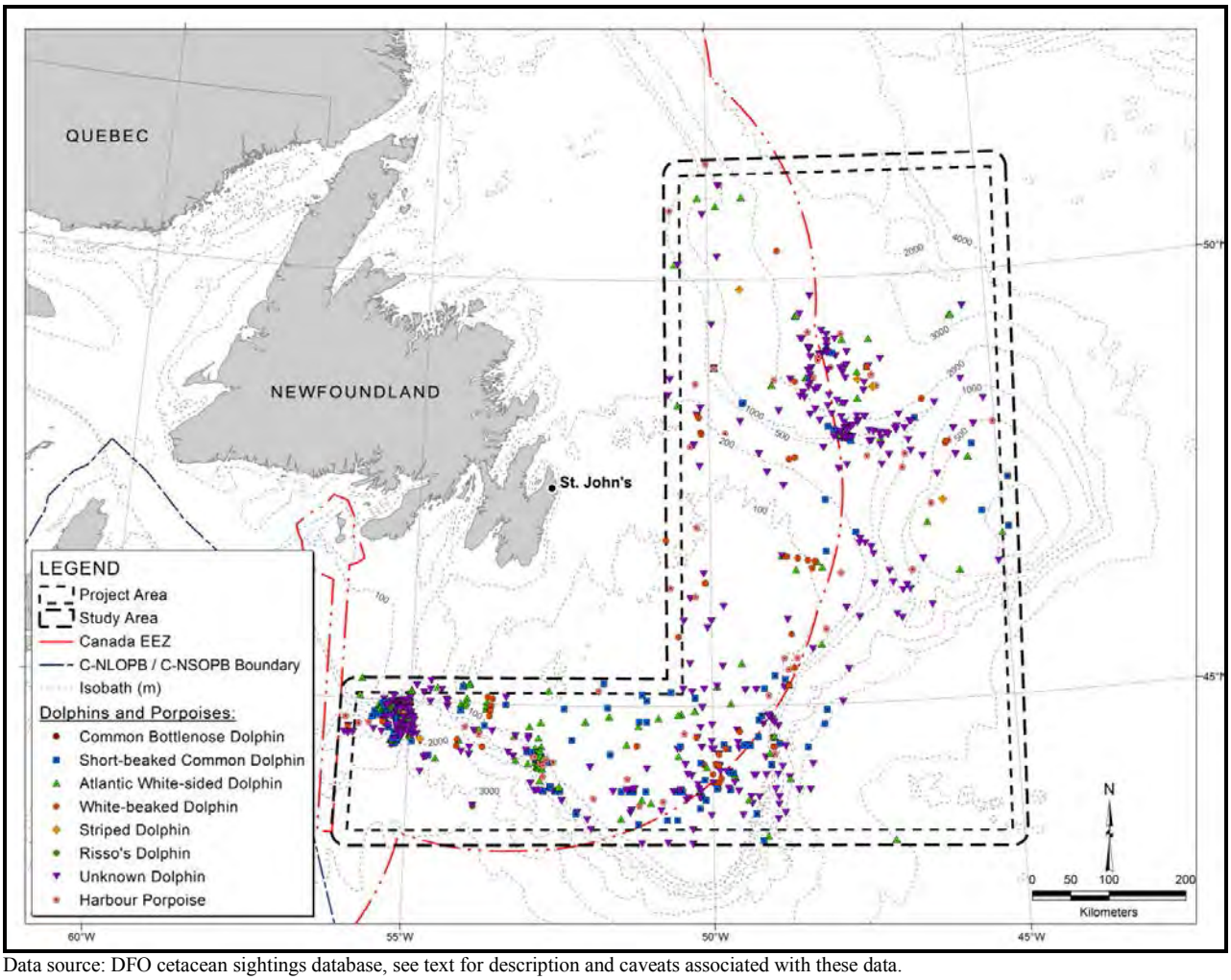


Data source: DFO cetacean sightings database, see text for description and caveats associated with these data.

Figure 4.38 Toothed Whale Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

Short-beaked Common Dolphin

An estimated 173,486 (CV = 0.55) short-beaked common dolphins occur 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 have been 164 sightings (2,145 individuals) of this species in the Study Area. Most of these sightings occurred during July to October (see Table 4.16). Sightings occurred in shelf, upper slope and deep water regions (Figure 4.39). The short-beaked common dolphin is considered common in the Study Area.



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

Figure 4.39 Dolphin and Porpoise Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

White-beaked Dolphin

Compared to Atlantic white-sided and common dolphins, white-beaked dolphins occur in lower numbers in the Study Area. Based on the DFO sightings database, 59 sightings (417 individuals) of white-beaked dolphins have been recorded in the Study Area. Most sightings occurred during June to August (see Table 4.16; Figure 4.39). 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, 171 sightings of Atlantic white-sided dolphins (2,371 individuals) have been recorded in the Study Area . Sightings occurred primarily during

July to September (see Table 4.16; Figure 4.39). This species is considered common in the Study Area.

Common Bottlenose Dolphin

Two morphologically and genetically distinct stocks occur in the NW Atlantic; the coastal and offshore forms (Hoelzel et al. 1998). The most reliable 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 is only one common bottlenose dolphin sighting (15 individuals) in the DFO cetacean sighting database; it occurred in September (see Table 4.16; Figure 4.39). The common bottlenose dolphin is considered rare in the Study Area.

Risso's Dolphin

The best abundance estimate for Risso's dolphins in the NW Atlantic is 18,250 (CV = 0.46) (Waring et al. 2015), but there is no current population estimate off Newfoundland. In the Study Area, there have been five sightings of Risso's dolphins (41 individuals) recorded in the DFO sightings database. All sightings occurred during June and July (see Table 4.16; Figure 4.39). Risso's dolphins are expected considered rare in the Study Area.

Killer Whale

Based on the DFO sightings database, there have been 46 sightings of killer whales (203 individuals) recorded in the Study Area. Most of these sightings occurred in June and July (see Table 4.16; Figure 4.38). Killer whales have been seen in small numbers from seismic vessels in the Jeanne d'Arc Basin and Flemish Pass in recent years (2013-2015; LGL, unpubl. data). Killer whales are considered uncommon in the Study Area.

Long-finned Pilot Whale

Based on the DFO sightings database, long-finned pilot whales are the most commonly recorded odontocete in the Study Area. Sightings have been recorded year-round (see Table 4.16; Figure 4.38) but mostly during July and August. Long-finned pilot whales are considered common in the Study Area.

Harbour Porpoise

Most of the 76 harbour porpoise sightings (704 individuals) made in the Study Area occurred during June to August (see Table 4.16; Figure 4.39). Harbour porpoises are considered uncommon in the Study Area.

4.5.1.4 True Seals (Phocids)

Harp, hooded, and grey seals are considered uncommon in the Study Area during the period seismic surveys are proposed.

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 4.17. 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 4.40 shows locations of leatherback sea turtle sightings in the Study Area, based on the DFO sightings database.

Table 4.17 Sea Turtles with Reasonable Likelihood of Occurrence in the Study Area.

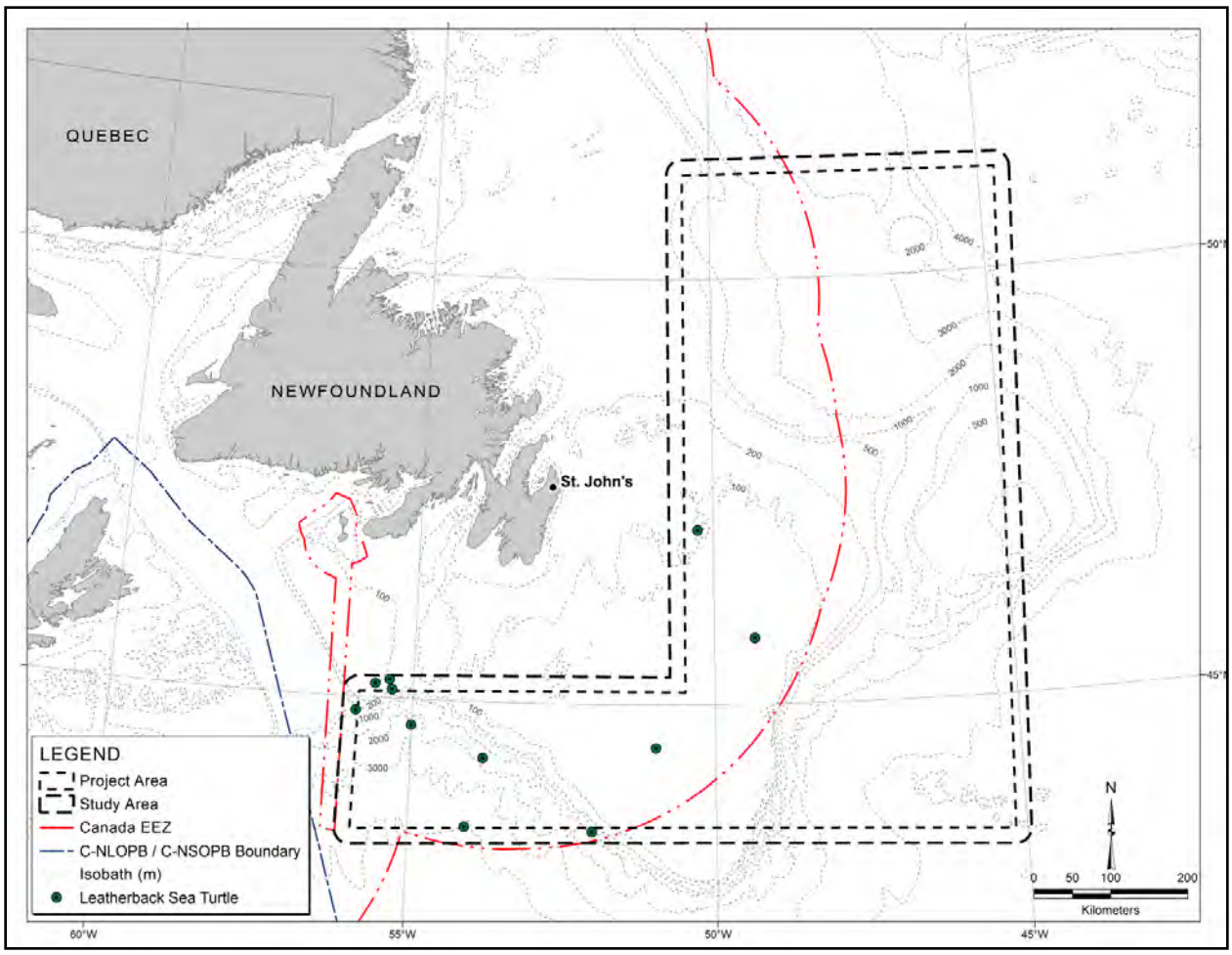
Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Leatherback sea turtle (*Dermochelys coriacea*)	Rare	April to December	Pelagic & Shelf	Schedule 1: Endangered	E
Loggerhead sea turtle (*Caretta caretta*)	Rare	Summer and fall	Pelagic	NS	E
Green sea turtle (*Chelonia 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

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

The following data gap associated with the Marine Mammal and Sea Turtle VEC was identified in the 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.



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

Figure 4.40 Leatherback Sea Turtle Sightings in the Study Area (compiled from the DFO sightings database, 1947-2008).

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; however, these data are not usually publically available.

4.6 Species at Risk

The Species at Risk VEC of the Study Area has been recently described in 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 two site-specific EAs (§ 4.6 of LGL 2015a, b). An overview of the species at risk of the Study Area, based primarily on information from these two SEAs and two site-specific EAs, is provided below. New information not included in the two SEAs and the two 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* status or damaging or destroying their critical habitat). Species/populations are listed under *SARA* on Schedules 1 to 3, with only those with either an *endangered* or *threatened* status under Schedule 1 having immediate legal implications. Schedule 1 is the official list of wildlife species/populations at risk in Canada. Once a species/population is designated, the measures to protect and recover that species/population are implemented. 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 4.18). 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 4.18, as are species/populations with *endangered*, *threatened,* or *special concern* statuses under COSEWIC.

Table 4.18 *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 (Newfoundland and Labrador population)	*Gadus morhua*				X		
Atlantic Cod (Southern population)	*Gadus morhua*				X		
Atlantic Bluefin Tuna	*Thunnus thynnus*				X		
Porbeagle Shark	*Lamna nasus*				X		
Roundnose Grenadier	*Coryphaenoides rupestris*				X		
Cusk	*Brosme brosme*				X		
Deepwater Redfish (Gulf of St. Lawrence-Laurentian Channel population)	*Sebastes mentella*				X		
Atlantic Salmon (Anticosti Island population)	*Salmo salar*				X		
Atlantic Salmon (Eastern Cape Breton population)	*Salmo salar*				X		
Winter Skate (Eastern Scotian Shelf-Newfoundland population)	*Leucoraja ocellata*				X		
American Eel	*Anguilla rostrata*					X	
Shortfin Mako Shark (Atlantic population)	*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	

SPECIES		*SARA*[a]			COSEWIC[b]		
Common Name	**Scientific Name**	***Endangered***	***Threatened***	***Special Concern***	***Endangered***	***Threatened***	***Special Concern***
White Hake (Atlantic and Northern Gulf of St. Lawrence 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
Atlantic Salmon (Quebec Eastern North Shore population)	*Salmo salar*						X
Atlantic Salmon (Gaspe-Southern Gulf of St. Lawrence population)	*Salmo salar*						X
Seabirds							
Ivory Gull	*Pagophila eburnea*	Schedule 1			X		
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
Killer Whale (Northwest Atlantic/Eastern Arctic populations)	*Orcinus orca*						X
Northern Bottlenose Whale (Davis Strait-Baffin Bay-Labrador Sea population)	*Hyperoodon ampullatus*						X
Sea Turtles							
Leatherback Sea Turtle	*Dermochelys coriacea*	Schedule 1					
Leatherback Sea Turtle (Atlantic population)	*Dermochelys coriacea*				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.

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 (EC 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*.

CGG 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. CGG will comply with relevant regulations pertaining to *SARA* Recovery Strategies and Action Plans.

CGG acknowledges the possibility of other marine species/populations receiving *endangered* or *threatened* statuses under Schedule 1 during the course of the Project. Due caution will also be extended to any other species added to Schedule 1 during the life of this Project.

4.6.1 Profiles of Marine Species with Endangered or Threatened Status on Schedule 1 of the *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 4.18 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 § 4.6.1.1 of LGL (2015a,b).

An adult female, 'Katharine,' originally tagged in August 2013 off Cape Cod was present either in or close to 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 § 4.6.1.1 of LGL (2015a,b).

During DFO RV surveys in the Study Area during May to November, 2013 northern wolffish were caught primarily in the northeastern, eastern and southeastern slope areas of the Grand Banks (see Figure 4.29 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 § 4.6.1.2 of LGL (2015a,b).

During DFO RV surveys in the Study Area during May to November, 2013 spotted wolffish were caught primarily in the northeastern, eastern and southeastern slope areas of the Grand Banks (see Figure 4.31 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 § 4.6.1.2 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 4.15 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 (North Atlantic Population)

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, 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 47 sightings (49 individuals) in the Study Area in the DFO sightings database. Most of them occurred in July and August although others were made in spring and fall (see Table 4.16 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 4.37 in § 4.5). Blue whales are 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 Subsections 4.6.1.3 of LGL (2015a,b).

There is a single sighting of two right whales in the Study Area in June in the DFO sightings database (see Figure 4.37 in § 4.5). This species is expected to be rare in the Study Area.

Northern Bottlenose Whale (Scotian Shelf Population)

The Scotian Shelf population of the northern bottlenose whale currently has an *endangered* status under both Schedule 1 of *SARA* and COSEWIC. Profiles of this population of northern bottlenose whale are provided in § 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 41 sightings (174 individuals) of northern bottlenose whales in the Study Area in the DFO sightings database. Most sightings occurred in the deeper waters and near the shelf break during March to October (see Table 4.16 and Figure 4.38 in § 4.5). Northern bottlenose whales are expected to be uncommon 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 11 sighting records (12 individuals) of leatherback turtles within the Study Area (see Figure 4.40 in § 4.5.2) in the DFO sightings database, all made 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 tags 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 Eastern Newfoundland SEA (§ 4.2.4 of C-NLOPB 2014), the Southern Newfoundland SEA (§ 3.8 of C-NLOPB 2010), and two site-specific EAs (§ 4.7 of LGL 2015a, b). An overview of the sensitive areas occurring in the Study Area, based primarily on information from the two SEAs and two site-specific EAs, is provided below. New information not included in the two SEAs and the two 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:

- Twelve NAFO coral/sponge fishery closure areas, including the 3O Coral Protection Zone;
- Two seamount fishery closure areas: Orphan Knoll Seamount and Newfoundland Seamount;
- Seven Ecologically and Biologically Significant Areas (EBSAs): Northeast Shelf and Slope, Virgin Rocks, Orphan Spur, Southwest Shelf Edge and Slope, Lilly Canyon-Carson Canyon, Laurentian Channel Cold Seep, and Southeast Shoal and Tail of the Banks; and
- Bonavista Cod Box.

The locations of these sensitive areas are shown in Figure 4.41.

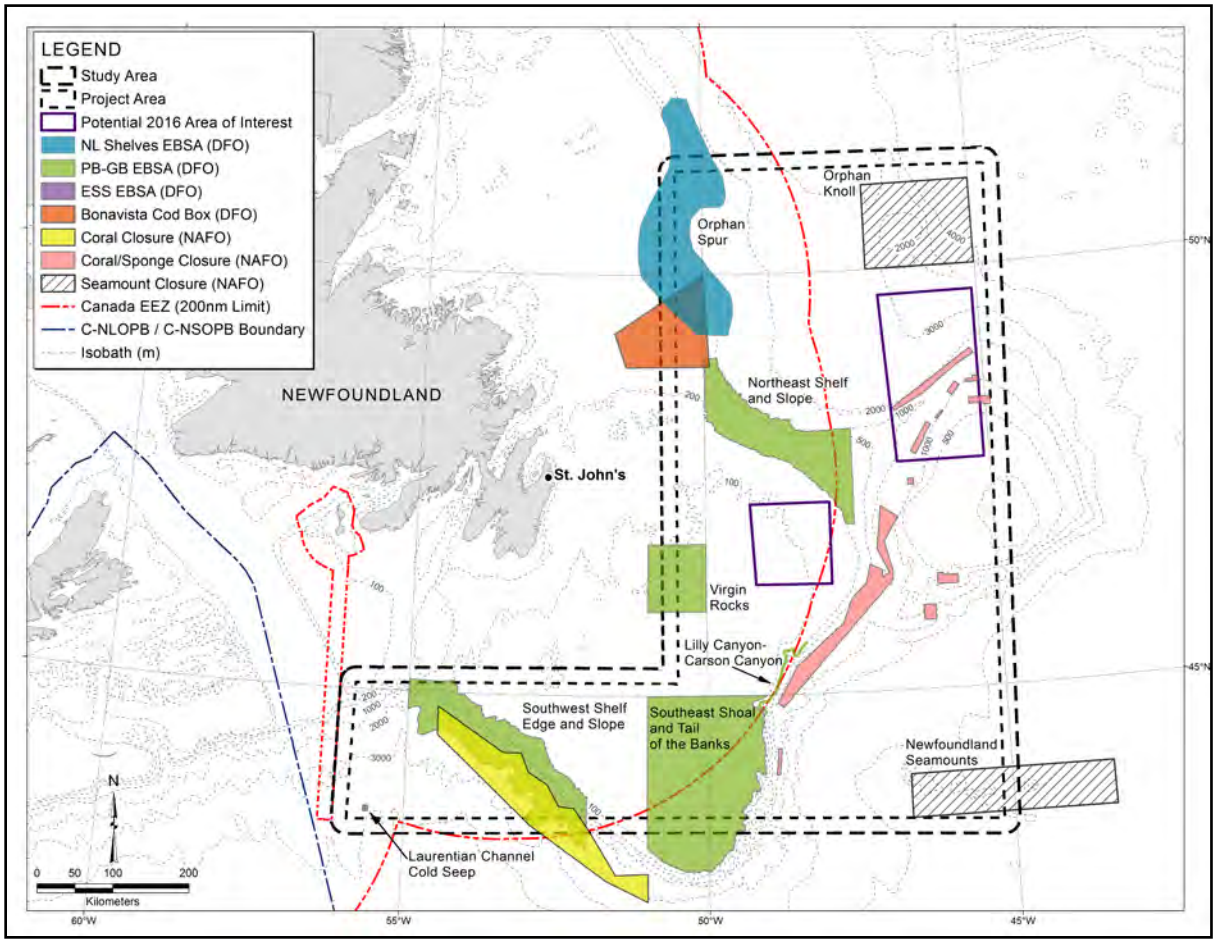


Figure 4.41 Locations of Sensitive Areas that Overlap with Study Area.

As indicated above, details regarding these sensitive areas are provided in the two SEAs (C-NLOPB 2010, 2014) and the two WesternGeco EAs (LGL 2015a,b).

5.0 Effects Assessment

The various aspects of the effects assessment methodology have been recently described in 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 November 19 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 2010, 2014) and EAs (LGL 2015a,b).

5.1.1 Consultations

5.1.1.1 CCG's Consultation Policy and Approach

CCG's policy for consultation on marine seismic projects is to consult (primarily through in-person meetings) with relevant agencies, stakeholders and rights-holders (e.g., beneficiaries) during the pre-survey and survey stages. CGG will initiate meetings and respond to requests for meetings with the interested groups throughout this period. After the survey is complete CGG 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 CGG 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 CGG's Marine Shore Manager.

5.1.1.2 Program Consultations

The program consultations were organized and coordinated by Canning & Pitt. Project information packages were sent to all relevant stakeholder groups in October 2015. In addition to a representative of Canning & Pitt, representatives of CGG and LGL also attended the consultation meetings. All requested face-to-face meetings were held in St. John's. Initial contact and requested face-to-face meetings were conducted between October 22 and December 10, 2015. Appendix 1 includes the full report on consultations conducted for this EA.

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).

As has been the case for other seismic project assessments in the Newfoundland and Labrador sector, the issue most consistently raised during the consultations related to potential conflict with the commercial fisheries. Consequently, fish harvester groups and agencies were a key focus of the consultations.

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

- 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 CGG [addressed in § 4.3 of the EA].
- OCI: Need for better communication between the seismic and fishing industries [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 [CGG has not yet seen the results].
- OCI: Feedback regarding fishing activities typically conducted in the two potential 2016 survey areas presented by CGG [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 CGG's potential 2016 survey areas [CGG 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.

5.1.1.3 Follow-Up

As described above, CGG 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 (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 (see Figure 1.1).

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 (2015a,b).

5.5 Mitigation Measures

The effects assessments that follow (§ 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. CGG 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 (2015a,b).

5.5.1 Summary of Mitigation Measures

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

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 spatial/temporal 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 and experienced 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 streamers

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 (§ 3.4.2). Within the Project time frame, icebergs may require the vessels to detour in May when about 30% of the yearly total of icebergs are expected to occur based on monthly iceberg distribution data (see Table 3.19 in § 3.4.2).

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 typically reached at a consistent level 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 six 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 27 shipwrecks and three legacy sites present within the Study Area. It is understood that the proposed seismic activities to be conducted will have no interaction with the sea floor; therefore the associated unexploded ordnance (UXO) risk is negligible. Nonetheless, 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 (summarized in Table 5.1 in § 5.5.1) 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.

It is predicted that atmospheric emissions produced by the Project will therefore have *negligible* effect on the environment in the Project Area.

5.7.2 Generic Activities - Marine Use

Project-related traffic will include one seismic survey vessel, one picket vessel and one supply vessel. 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 (summarized in Table 5.1 in § 5.5.1) 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).

CGG 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 50-60 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.

Considering that waste produced by the Project will be handled and treated appropriately, it is predicted that it 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.

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 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.5.1.2 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 on marine invertebrates and fishes.

Note that the only accurate way of determining the sound level to which an animal is exposed is by measurement of sound, both sound pressure and particle motion components, at the receiving animal. The degree of underwater sound attenuation is affected by a number of factors (e.g., water column stratification, water temperature, bottom topography).

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).

Table 5.2 Potential Interactions of the Project Activities and the Fish and Fish Habitat VEC.

Valued Environmental Component: Fish and Fish Habitat							
Project Activities	**Non-Biological Environment**	**Feeding**		**Reproduction**		**Adult Stage**	
	Water and Sediment Quality	**Plankton**	**Benthos**	**Eggs and Larvae**	**Juveniles [a]**	**Pelagic Fish**	**Groundfish**
Sound							
Airgun Array (2D, 3D and 4D)		X	X	X	X	X	X
Seismic Vessel		X	X	X	X	X	X
Supply Vessel		X	X	X	X	X	X
Picket Vessel		X	X	X	X	X	X
Helicopter							
Echo Sounder						X	
Side Scan Sonar						X	
Vessel Lights		X				X	
Vessel/Equipment Presence							
Seismic Vessel and Equipment							
Supply Vessel							
Picket Vessel							
Sanitary/Domestic Waste	X	X		X		X	
Atmospheric Emissions	X	X		X		X	
Garbage [b]							
Helicopter Presence							
Shore Facilities [c]							
Accidental Releases	X	X	X	X	X	X	X
Other Projects and Activities in Region of Study Area							
Oil and Gas Activities	X	X	X	X	X	X	X
Fisheries	X	X	X	X	X	X	X
Marine Transportation	X	X	X	X	X	X	X

[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.

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 CGG'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 CGG's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.4). The level of confidence associated with this prediction is *medium* to *high* (Table 5.4).

Sanitary/Domestic Waste

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} (Table 5.3). Based on these criteria ratings, the *reversible* residual effects of sanitary/domestic wastes produced during CGG's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.4). The level of confidence associated with this prediction is *high* (Table 5.4).

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 km*^{2}. Based on these criteria ratings, the *reversible* residual effects of atmospheric emissions produced during CGG's proposed 2D/3D/4D seismic program on the Fish and Fish Habitat VEC are predicted to be *not significant* (Table 5.4). The level of confidence associated with this prediction is *high* (Table 5.4).

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

Valued Environmental Component: Fish and Fish Habitat								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Sound								
Airguns (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	-	-	-	-	-	-	-
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 = 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	-	-
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

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.

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 CGG'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 CGG'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.

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 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, or streamers). Section 5.5 provides information on mitigation measures, including those associated with the Fisheries VEC.

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 FLOs on all seismic vessels.

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 CGG'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 (7,000–8,100 m) used during CGG'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 FLOs on all seismic vessels.
- 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 CGG'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 CGG'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 CGG'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 Bird
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
Vessel Lights	X
Vessel/Equipment Presence	
Seismic Vessel and Equipment	X
Supply Vessel	X
Picket Vessel	X
Sanitary/Domestic Waste	X
Atmospheric Emissions	X
Garbage[a]	
Helicopter Presence	X
Shore Facilities[b]	
Accidental Releases	X
Other Projects And Activities in 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. Section 5.7.6.1 LGL (2015a,b) describe 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 CGG'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 Lights

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). Section 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; Williams and Chardine 1999; Le Corre et al. 2002; Abgrall et al. 2008c; Rodríguez and Rodríguez 2009). 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 CGG'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)		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
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)		0	1	4	1-2	R	2
Atmospheric Emissions	Air Contaminants (N)		0	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1-2	R	2
Accidental Releases	Mortality (N)	Solid streamer; spill response	1-2	1-2	1	1	R	2

Key:

Magnitude:
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	-	-
Vessel Lights	NS	2-3	-	-
Vessel/Equipment Presence				
Seismic Vessel and Gear (2D,	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Sanitary/Domestic Wastes	NS	3	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter Presence	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

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.

5.7.6.3 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 CGG'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 CGG'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 CGG's proposed 2D/3D/4D seismic program on the Marine-associated Bird VEC are predicted to be *not*

significant (see Table 5.10). The level of confidence associated with this prediction is *high* (see Table 5.10).

Helicopter Presence

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

As indicated in Table 5.9, helicopter presence associated with the Project is predicted to have residual effects on the Marine-associated Bird VEC that are *negligible* to *low* in magnitude for a duration of *<1* to *1 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 CGG'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 CGG'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 Southern and Eastern Newfoundland SEAs (C-NLOPB 2010, 2014), previous EAs for seismic programs offshore Newfoundland and Labrador (e.g., LGL 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 appear in § 5.7.7.1 and Appendices 4 and 5 of LGL (2015a,b), § 5.3.1 of the Eastern Newfoundland SEA (C-NLOPB 2014), and § 4.5.1.5 and § 4.5.1.6 of the Southern Newfoundland SEA (C-NLOPB 2010). The characteristics of airgun sounds are also summarized in Appendix 4 of LGL (2015a,b). Descriptions of the hearing abilities of marine mammals and sea turtles are also provided in Appendices 4 and 5, respectively, of the WesternGeco Eastern and Southeastern Newfoundland EAs (LGL 2015a,b).

The potential effects of airgun sounds considered in this assessment include: (1) masking of natural sounds; (2) behavioural disturbance; (3) non-auditory physical or physiological effects; and (4) at least in theory, temporary or permanent hearing impairment (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). 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	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
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
Vessel Lights				
Helicopter 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 statistically 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 statistically significant response (e.g., lateral displacement, localized 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* 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 CGG'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* 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 CGG'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								
Project Activity	**Potential Positive (P) or Negative (N) Environmental Effect**	**Mitigation**	**Evaluation Criteria for Assessing Environmental Effects**					
			Magnitude	**Geographic Extent**	**Frequency**	**Duration**	**Reversibility**	**Ecological/ Socio-Cultural and Economic Context**
Sound								
Airgun Array (2D, 3D and 4D)	Hearing Impairment (N) Physical Effects (N)	Pre-watch; Ramp-up; Delay start[a]; Shutdown[b]	0-1	1-2	6	1-2	R	2
Airgun Array (2D, 3D and 4D)	Disturbance (N)	Pre-watch; Ramp-up; Delay start[a]; Shutdown[b]	1-2	1-4	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
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
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	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter 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* 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 CGG'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 CGG'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 CGG'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 CGG'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 CGG'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 CGG'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								
			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	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
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
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	-	-
Vessel/Equipment Presence				
Seismic Vessel/Gear (2D, 3D and 4D)	NS	3	-	-
Supply Vessel	NS	3	-	-
Picket Vessel	NS	3	-	-
Helicopter 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 § 5.7.7.2 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 CGG'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 CGG'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 CGG'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), § 5.3 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 is 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 CGG'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 Subsection 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 4.18 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 4.18) are included in the interactions table (Table 5.16).

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 CGG'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).

The potential effects of activities associated with CGG's proposed seismic program are not expected to contravene the prohibitions of *SARA* (Sections 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[a]			X	X	X
Echosounder	X	X	X	X	X
Side Scan Sonar	X	X	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
Sanitary/ Domestic Waste	X	X	X	X	X
Atmospheric Emissions	X	X	X	X	X
Garbage[b]					
Helicopter Presence[a]			X	X	X
Shore Facilities[c]					
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] No helicopter use is planned for 2016 but helicopters may be used during 2017-2025.
[b] Not applicable as garbage will be brought ashore.
[c] There will not be any new onshore facilities. Existing infrastructure will be used.

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
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
Sanitary/Domestic Waste	Increased food (N/P)	-	0-1	1	4	1-2	R	2
Atmospheric Emissions	Surface contaminants (N)	-	0	1	6	1-2	R	2
Helicopter Presence	Disturbance (N)	Maintain high altitude	0-1	1-2	1	1	R	2
Accidental Releases	Injury/Mortality (N)	Solid Streamer[c]; Spill Response	0-2	1-2	1	1	R	2

Key:

Magnitude:
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	-	-
Vessel Lights	NS	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	-	-
Atmospheric Emissions	NS	3	-	-
Helicopter 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.

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 km²* (see Table 5.17). Based on these criteria ratings, the residual behavioural effects of activities associated with CGG's proposed 2D/3D/4D seismic program on white sharks and wolffishes are predicted to be *not significant* (see Table 5.18). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.18).

5.7.8.2 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 CGG's proposed 2D/3D/4D seismic program on Ivory Gulls are predicted to be *negligible* and *not significant* (see Table 5.18). The level of confidence associated with this prediction is *medium* to *high* (see Table 5.18).

5.7.8.3 Marine Mammal and Sea Turtle Species at Risk

Based on available information, blue 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:

- 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 CGG'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 CGG's proposed 2D/3D/4D seismic program on sensitive areas within the Study Area 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).

5.8 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 CGG seismic program activities in the Project Area. This includes the residual effects of two concurrent seismic surveys being conducted by CGG (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 CGG 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 CGG'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. CGG 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). CGG will advise the C-NLOPB prior to compensating and settling all valid lost gear/income claims promptly and satisfactorily.

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 spatial/temporal avoidance protocol
Temporary or permanent hearing damage/disturbance to marine animals	• delay 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

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).

CGG 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. CGG 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.

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 2015). Data collection for seabirds at sea will be in accordance with Gjerdrum et al. (2012). It is understood by CGG that a CWS *Migratory Birds Permit* will be required and that it will be secured as it has been in the past. CGG 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.

CGG 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 Collaborative Post-season Trap Survey for Snow Crab. CGG 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 CGG'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 CGG's proposed seismic program on the VECS are predicted to be *not significant*.

Table 5.20 Significance of Potential Residual Environmental Effects of CGG'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	-	-
Vessel Lights	NS	3	-	-
Vessel/Equipment Presence				
Seismic Vessel/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	-	-
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

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Appendix 1

CGG's Full Consultation Report

Industry and Agency Consultations for CGG Services (Canada) Inc. (CGG) Newfoundland Offshore Seismic Program, 2016-2025

During preparation of the environmental assessment of CGG'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 to 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 CGG 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)

CGG's representative met with EC managers and provided an overview of the proposed program. EC managers did not have any particular comments or questions.

Nature Newfoundland and Labrador (NNL)

Following CGG's presentation, NNL's representative offered several comments. He noted that, as NNL has stated during previous consultations, it has a "problem" with the multi-year temporal scoping period and the large spatial scoping area being assessed in the EA. The NNL is also concerned about cumulative impacts, particularly with respect to "chronic" impacts (versus acute impacts). NNL's representative also made the usual request that the survey proponent consider providing ADCP data to local researchers.

One Ocean

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

Fish, Food and Allied Workers Union/Unifor

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

A fisher asked if the survey could be conducted anytime of the year. There is a concern about damage/destruction of fishing gear. Fishing activities take place from April to November, and fishers would prefer that seismic activities not be conducted during this period. In response, CGG described the mitigative measures that would be in place to prevent any such gear damage.

It was noted that when past seismic operations were being conducted during the fishing season, fishers have noticed that catch rates are affected negatively. Some fishers have reported that they have lost the entire season's fishing in some cases. This raised the question about compensating fishers for "lost time" (i.e., due to gear being damaged, they could not fish for some time). CGG's consultant noted that fishers who have experienced gear damage in the past have been compensated for "lost time", among other claim items.

With respect to the C-NLOPB issuing calls for bids on new offshore lands, it was noted that government should be informing the fishing industry about what parcels of land are being considered for the bidding process. Fishers should be able to indicate that a particular parcel overlaps with a very good fishing ground and thus should not be opened up for exploration (i.e., seismic surveying). However, because some grounds have not been fished for 20 years or so, it is not possible to say or determine where the "hot spots" might be in the future.

LGL's representative noted that the suggestion that certain areas should be excluded from certain new offshore parcels has been raised with the Board during SEA consultations. He went on to say that CGG would like to have input from fishers regarding where they believe the "hot spots" might be in CGG's project area.

Fishers noted that the issue of seismic operations during the fishing season has been "on the table" for some time, and still nothing has been done about this. These concerns have not been taken seriously and there is no money for scientific research related to the potential effects of seismic surveying.

In general, there needs to be better communications between the two industries. It was noted that there was an incident between a survey vessel and some crab gear in 2015, and in another instance, a seismic vessel was told not to conduct its survey during the crab season (April to July period) when the gear is very densely set. It was also noted that FLOs are deployed on each seismic vessel in order to communicate with fishers but that this does not always happen. Fishers need assurance that the need for these at-sea communications is getting through to the seismic industry.

CGG indicated the two potential survey areas that are proposed for 2016. Fishers noted that the south survey block is particularly problematic because crab fishing activities are very concentrated there during June and July. Thus it would be better if survey were to take place after 1 August in that particular area. The southwest corner of this CGG block (an area known to fishers as "the 40th edge") is a very good area for groundfish (cod) harvesting and, that in the future, there may be other codfish grounds identified in that area. If so, groundfish are likely to be harvested during August and September.

There was also discussion of the Industry-DFO Collaborative Post-Season Trap Survey for Snow Crab which takes place from September 1 to the end of November. It was suggested by the PIL that there should not be any seismic activities close (within 30 km) to any of the survey stations until they had been sampled after September 1. With respect to the proximity of seismic operations to any Industry-DFO Collaborative Post-Season Trap Survey for Snow Crab stations, CGG's consultant asked if the DFO "buffer" protocols would be satisfactory. The FFAW PIL indicated that these parameters would not work because it is not easy to predict where crab science vessels would be at any particular time.

One of the fishers who attended this consultation meeting agreed that the 7-day/30-km temporal/spatial buffer is sufficient with respect to the Industry-DFO Collaborative Post-Season Trap Survey for Snow Crab. It was also noted that during the past several years, the FFAW has been working with seismic operators to ensure that their vessels avoid these activities, and it was acknowledged that this arrangement has worked out well.

Fishers reiterated that their chief concern is with seismic operations being conducted close to important crab fishing grounds in the southwest corner of CGG's southernmost potential 2016 survey area.

There was also a discussion about buffers (i.e. safety zones) around oil installations. Fishers are sometimes told they must not fish in or traverse through a 5-mile safety zone around a production facility. It was noted that this issue has been discussed within the One Ocean Working Group, and that communications at sea between both industries still need to be improved. The FFAW noted that it is essential to have a direct line of communication between fishing and seismic vessels.

Association of Seafood Producers (ASP)

ASP's Executive Director indicated that he had no immediate questions about the proposed program but that he would contact the proponent's consultant if anything comes to mind. He also attended the consultation meeting between Ocean Choice International and CGG representatives.

Ocean Choice International (OCI)

Following CGG's presentation, there was a short discussion about the exchange of vessel position and operations information between the two industries at sea. OCI would like to know where a survey vessel is at any point in time on a daily basis. One Ocean would also like to have this locational data and, in turn, will provide the survey vessel with VMS data that it receives under an arrangement between One Ocean and DFO.

One Ocean's manager also noted that her agency has become accustomed to getting the (seismic vessel's) line data on a daily basis, i.e., it is standard practice for the seismic vessel to indicate which line(s) would be shot on a particular day.

OCI managers noted that it undertook a study of the interactions between redfish harvesting and seismic noise. This research was conducted in the Flemish Pass area in co-operation with a seismic vessel that was surveying in that area. The results will soon be presented to One Ocean's Working Group for discussion and review. OCI noted that the study found a 10-12 tonne drop in daily catch rates when the OCI fishing vessel was harvesting redfish in proximity to the seismic operations.

Managers noted that OCI vessels harvest redfish on the slope of the shelf in the vicinity of CGG's southernmost potential 2016 survey area, and turbot in the CGG northernmost potential 2016 survey area. In the past, FPI (now OCI) vessels harvested American plaice in CGG's southernmost potential 2016 survey area, as well as to the north of Lilly Canyon. The company did not harvest redfish prior to 2013. It conducted a partial fishery in 2014 after purchasing a

new vessel in March 2014. Currently, OCI harvests redfish year-round in the vicinity of CGG's southernmost potential 2016 survey area.

One of OCI's concerns is the lack of historical, geo-referenced, catch data for key groundfish species, such as American plaice, on the Grand Banks and in the general vicinity of CGG's southernmost survey area. These data would be used to identify locations where groundfish harvesting activities might be taking place at some future date (if and when these stocks recover). This information would also be useful if, in future, the fishing industry wanted to argue that oil exploration activities should be excluded from specific, economically important, fishing grounds. To this end, OCI has been assembling historical catch data, for the period 1993 to 2015, using its vessel log-book records dating back more than two decades. OCI managers promised that they would provide these data for each of CGG's proposed survey areas.

OCI also indicated that the plan is to have GEAC serve as the SPOC for the relevant corporate fishing companies.

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 Limited Partnership

Clearwater's spokesperson had the following written comments:

"Thank you for the opportunity to comment on CGG'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)

NR's representative did not have any specific comments at this time. He noted that his firm receives information from OCI who keeps the industry posted. NR might also receive comments from GEAC or CAPP.

Agency/Stakeholder Individuals Involved in the Consultations

The following agencies, managers and fishing industry participants were consulted during preparation of CGG'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

Nature NL (and member organizations)

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

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, GEAC

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