Environmental Assessment

East Canada CSEM Survey 2014-2018

Prepared by

LGL Limited
environmental research associates

Prepared for

emgs

March 2014
Project No. SA1248

ENVIRONMENTAL ASSESSMENT
EAST CANADA CSEM SURVEY
2014-2018

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1.0 Introduction

Electromagnetic Geoservices Canada, Inc. (EMGS, the Proponent) prepared this Environmental Assessment (EA) for a proposed non-exclusive controlled source electromagnetic (CSEM) project for offshore Newfoundland and Labrador waters (the Project). It is submitted under the Canada-Newfoundland and Labrador Offshore Petroleum Board's (C-NLOPB) environmental assessment (EA) process. This EA was guided by the technical and scoping advice received from the C-NLOPB, other federal agencies, and stakeholders consulted by the Proponent.

The Project is proposed for the eastern offshore region of Newfoundland for 2014-2018. (Figure 1.1) The first phase of the Project has a tentative start of May 1, 2014, and pending on EMGS' client commitments may last until the weather window closes around November 30 (although a shorter "typical" campaign of 2-4 months is more likely). Controlled source electromagnetic technology is a useful tool at all phases of the exploration process, but is most commonly applied immediately prior to drilling as a "drill or drop" test. Drill or drop surveys are acquired mainly where seismic data has already been acquired prior to the exploration drilling. The electromagnetic (EM) data are then used to further reduce uncertainty and influence the decision of whether a prospect should be drilled, or dropped from the portfolio. The resulting CSEM data enable oil companies to de-risk potential hydrocarbon reservoir prior to drilling and ultimately increase exploration success by reducing the amount of dry offshore wells and thereby reducing the overall environmental footprint of drilling programs.

This Project would be the fourth CSEM campaign offshore Newfoundland. The previous three projects were all operated by ExxonMobil and acquired by EMGS. All three projects underwent the EA process, were delivered on time without environmental or safety incidents, and achieved their objectives.

1.1 Relevant Legislation and Regulatory Approvals

The *Canadian Environmental Assessment Act*, 2012 (*CEAA* 2012) came into force on 6 July 2012. The *Regulations Designating Physical Activities* list physical activities which fall under the *Act*. Marine CSEM surveys are not included on the list and therefore do not require an EA under *CEAA* 2012. However, an Authorization to Conduct a Geophysical Program will be required from the C-NLOPB. The C-NLOPB is mandated in this matter by the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland and Labrador Act* and the *Canada-Newfoundland Atlantic Accord Implementation Act*. Authorizations for the kinds of activities described in this EA will be issued under the *Atlantic Accord Implementation Act* at the discretion of the C-NLOPB. One of the specific guidelines issued by the C-NLOPB, the *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) are relevant to the proposed undertaking.

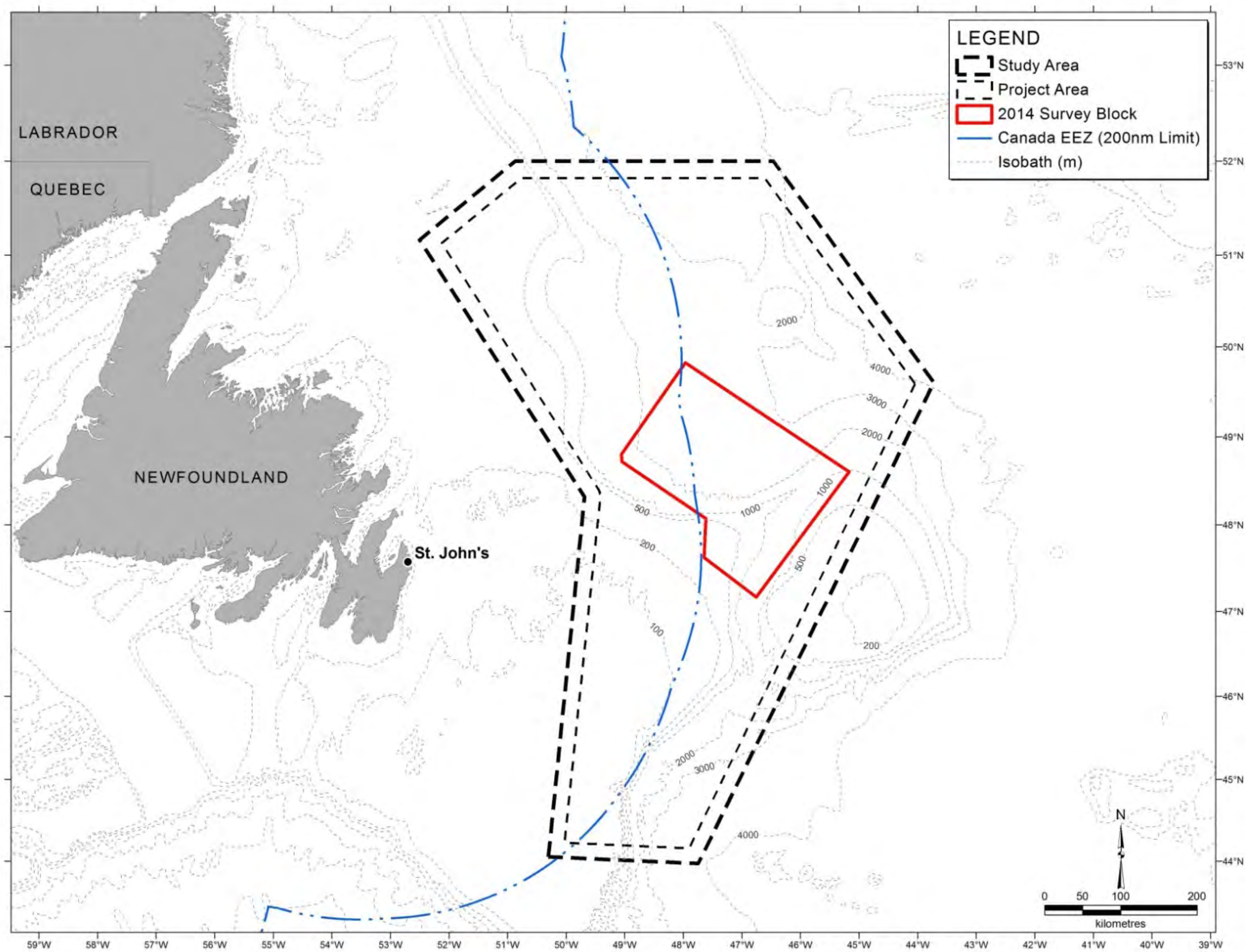

Figure 1.1 Study and Project Areas for the Proposed CSEM Survey, 2014-2018. Note that the proposed 2014 survey block may change slightly depending upon final survey design.

Other legislation that is relevant to the environmental aspects of the Project includes:

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

1.2 The Proponent

The Proponent EMGS is the global market leader in the CSEM industry with more than 650 surveys conducted worldwide since the company was founded in 2002. The company's primary business is focused towards the use of resistivity data as a direct hydrocarbon indicator (DHI). EMGS has conducted all of the CSEM surveys to date in Newfoundland and Labrador waters, and acquired the 2006, 2007 and 2009 CSEM data in the Orphan Basin for ExxonMobil.

Electromagnetic Geoservices' North American offices are located in Vancouver, BC and Houston, TX. The company currently operates a fleet of four dedicated 3D electromagnetic survey vessels; the M/V *Atlantic Guardian*, M/V *EM Leader*, S/V *BOA Galatea* and S/V *BOA Thalassa*, with extensive experience across the world's mature and frontier offshore basins.

Electromagnetic Geoservices' key contacts for the Project are listed below.

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1.3 EMGS Environmental Policy

EMGS believe that businesses are responsible for achieving good environmental practice and operation in a sustainable manner.

We are therefore committed to reducing our environmental impact and continually improving our environmental performance as an integral and fundamental part of our business strategy and operating methods.

It is our priority to encourage our customers, suppliers and all business associates to do the same. Not only is this sound commercial sense for all, it is also a matter of delivering on our duty of care towards future generations.

It is EMGS policy to:

- Wholly support and comply with or exceed the requirements of current environmental laws and regulations and apply responsible standards where laws and regulations do not exist
- Manage its business with the goal of preventing incidents and of controlling wastes to below harmful levels
- Minimize our waste and then reuse or recycle as much of it as possible
- Minimize energy and water usage in our buildings, vehicles and processes in order to conserve supplies and minimize our consumption of natural resources, especially where they are non-renewable
- Apply the principles of continuous improvement in respect of air, water, noise and light pollution from our premises and reduce any impacts from our operations on the environment
- Purchase products and services that do the least damage to the environment and encourage others to do the same

- Assess the environmental impact of any new processes or products we intend to introduce in advance

- Ensure that all employees understand our environmental policy and conform to the high standards required

- Address complaints about any breach of our Environmental Policy promptly and to the satisfaction of all concerned

- Update our Environmental Policy annually in consultation with staff, associates and customers

1.4 Canada-Newfoundland and Labrador Benefits

Electromagnetic Geoservices is cognizant of the requirements of the *Canada-Newfoundland and Labrador Atlantic Accord Implementation Newfoundland Labrador Act* and the *Canada-Newfoundland Atlantic Accord Implementation Act*. Electromagnetic Geoservices 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 EMGS' requirements.

Electromagnetic Geoservices will manage the operations for the CSEM surveys from St. John's, Newfoundland and Labrador. Electromagnetic Geoservices 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 level of health, safety and environmental performance, and be competitive in terms of quality and cost. Contractors and subcontractors working for EMGS in Newfoundland and Labrador must also apply these principles in their operations.

A Canadian Benefits Plan will be submitted under separate cover in accordance with C-NLOPB guidelines.

2.0 Project Description

The official name of the Project is the East Canada CSEM Survey, 2014-2018. EMGS is proposing to conduct one or more CSEM programs between 2014 and 2018, starting as early as May 2014, anywhere within its proposed Project Area (see Figure 1.1). The timing of the surveys is subject to EMGS's client priorities and circumstances, weather conditions, contractor availability and regulatory approvals.

2.1 Spatial and Temporal Boundaries

The Study Area is composed of the Project Area plus a 20 km "buffer" around the Project Area to account for any potential effects such as sound, accidental spills, or electromagnetic emissions on marine animals that may occur outside the Project Area (see Figure 1.1). The Project Area contains all of the Project's routine activities as per the C-NLOPB Scoping Document (C-NLOPB 2014) including deployment and turns. The areas of the Study Area and Project Area are 325,617 km^2 and 276,438 km^2, respectively. The survey areas for any particular area of interest will likely be much smaller than these. At least half of the Study Area and Project Area is located outside of Canada's Exclusive Economic Zone (EEZ) (200 nm limit). The "corner" coordinates (decimal degrees, WGS84 projection) of the Study and Project areas are shown in Table 2.1.

The temporal boundaries of the proposed Project are between 1 May and 30 November, from 2014-2018. The duration of a CSEM survey is estimated at 60 to 150 days in a given year.

Table 2.1 Proposed Study and Project Area Corner Coordinates.

Study Area (WGS84, decimal degrees)		Project Area (WGS84, decimal degrees)	
Latitude	**Longitude**	**Latitude**	**Longitude**
51.16069	-52.50388	51.12630	-52.12409
51.99899	-50.87087	51.81937	-50.76807
51.99890	-50.27063	51.81908	-50.27190
51.99889	-49.48030	51.81910	-49.48187
51.99920	-48.19808	51.81946	-48.20051
51.99844	-47.11023	51.81879	-47.11271
51.99885	-46.46673	51.81944	-46.61169
49.60448	-43.72549	49.59088	-44.04801
43.97110	-47.74772	44.15804	-47.90390
44.05379	-50.30505	44.22781	-50.03021
48.31947	-49.68887	48.36087	-49.40997
51.16069	-52.50388	51.12630	-52.12409

2.2 Project Overview

The Study and Project areas for the five year period are indicated in Figure 1.1 and Table 2.1. The CSEM survey will be conducted along pre-plotted lines, as per C-NLOPB *Geophysical, Geological, Environmental and Geotechnical Program Guidelines*. Final survey location maps will be submitted to CNLOPB 4-6 weeks prior to acquisition start-up.

During the survey, an array of receivers will be deployed on the seabed, commonly 1-3 km apart. An electromagnetic source is then deployed and towed behind the survey vessel, roughly 30 m above the seabed. The electromagnetic signal propagates through the subsurface and is recorded by receivers sitting on the sea bed. By modeling, integrating and interpreting these recordings, subsurface resistivity can be inferred. The end product can increase drilling success since water has a different resistivity than petroleum hydrocarbons.

The C-NLOPB's *Geophysical, Geological, Environmental and Geotechnical Program Guidelines* (C-NLOPB 2012) will be used as the basis for a marine mammal monitoring and mitigation program, if required. In addition, the environmental observers (EOs) (potentially the marine mammal or seabird observers, if required) 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 (FFAW) will be on board the survey vessel to ensure implementation of communication procedures intended to minimize conflict with the commercial fishery. The FLO will also assist the EOs as demands may require.

2.3 Objectives and Rationale

Controlled source electromagnetic methods produce valuable resistivity information that can be used to assess the type of fluids in a reservoir. The existence of a subsurface resistor co-located with a prospective structure identified on a seismic image can significantly increase the probability of success when the prospect is drilled. Quantitative interpretation of resistivity data can further reduce commercial risk for the oil company by assessing the scale (and thus commerciality) of the oil and reserves in place.

2.4 Project Scheduling

The CSEM surveys may occur between 1 May and 30 November of any given year from 2014 to 2018. The estimated duration of the proposed 2014 survey could be as long as 120-150 days.

2.5 Site Plans

Survey design planning for 2014 is still in progress and will depend upon client seismic results; thus detailed survey lines are not yet available and 2014 survey boundaries may change slightly. As previously noted, these details will be submitted to the Board 4-6 weeks in advance of the survey. Survey line length and orientation is to be determined. Grid and survey line spacing will range from about 1 to 3 km. Water depths in the Project Area range from about <100 m to >4,000 m (see Figure 1.1). Much of the CSEM program will occur beyond Canada's Exclusive Economic Zone (EEZ).

A typical CSEM survey grid is shown in Figure 2.1.

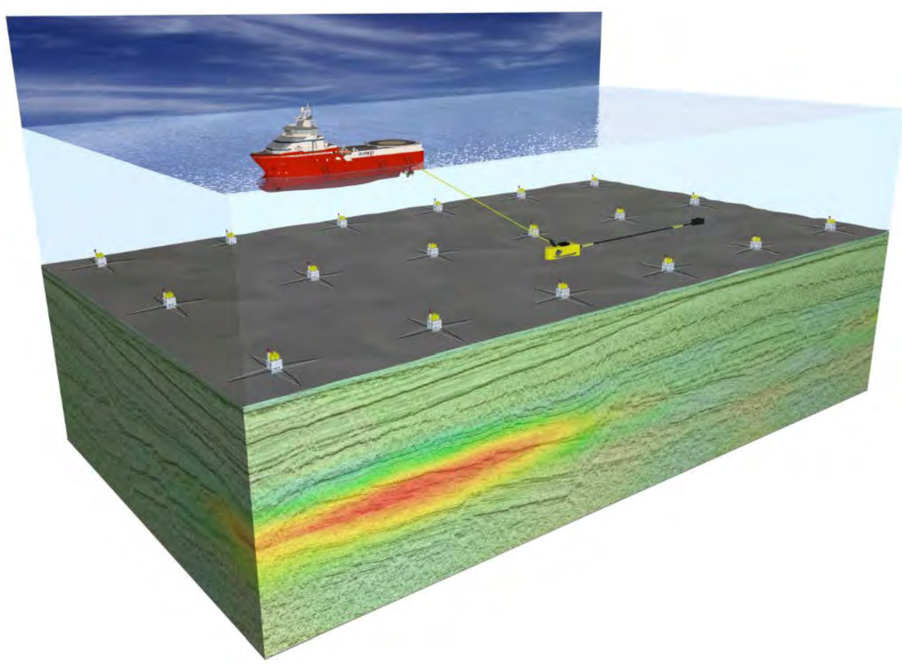


Figure 2.1 Typical CSEM Survey Grid.

2.6 Personnel

A typical survey vessel can accommodate approximately 35-50 personnel. Personnel on a survey vessel include ship's officers and marine crew as well as technical and scientific personnel. The survey vessel will have a FLO and possibly two MMOs on board. All project personnel will have all of the required certifications as specified by the relevant Canadian legislation and the C-NLOPB.

2.7 Survey Vessel

The survey will be conducted using one of EMGS' four exploration vessels which can hold up to 200 receivers. These vessels are not significantly different than offshore supply vessels typically used on the east coast and similar to the vessel used previously in Orphan Basin. The vessel will have an onboard technical crew from EMGS in addition to a maritime crew employed by the ship-owner. Total crew is 35-50 persons, including technical staff and observers, on five week rotations.

2.8 CSEM Source

The source system is designed to meet state of the art CSEM requirements with respect to performance, physical dimensions and safety when handling the equipment. The CSEM source system consists of a power supply and control unit at the topside transmitter mounted on towed subsea-frame (tow fish) horizontal electric dipole connected to the tow fish (Figure 2.2).

The topside unit is controlling the power to generate the predefined EM pulse at the electric dipole. The power is transformed to high voltage/low current and transferred via umbilical to the subsea system. At the subsea system the power is transformed back to low voltage/high current. A trailing electric dipole (antenna) is connected to the subsea signal source. This antenna is fed with a periodic current (AC). The waveform, amplitude and periodic time can be defined and changed at the topside operator station.

A separate power supply feeds the instrumentation on the tow fish.

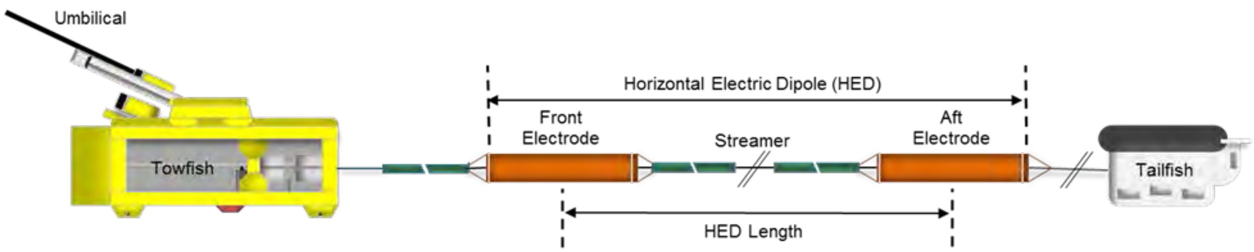


Figure 2.2 Schematic Drawing of the CSEM Source.

The electric dipole (antenna) is neutrally balanced for in-line towing operation. A tail fish is designed to keep tension on the antenna system. Tow fish and tail fish are carrying additional survey and navigation equipment.

2.9 CSEM Streamer

The CSEM streamer consists of tow and conductor cables and a floatation section containing Isopar M fluid (see Figure 2.2). The flotation sections are segregated into five 50-m sections (containing 670 L each) and one 14-m section containing 187 L. The total length of the tow package will vary with the depth being surveyed, with a maximum length of several thousand metres. Compared to a typical 3D seismic survey, a CSEM towed system is very different in that it consists of only one streamer and it is much shorter. As such a CSEM survey occupies relatively little “sea-space” and other vessels can pass safely as close as one kilometre astern.

2.10 CSEM Receiver Packages

Controlled source electromagetic receiver nodes are placed on the seabed in a grid pattern. The node consists mainly of antenna, receiver, positioning transponder, release system, buoyancy, and an environmentally benign anchor (Figure 2.3). Sonardyne Programmable Generic Transponders (PGT) are used on both the Receivers and the Towed source in order to position them in the water. The PGT also can release the receiver from the anchor by primary or secondary release. Primary release is an electric motor which releases the wire from the PGT. The secondary release uses a burn wire in case the primary fails to release. Buoyancy is provided in order to bring the receivers back to the surface after the anchor release. The system consists of five glass spheres enclosed in high quality yellow plastic. The

PGT is also used to position the receivers on the seabed using the shipboard Sonardyne or Kongsberg Ultra Short Base Line (USBL) system. It works by sending an acoustic interrogation signal to the PGT which in turn sends a reply signal enabling its precise position to be calculated.

Each receiver is mounted with a compacted sand anchor, typically about 810 mm x 920 mm in length-width and 102 mm in thickness, in order to provide negative buoyancy during deployment, and to provide stability during seabed recording. The anchor remains at the seabed after release and recovery of the receiver. The anchor contains no components harmful to the marine environment. All ingredients are found in natural gravel, limestone and/or seawater and do not contain any organic admixtures.

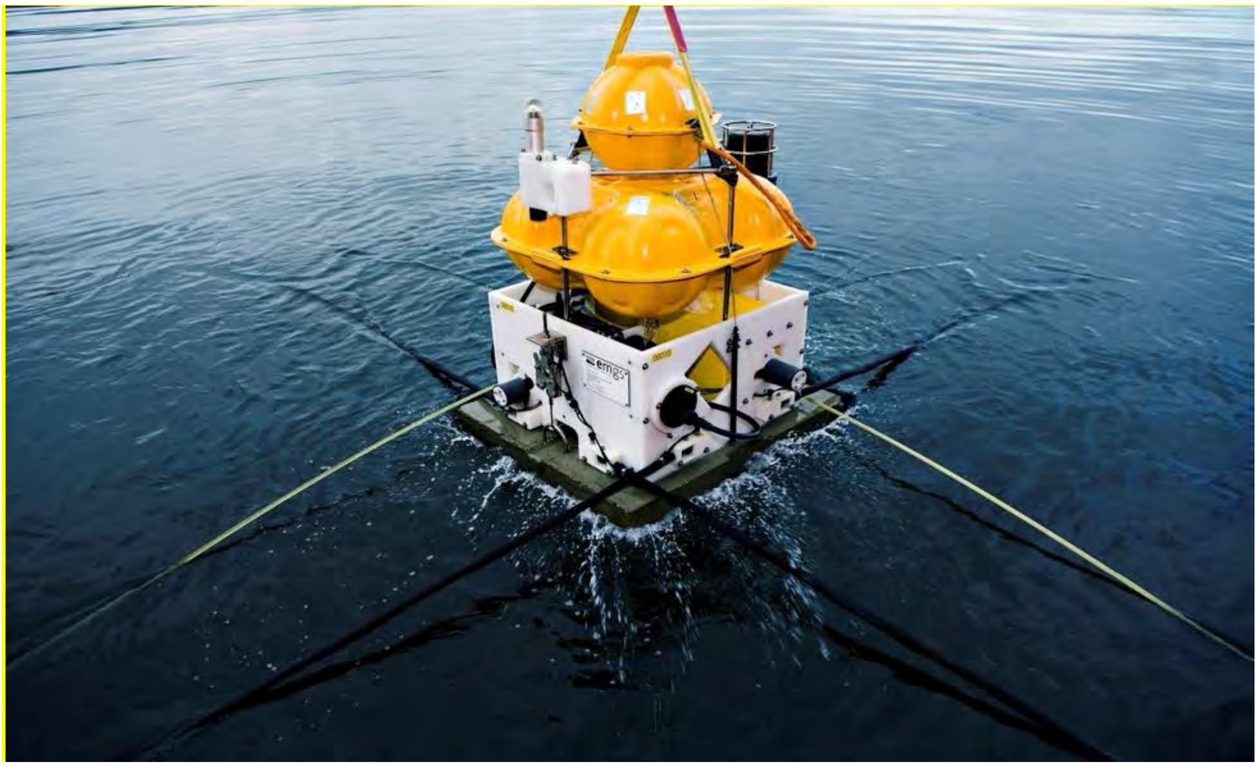


Figure 2.3 CSEM Receiver Package.

2.11 Support Vessels

Depending upon the final logistic plan, a supply vessel may be required to facilitate technician changes and for re-supply. It is anticipated that the 2014 survey will conduct crew changes through port calls.

2.12 Helicopters

The survey vessel will be equipped with a helicopter deck and helicopters may be used for crew changes and light re-supply. It is not known at this time whether helicopters will be used for crew changes during the proposed survey program (s). Once the final extents of the CSEM programs are determined, the necessity for and feasibility of helicopter support for crew changes will be determined. Helicopter support is not envisaged for 2014.

2.13 Shore Base, Support and Staging

Logistics such as crew changes and re-supply will be coordinated in St. John's. No new shore base facilities will be established as part of the Project.

2.14 Waste Management

Waste management will be consistent with industry best practices in offshore Newfoundland and Labrador. The vessel will be MARPOL-compliant. Specific EMGS practices include:

- The vessel complies with all maritime requirements for waste and pollution control as defined in the Marpol 73/78 conventions.
- Where fitted, food macerators are used to reduce size of food scraps before dumping at sea.
- Where they are currently not fitted, food will be cut up into small pieces.
- Waste is either incinerated at sea in a SOLAS approved incinerator or held in hygienic store for disposal on shore.
- Approved waste management specialists segregate hazardous materials from other waste for disposal.
- The vessel carries facilities to avoid small spillages of oil and chemicals into the sea. Larger spills associated with structural damage to the vessel are dealt with in individual vessels' own Shipboard Oil Spill Emergency plan as required by Regulation 26 of MARPOL 73/74.

2.15 Air Emissions

Air emissions will be those associated with standard operations for marine vessels using marine diesel, including the CSEM vessel and any potential supply vessel.

2.16 Accidental Events

In the unlikely event of the accidental release of hydrocarbons during the Project, the measures outlined in EMGS' oil spill response plan will be implemented. The oil spill response plan will be filed with the C-NLOPB. In addition, EMGS will have an emergency response plan in place. These have been submitted to the C-NLOPB under separate cover.

The effects section (Section 5.0) considers accidental petroleum hydrocarbon spills with focus on Isopar M spills.

2.17 Mitigation and Monitoring

Project mitigations will be detailed in the EA and will be based on C-NLOPB guidelines and other appropriate regulatory guidelines. Mitigations are described in the various VEC assessment subsections in Section 5.0 and summarized in Section 6.0.

3.0 Physical Environment

The Scoping Document (C-NLOPB 2014) required that the EA include a review of the meteorological and oceanographic characteristics, 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 White Rose Comprehensive Study (Husky 2000), the Orphan Basin Strategic Environmental Assessment (SEA) (LGL 2003), and the White Rose Extension Project Environmental Assessment (Husky 2012). A summary of the physical environment of the Study Area, based primarily on the Orphan Basin SEA, with updated information from recent reports (e.g. Oceans 2012, 2014) is provided below, with reference to weather, oceanography, and ice conditions, particularly during May to November.

3.1 Bathymetry and Geology

As indicated in the Orphan Basin SEA (LGL 2003) and the White Rose Comprehensive Study (Husky 2000), the topography of the Study Area is highly diverse and includes at least six distinct types as characterized by depth, location, and physiography: (1) the eastern portion of the northeast Newfoundland Shelf (depths ≤ 200 m); (2) the northeast Newfoundland Shelf Slope and Flemish Cap Shelf (depths >200 to 2,000 m); (3) Orphan Basin proper (depths 2,000 to 3,000 m); (4) Orphan Knoll (rising steeply from 3,000 to 1,800 m); (5) Flemish Pass (deep water in excess of 1,000 m confined between the Grand Banks (≤ 200 m) and the Flemish Cap (≥ 200 m); and (6) Jeanne d'Arc Basin (depths ≤ 200 m).

The characterization of surficial sediment in the Study Area ranges from fine (mud and clay) to extremely coarse (boulders and bedrock). Orphan Knoll is a fragment of continental crust that detached from North America during continental rifting (Keen and Beaumont 1990 *in* Toews and Piper 2002). Surficial sediments in the area are primarily hemipelagic, ice-rafted, and from glacial plume deposits (Toews and Piper 2002). The Study Area contains several fault zones in the Flemish Pass area. It is bounded on the east by the East Newfoundland Hinge Zone and on the north by the Charlie Fracture Zone (Mobil 1985 *in* Petro-Canada 1996). Considerable geological data have been collected for Flemish Pass by the Geological Survey of Canada, and work has included over 70 sediment samples in Flemish Pass using box cores, gravity and piston cores, and extensive surveys with side scan sonar and high resolution seismic (Campbell et al. 2002). Flemish Pass is a saddle-shaped, mid-slope basin (1,000-m depth) bounded on the west by the Grand Banks and the east by the Flemish Cap. Its topography is unusual in that it allows the trapping of sediments that elsewhere on most areas of the East Coast would be transported across the slope to the abyssal plain (Piper and Pereira 1992 *in* Campbell et al. 2002). The bottom is overlain by Miocene sediments over a thick Mesozoic sequence (Kennard et al. 1990 *in* Campbell et al. 2002).

3.2 Climatology

Every marine survey program is influenced by weather conditions both from routine operational and environmental safety perspectives. During routine activities, data quality and hence, survey time on site can be affected by weather, particularly wind and wave conditions. This section provides a general overview of climatic conditions in the Study Area with a more detailed description of extreme events. Further details can be found in Section 2 of Oceans (2012, 2014).

3.2.1 Weather Systems

The Study Area, including the northeast Newfoundland Shelf, northeast Grand Banks, Orphan Basin, Flemish Pass, and Jeanne d'Arc Basin, experiences weather conditions typical of a marine environment that moderates air temperatures. In general, marine climates experience cooler summers and milder winters than continental climates and have a much smaller annual temperature range. Furthermore, a marine climate tends to be fairly humid, resulting in reduced visibilities, low cloud heights, and significant amounts of precipitation.

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 arises because of the normal tropical to polar temperature gradient and typifies the upper levels of the atmosphere in the mid-latitudes. 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.].

At any given time, the upper level flow is a wave-like pattern of large and small amplitude ridges and troughs. These ridges and troughs tend to act as a steering mechanism for surface features and therefore their positions in the upper atmosphere determine the weather at the earth's surface. Upper ridges tend to support areas of high pressure at the surface, while upper troughs lend support to low pressure developments. The amplitude of the upper flow pattern tends to be greater in winter than summer, which is conducive to the development of more intense storm systems.

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: one from the Great Lakes Basin, one from Cape Hatteras, North Carolina, and 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.

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 the 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 these 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. 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

(Rogers and Bosart 1986) are typical of weather bombs. 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 over the area.

With increasing solar radiation during spring, there is a general warming of the atmosphere that is relatively greater at higher latitudes. This spring warming results in a decrease in the north-south temperature gradient. By summer, the main storm tracks have moved further north than in winter, and storms are less frequent and much weaker. With the low pressure systems passing to the north of the region, the prevailing wind direction during the summer months is from the southwest to south. As a result, the incidences of gale or storm force winds are relatively infrequent during summer.

3.2.2 Extreme Wind and Wave Analysis

The extreme value analysis was carried out using four grid points within the Study Area: grid point 14854 in southern Orphan Basin, at 48.9°N; 47.4°W; grid point 13912 on the Grand Banks north of White Rose, at 48.3°N; 46.3°W; grid point 11423 in the Flemish Pass, at 46.9°N; 48.1°W; and grid point 08026 on the southern Grand Banks, at 45.0°N; 50.0°W.

An analysis of extreme wind and waves was performed by Oceans using the MSC50 data set. This 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. The extreme values for wind speeds and waves were calculated using the peak-over-threshold method. After considering four different distributions, the Gumbel distribution was chosen to be the most representative as it provided the best fit to the data. Since extreme values can vary, depending on how well the data fits the distribution, a sensitivity analysis was carried out to determine how many storms to use in the analysis. The number of storms determined to provide the best fit annually and monthly for each of four grid points used in the analyses are presented in Table 3.1. A detailed description of the methodologies used is contained in Oceans (2012).

Table 3.1 Number of Storms with Best Fit for Extreme Value Analysis of Winds and Waves.

Grid Point No.	Parameter	Annually	Monthly
14845	Wind	265	66
	Wave	181	58
13912	Wind	314	84
	Wave	192	79
11423	Wind	259	107
	Wave	251	76
08026	Wind	191	80
	Wave	267	58

3.2.2.1 Extreme Value Estimates for Winds from the Gumbel Distribution

The extreme value estimates for wind were calculated by Oceans using Oceanweather's Osmosis software for the return periods of 1-year, 10-years, 25-years, 50-years and 100-years. The analysis used hourly mean wind values for the reference height of 10 m above sea level. These values were converted to 10-minute and 1-minute wind values using a constant ratio of 1.06 and 1.22, respectively (U.S. Geological Survey 1979).

The calculated annual and monthly wind values for 1-hour, 10-minutes and 1-minute are presented in Tables 3.2 to 3.4. The annual 100-year extreme 1-hour wind speed was determined to be 32.8 m/s for grid point 14845, 33.1 m/s for grid point 13912, 32.3 m/s for grid point 11423, and 32.3 m/s for grid point 08026. Monthly, the highest 100-year extreme winds occurred during the month of February, while the lowest occurred in July.

3.2.2.2 Extreme Value Estimates for Waves from a Gumbel Distribution

The annual and monthly extreme value estimates for significant wave height for return periods of 1-year, 10-years, 25-years, 50-years and 100-years are given in Table 3.5. The annual 100-year extreme significant wave height was 14.9 m at grid point 14845, 16.0 m at grid point 13912, 15.0 m at grid point 11423, and 14.1 m at grid point 08026. 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 maximum individual wave heights and extreme associated peak periods are presented in Table 3.6 and Table 3.7. Maximum individual wave heights peak during the month of December at grid point 14845, and during the month of February at grid points 13912, 11423, and 08026.

3.2.3 Temperature

The moderating influence of the ocean serves to limit both the diurnal and the annual temperature variation on the Grand Banks. 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 season.

Air and sea surface temperatures for each of the grid points were extracted from the ICOADS data set (Oceans 2012, 2014). Mean monthly air and sea surface temperatures are presented in Table 3.8, and are the mean of all temperatures recorded at the site during that month.

At grid point 14845, in southern Orphan Basin, the atmosphere is coldest in March with a mean monthly air temperature of 4.5°C, and warmest in August with a mean monthly air temperature of 10.8°C. Similarly, sea surface temperature is coldest in March with a mean monthly temperature of 3.7°C and warmest in August with a mean monthly temperature of 11.3°C (Table 3.8). Mean sea surface temperatures are cooler than mean air temperatures from October to June, with the greatest difference occurring in the month of January. From July to September, mean sea surface temperatures are warmer than mean air temperatures.

Table 3.2 One-hour Extreme Wind Speed (m/s) Estimates for Return Periods of 1, 10, 25, 50 and 100 Years.

Month	Grid Point #14845					Grid Point #13912				
	1	10	25	50	100	1	10	25	50	100
January	23.3	26.8	27.8	28.6	29.3	23.3	27.1	28.4	29.3	30.3
February	22.5	28.1	29.8	31.1	32.4	23.0	28.0	29.6	30.9	32.1
March	20.9	25.9	27.4	28.6	29.7	20.8	20.6	27.2	28.4	29.6
April	18.6	22.4	23.6	24.4	25.3	18.7	22.5	23.8	24.8	25.7
May	16.1	21.0	22.5	23.6	24.7	16.5	20.9	22.4	23.5	24.6
June	14.8	19.0	20.2	21.2	22.1	15.1	18.8	20.1	21.0	21.9
July	13.5	16.6	17.6	18.3	19.0	13.6	16.8	17.8	18.6	19.4
August	14.2	19.4	21.0	22.1	23.3	14.4	20.7	22.9	24.5	26.0
September	17.3	23.3	25.1	26.5	27.9	17.7	24.0	26.2	27.8	29.4
October	18.3	25.0	27.0	28.5	30.0	19.0	24.4	26.3	27.7	29.0
November	20.3	25.0	26.4	27.8	28.5	20.5	24.8	26.3	27.3	28.4
December	22.2	27.6	29.2	30.4	31.6	22.4	27.6	29.3	30.6	31.8
Annual	26.0	29.5	30.8	31.8	32.8	25.9	29.6	31.0	32.1	33.1

Month	Grid Point #11423					Grid Point #08026				
	1	10	25	50	100	1	10	25	50	100
January	22.8	26.5	27.8	28.8	29.7	21.6	26.2	27.7	28.8	30.0
February	22.4	27.2	28.9	30.2	31.5	21.3	26.9	28.7	30.1	31.5
March	20.5	24.9	26.5	27.7	28.8	19.7	24.2	25.7	26.8	27.8
April	18.2	22.5	24.0	25.2	26.3	17.8	22.0	23.4	24.5	25.5
May	15.7	19.7	21.1	22.1	23.2	15.1	18.9	20.1	21.0	22.0
June	14.7	18.4	19.8	20.8	21.8	13.8	17.2	18.3	19.1	20.0
July	13.5	16.7	17.9	18.7	19.6	12.7	17.1	18.5	19.6	20.7
August	14.7	21.1	23.3	25.0	26.7	13.6	20.9	23.3	25.1	26.9
September	17.2	22.6	24.6	26.0	27.4	16.3	22.8	25.0	26.6	28.2
October	18.6	23.5	25.3	26.6	27.9	18.0	22.6	24.3	25.6	26.9
November	20.0	24.4	25.9	27.1	28.2	19.2	23.8	25.4	26.5	27.6
December	22.0	26.5	28.1	29.3	30.4	21.6	25.9	27.4	28.4	29.5
Annual	25.3	28.9	30.2	31.2	32.3	24.8	28.7	30.1	31.2	32.3

Table 3.3 Ten-minute Extreme Wind Speed (m/s) Estimates for Return Periods of 1, 10, 25, 50 and 100 Years.

Month	Grid Point #11423					Grid Point #13912				
	1	10	25	50	100	1	10	25	50	100
January	24.7	28.4	29.5	30.3	31.1	24.7	28.7	30.1	31.1	32.1
February	23.9	29.8	31.6	33.0	34.3	24.4	29.6	31.4	32.7	34.0
March	22.1	27.4	29.1	30.3	31.5	22.1	21.8	28.8	30.1	31.4
April	19.8	23.8	25.0	25.9	26.8	19.8	23.9	25.2	26.3	27.3
May	17.1	22.3	23.8	25.0	26.2	17.5	22.1	23.7	24.9	26.1
June	15.7	20.1	21.4	22.4	23.4	16.0	19.9	21.3	22.3	23.2
July	14.3	17.6	18.6	19.4	20.1	14.4	17.8	18.9	19.8	20.6
August	15.0	20.5	22.2	23.5	24.7	15.2	22.0	24.2	25.9	27.6
September	18.3	24.7	26.6	28.1	29.5	18.7	25.5	27.8	29.5	31.2
October	19.4	26.4	28.6	30.2	31.8	20.1	25.9	27.9	29.3	30.8
November	21.5	26.5	28.0	29.4	30.3	21.8	26.3	27.8	29.0	30.1
December	23.6	29.2	30.9	32.2	33.5	23.8	29.2	31.0	32.4	33.8
Annual	27.5	31.2	32.6	33.7	34.8	27.5	31.4	32.8	34.0	35.1

Month	Grid Point #14845					Grid Point #08026				
	1	10	25	50	100	1	10	25	50	100
January	24.1	28.0	29.4	30.5	31.5	22.9	27.8	29.4	30.6	31.8
February	23.8	28.9	30.7	32.0	33.4	22.5	28.5	30.5	31.9	33.4
March	21.7	26.4	28.1	29.3	30.5	20.9	25.6	27.2	28.4	29.5
April	19.2	23.8	25.5	26.7	27.9	18.9	23.4	24.8	26.0	27.1
May	16.6	20.8	22.3	23.5	24.6	16.0	20.0	21.3	22.3	23.2
June	15.5	19.5	21.0	22.0	23.1	14.6	18.2	19.4	20.3	21.2
July	14.3	17.7	18.9	19.9	20.8	13.5	18.1	19.6	20.8	21.9
August	15.6	22.3	24.7	26.5	28.3	14.4	22.1	24.7	26.6	28.5
September	18.2	24.0	26.0	27.5	29.1	17.3	24.2	26.5	28.2	29.9
October	19.7	24.9	26.8	28.2	29.6	19.1	23.9	25.8	27.1	28.5
November	21.2	25.8	27.5	28.7	29.9	20.4	25.3	26.9	28.1	29.3
December	23.3	28.0	29.7	31.0	32.3	22.9	27.5	29.0	30.1	31.2
Annual	26.8	30.6	32.0	33.1	34.2	26.3	30.4	31.9	33.1	34.2

Table 3.4 One-minute Extreme Wind Speed (m/s) Estimates for Return Periods of 1, 10, 25, 50 and 100 Years.

Month	Grid Point #14845					Grid Point #13912				
	1	10	25	50	100	1	10	25	50	100
January	28.5	32.6	33.9	34.9	35.8	28.4	33.1	34.6	35.8	37.0
February	27.5	34.3	36.4	37.9	39.5	28.1	34.1	36.2	37.7	39.2
March	25.4	31.6	33.4	34.8	36.2	25.4	25.1	33.2	34.6	36.1
April	22.7	27.3	28.7	29.8	30.8	22.8	27.5	29.0	30.2	31.4
May	19.7	25.6	27.4	28.8	30.1	20.1	25.5	27.3	28.7	30.0
June	18.1	23.1	24.7	25.8	27.0	18.4	23.0	24.5	25.6	26.8
July	16.5	20.3	21.4	22.3	23.2	16.6	20.5	21.8	22.7	23.7
August	17.3	23.6	25.6	27.0	28.4	17.5	25.3	27.9	29.8	31.8
September	21.1	28.4	30.7	32.3	34.0	21.6	29.3	32.0	33.9	35.9
October	22.3	30.4	32.9	34.8	36.6	23.1	29.8	32.1	33.7	35.4
November	24.8	30.5	32.2	33.9	34.8	25.0	30.3	32.0	33.4	34.7
December	27.1	33.6	35.6	37.1	38.6	27.4	33.6	35.7	37.3	38.8
Annual	31.7	35.9	37.6	38.8	40.0	31.6	36.1	37.8	39.1	40.4

Month	Grid Point #11423					Grid Point #08026				
	1	10	25	50	100	1	10	25	50	100
January	27.8	32.3	33.9	35.1	36.3	26.4	32.0	33.8	35.2	36.6
February	27.3	33.2	35.3	36.9	38.4	25.9	32.8	35.1	36.7	38.4
March	25.0	30.4	32.3	33.7	35.2	24.1	29.5	31.3	32.6	34.0
April	22.2	27.4	29.3	30.7	32.1	21.7	26.9	28.6	29.9	31.1
May	19.1	24.0	25.7	27.0	28.3	18.5	23.0	24.5	25.7	26.8
June	17.9	22.5	24.1	25.4	26.6	16.8	21.0	22.3	23.4	24.4
July	16.5	20.4	21.8	22.9	23.9	15.5	20.8	22.6	23.9	25.2
August	17.9	25.7	28.4	30.5	32.5	16.6	25.5	28.4	30.6	32.8
September	21.0	27.6	30.0	31.7	33.5	19.9	27.8	30.5	32.5	34.4
October	22.7	28.7	30.9	32.5	34.1	22.0	27.5	29.7	31.2	32.8
November	24.4	29.7	31.6	33.0	34.4	23.4	29.1	30.9	32.3	33.7
December	26.8	32.3	34.2	35.7	37.1	26.4	31.6	33.4	34.7	36.0
Annual	30.9	35.2	36.9	38.1	39.4	30.3	35.0	36.7	38.1	39.4

Table 3.5 Extreme Significant Wave Height Estimates (m) for Return Periods of 1, 10, 25, 50 and 100 Years.

Month	Grid Point #14845					Grid Point #13912				
	1	10	25	50	100	1	10	25	50	100
January	9.2	12.1	12.9	13.5	14.0	10.1	12.8	13.7	14.4	15.0
February	8.5	12.1	13.0	13.7	14.4	9.4	13.0	14.2	15.0	15.9
March	6.8	10.1	10.9	11.6	12.2	7.8	10.5	11.4	12.1	12.8
April	5.7	9.0	9.9	10.5	11.1	6.4	9.2	10.0	10.7	11.4
May	4.2	8.1	9.1	9.9	10.6	5.1	8.1	9.1	9.9	10.6
June	3.4	6.5	7.3	7.9	8.5	4.1	6.5	7.3	7.9	8.5
July	3.1	5.2	5.8	6.2	6.6	3.3	5.4	6.0	6.4	6.8
August	3.5	6.2	6.9	7.4	7.9	4.1	6.5	7.2	7.8	8.4
September	4.5	10.1	11.5	12.6	13.6	5.8	10.3	11.7	12.8	13.9
October	5.7	10.8	12.2	13.1	14.1	6.7	11.1	12.5	13.6	14.6
November	7.2	11.3	12.4	13.1	13.9	8.1	11.5	12.6	13.4	14.2
December	9.0	12.5	13.5	14.2	14.9	9.7	12.9	14.0	14.8	15.6
Annual	11.3	13.2	13.9	14.4	14.9	11.8	14.0	14.8	15.4	16.0

Month	Grid Point #11423					Grid Point #08026				
	1	10	25	50	100	1	10	25	50	100
January	9.2	12.0	12.9	13.5	14.2	8.2	11.1	12.1	12.8	13.5
February	8.5	12.2	13.4	14.3	15.2	7.7	11.0	12.0	12.8	13.6
March	7.1	10.0	11.0	11.7	12.4	6.5	9.6	10.6	11.4	12.1
April	5.7	8.6	9.6	10.3	11.0	5.4	8.1	8.9	9.6	10.2
May	4.6	7.2	8.1	8.7	9.4	4.3	6.4	7.0	7.5	8.0
June	3.8	6.1	6.9	7.4	8.0	3.5	5.7	6.4	6.9	7.4
July	3.4	5.3	5.9	6.3	6.8	3.2	5.2	5.8	6.3	6.8
August	3.8	6.7	7.7	8.4	9.1	3.6	6.6	7.5	8.3	9.0
September	5.3	9.3	10.6	11.6	12.5	4.8	8.5	9.6	10.5	11.4
October	6.3	10.0	11.2	12.1	13.0	5.7	8.8	9.8	10.5	11.2
November	7.4	10.5	11.5	12.3	13.0	6.9	9.7	10.6	11.2	11.9
December	8.9	11.7	12.7	13.4	14.1	8.1	10.7	11.5	12.1	12.8
Annual	10.8	13.0	13.8	14.4	15.0	9.9	12.0	12.8	13.5	14.1

Table 3.6 Extreme Maximum Wave Height Estimates (m) for Return Periods of 1, 10, 25, 50 and 100 Years.

Month	Grid Point #14845					Grid Point #13912				
	1	10	25	50	100	1	10	25	50	100
January	16.9	22.6	24.1	25.3	26.4	18.8	24.0	25.7	27.0	28.3
February	15.8	22.4	24.2	25.4	26.7	17.5	24.1	26.2	27.9	29.5
March	12.5	19.1	20.8	22.1	23.4	14.5	19.7	21.4	22.7	24.0
April	10.6	16.5	18.0	19.2	20.3	12.1	17.1	18.7	20.0	21.2
May	7.5	15.6	17.7	19.2	20.7	9.9	15.7	17.7	19.1	20.5
June	6.6	12.0	13.4	14.4	15.4	7.9	12.1	13.5	14.5	15.6
July	5.9	9.9	10.9	11.7	12.4	7.0	10.0	11.1	11.8	12.6
August	6.7	11.5	12.7	13.6	14.5	7.8	12.2	13.7	14.7	15.8
September	8.7	18.4	20.9	22.8	24.6	10.9	18.6	21.2	23.1	25.0
October	10.5	20.0	22.5	24.3	26.1	12.8	20.5	23.1	25.0	26.9
November	13.5	21.0	22.9	24.3	25.7	15.0	21.2	23.2	24.7	26.2
December	16.6	23.1	24.9	26.3	27.6	18.0	23.9	25.8	27.3	28.7
Annual	20.9	24.4	25.7	26.6	27.6	21.8	25.7	27.2	28.3	29.4

Month	Grid Point #11423					Grid Point #08026				
	1	10	25	50	100	1	10	25	50	100
January	17.0	22.0	23.6	24.8	26.0	15.8	20.4	21.9	23.0	24.1
February	15.8	22.6	24.8	26.5	28.1	14.9	20.3	22.1	23.4	24.6
March	13.4	18.7	20.4	21.7	23.0	12.5	19.0	21.0	22.6	24.1
April	10.7	15.9	17.7	18.9	20.2	10.1	14.9	16.5	17.6	18.7
May	8.7	14.0	15.7	17.0	18.3	8.2	12.4	13.8	14.8	15.8
June	7.4	11.6	13.0	14.0	15.0	6.8	10.8	12.1	13.1	14.0
July	6.5	9.9	11.0	11.8	12.6	6.4	9.6	10.6	11.4	12.2
August	7.2	12.3	14.0	15.3	16.6	7.0	11.8	13.4	14.5	15.6
September	10.0	17.0	19.2	20.9	22.6	9.8	16.2	18.3	19.8	21.4
October	11.8	18.5	20.7	22.4	24.0	11.4	16.6	18.2	19.5	20.7
November	13.8	19.5	21.3	22.7	24.0	12.8	17.9	19.6	20.8	22.0
December	16.3	21.7	23.5	24.8	26.1	15.3	19.9	21.3	22.4	23.5
Annual	20.0	23.9	25.3	26.5	27.6	18.4	22.1	23.5	24.6	25.7

Table 3.7 Extreme Associated Peak Period Estimates (m) for Return Periods of 1, 10, 25, 50 and 100 Years.

Month	Grid Point #14845					Grid Point #13912				
	1	10	25	50	100	1	10	25	50	100
January	12.8	14.5	14.9	15.2	15.5	13.4	14.9	15.3	15.7	16.0
February	11.9	14.6	15.3	15.7	16.2	12.7	14.9	15.6	16.1	16.5
March	11.7	13.1	13.5	13.7	13.9	12.1	13.3	13.7	14.0	14.2
April	10.6	13.1	13.6	14.0	14.4	11.4	12.9	13.3	13.6	13.9
May	9.3	12.3	12.9	13.4	13.8	10.2	12.3	12.9	13.3	13.7
June	8.6	11.1	11.6	11.9	12.3	9.2	11.2	11.7	12.1	12.5
July	7.9	10.4	10.9	11.3	11.7	8.3	10.6	11.2	11.6	12.0
August	9.1	10.9	11.3	11.6	11.8	9.4	11.3	11.9	12.3	12.6
September	9.9	13.6	14.3	14.8	15.3	11.1	13.8	14.6	15.1	15.6
October	11.3	13.6	14.1	14.4	14.7	11.8	14.0	14.5	15.0	15.3
November	11.6	13.8	14.3	14.6	15.0	12.3	13.9	14.4	14.7	15.1
December	12.6	14.5	14.9	15.3	15.6	13.2	14.9	15.4	15.7	16.1
Annual	13.9	15.0	15.3	15.6	15.9	14.3	15.5	15.9	16.3	16.6

Month	Grid Point #11423					Grid Point #08026				
	1	10	25	50	100	1	10	25	50	100
January	12.8	14.4	14.9	15.3	15.6	12.6	14.4	14.9	15.3	15.6
February	12.4	14.3	14.9	15.3	15.7	12.0	13.9	14.5	14.9	15.3
March	11.8	13.2	13.6	13.9	14.2	11.4	13.5	14.0	14.4	14.8
April	10.7	12.3	12.8	13.1	13.4	10.5	12.1	12.6	12.9	13.2
May	9.9	12.0	12.6	13.0	13.4	9.7	11.4	11.9	12.2	12.6
June	8.8	10.9	11.5	11.9	12.3	8.6	10.8	11.4	11.8	12.2
July	8.5	10.6	11.2	11.6	12.1	8.4	10.2	10.7	11.1	11.4
August	9.0	11.8	12.6	13.2	13.7	9.2	11.7	12.4	12.9	13.3
September	10.9	13.2	13.9	14.3	14.7	10.1	12.8	13.5	13.9	14.4
October	11.4	13.4	14.0	14.4	14.8	10.9	12.9	13.5	13.9	14.2
November	12.1	13.4	13.8	14.0	14.3	11.7	13.4	13.8	14.2	14.5
December	12.8	14.3	14.7	15.1	15.4	12.5	14.0	14.4	14.7	15.0
Annual	13.7	14.9	15.3	15.6	15.9	13.5	14.6	15.0	15.2	15.5

In grid point 13912, on the Grand Banks north of White Rose, the atmosphere is coldest in February with a mean monthly air temperature of 3.1°C, and warmest in August with a mean monthly air temperature of 11.5°C. Similarly, sea surface temperature is coldest in February with a mean monthly temperature of 3.1°C and warmest in August with a mean monthly temperature of 11.8°C (Table 3.8). Mean sea surface temperatures are cooler than mean air temperatures from October to June, with the greatest difference occurring in the month of May. From July to September, mean sea surface temperatures are warmer than mean air temperatures.

At grid point 11423, in the Flemish Pass, the atmosphere is coldest in February with a mean monthly air temperature of -0.3°C, and warmest in August with a mean monthly air temperature of 14.2°C. Similarly, sea surface temperature is coldest in February with a mean monthly temperature of 0.8°C and warmest in August with a mean monthly temperature of 13.6°C (Table 3.8). Mean sea surface temperature is cooler than mean air temperatures from October to June, with the greatest difference occurring in the month of January. From July to September, mean sea surface temperatures are warmer than mean air temperatures.

At grid point 08026, on the southern Grand Banks, the atmosphere is coldest in February with a mean monthly air temperature of 1.3°C, and warmest in August with a mean monthly air temperature of 17.7°C. Sea surface temperature is coldest in March with a mean monthly temperature of 2.2°C and warmest in August with a mean monthly temperature of 17.9°C (Table 3.8). Mean sea surface temperatures are cooler than mean air temperatures from April to July, with the greatest difference occurring in the month of April. From August to March, mean sea surface temperatures are warmer than mean air temperatures.

Table 3.8 Mean Monthly Air and Sea Surface Temperatures.

Month	Air Temperature (ºC)				Sea Surface Temperature (ºC)			
	Grid Point #14845	Grid Point #13912	Grid Point #11423	Grid Point #08026	Grid Point #148845	Grid Point #13912	Grid Point #11423	Grid Point #08026
January	5.0	3.9	0.2	2.3	4.1	4.0	1.3	3.6
February	4.6	3.1	-0.3	1.3	3.8	2.9	0.8	2.5
March	4.5	3.7	0.7	2.0	3.7	3.3	0.9	2.2
April	4.7	3.8	2.3	3.9	3.9	3.3	1.3	2.8
May	5.0	5.2	4.3	6.2	4.4	4.7	3.2	5.2
June	6.6	6.7	7.1	9.9	6.5	6.6	6.0	8.9
July	8.6	9.3	11.8	15.4	8.9	9.2	10.4	14.5
August	10.8	11.5	14.2	17.7	11.3	11.8	13.6	17.9
September	10.0	11.3	12.6	15.6	10.4	11.6	12.7	17.1
October	8.8	9.4	8.9	12.5	8.7	9.9	9.3	13.0
November	7.0	7.4	5.2	8.0	6.8	7.2	5.7	8.9
December	6.1	5.8	2.2	5.1	5.6	5.6	2.9	6.0

3.2.4 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)
- Blowing Snow

During the winter months, the main obstruction is snow, although mist and fog may also reduce visibilities at times. As spring approaches, the visibility reduction attributed to snow decreases. As air temperature increases, the occurrence of advection fog also increases. Advection fog forms when warm moist air moves over cooler waters. 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 can also contribute to the reduction in visibility. In 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. September and October have the lowest occurrence of reduced visibility since the air temperature has, on average, decreased below the sea surface temperature and it is not yet 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.

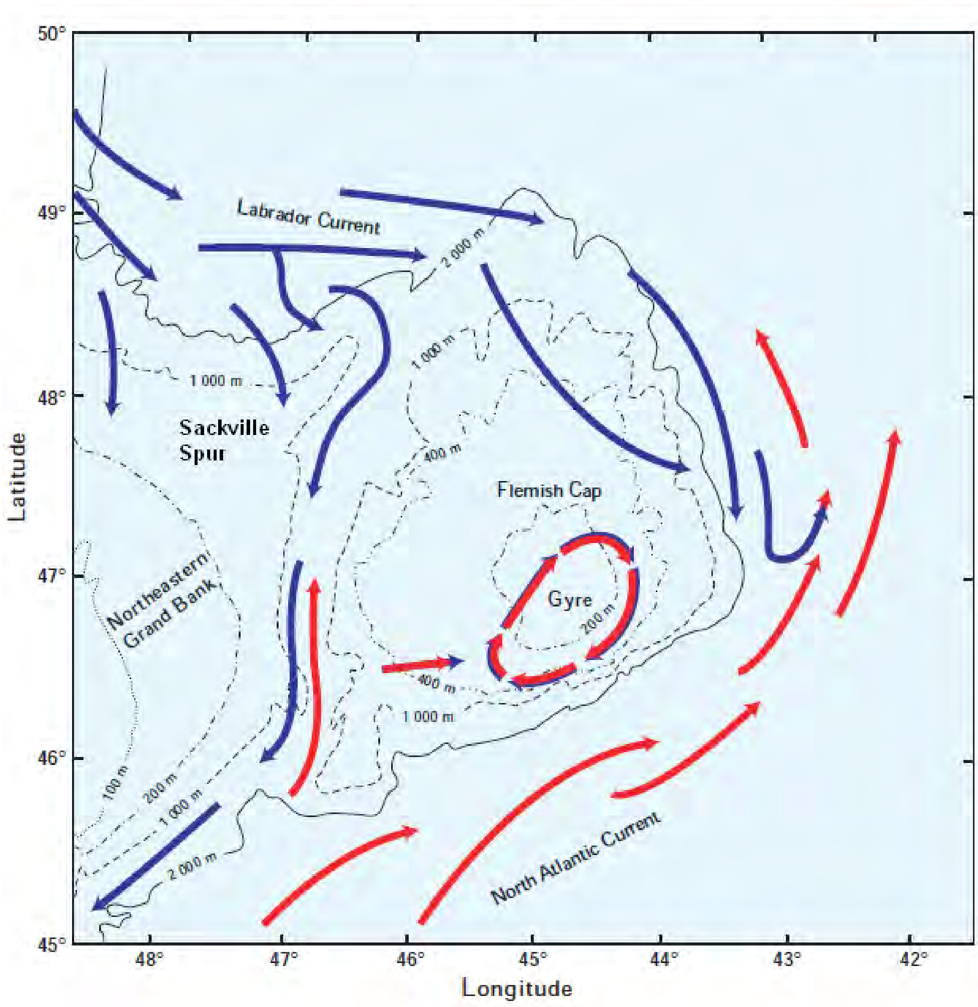
3.3 Physical Oceanography

A summary of the major currents in the Study Area is provided below. Current velocities and water mass properties (temperature and salinity) at various water depths are provided in Section 4 of Oceans (2012, 2014). Further information can also be found in the Orphan Basin SEA (LGL 2003).

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 two major current systems in the area are the Labrador Current and the North Atlantic Current (Colbourne and Foote 2000). The Labrador Current is the main current in the Study Area, and it transports sub-polar water to lower latitudes along the Continental Shelf of eastern Canada. Oceanographic studies show that this strong western boundary current follows the shelf break with relatively low variability compared to the mean flow. Over the Grand Banks, a weaker current system is observed where the variability often exceeds that of the mean flow (see Figure 4.1 *in* Oceans 2012).

The Labrador Current consists of two major branches. The inshore branch of the Labrador Current is ~ 100 km wide (Stein 2007) and is steered by the local underwater topography through the Avalon Channel. The stronger offshore branch flows along the shelf break over the upper portion of the Continental Slope. The offshore branch passes between the 400 m and 1,200 m isobaths (Lazier and Wright 1993). This branch of the Labrador Current divides east of 48°W, resulting in part of the branch flowing to the east around Flemish Cap and the other 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 (Stein 2007). 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 (Figure 3.1).



Source: Modified from Colbourne and Foote 2000.

Figure 3.1 The Major Circulation Features Around the Flemish Cap and Sackville Spur.

The outer branch of the Labrador Current exhibits a distinct seasonal variation in flow speeds (Lazier and Wright 1993), in which mean flows are 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 open ocean is 0.09 m greater than in winter (Lazier and Wright 1993). This difference produces a greater horizontal surface pressure gradient and hence, stronger mean flows.

3.4 Sea Ice and Icebergs

An important physical feature of the Study Area is the presence of sea ice and icebergs throughout much of the year. Ice is important operationally but also biologically because it affects sea state, air and water temperatures, salinity, and light penetration. The underside of the ice provides habitat for specialized algal and invertebrate species, and food for certain species of fish and seabirds. Ice edges may provide important feeding habitat for marine birds and mammals.

3.4.1 Sea Ice

Median extent of sea ice coverage by month over a 30-year period is shown in Figure 3.2. 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 3.2). During median years, only the western portion of the Study Area would have at least some ice cover whereas in extreme years, ice cover could occur throughout the Study Area, with the exception of the southern portion (Figure 3.2). Pack ice velocities up to 0.5 - 0.75-m/s can be expected flowing south through the middle of the Study Area between the 1,000 and 2,000-m contours (Peterson 1990 *in* Petro-Canada 1996). The maximum median sea ice extent reaches to approximately 48°N, 49°W. The majority of the Study Area will be free of sea ice from mid-April to January.

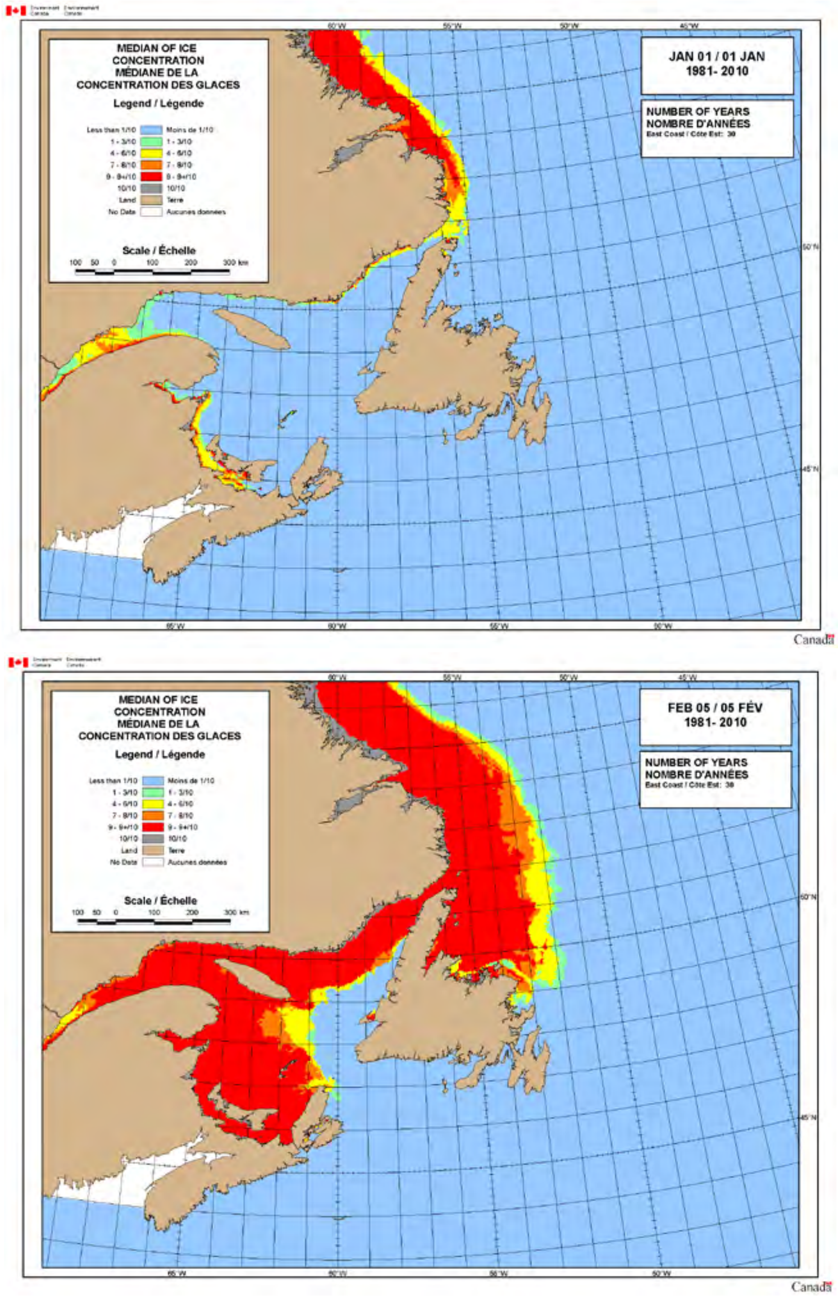
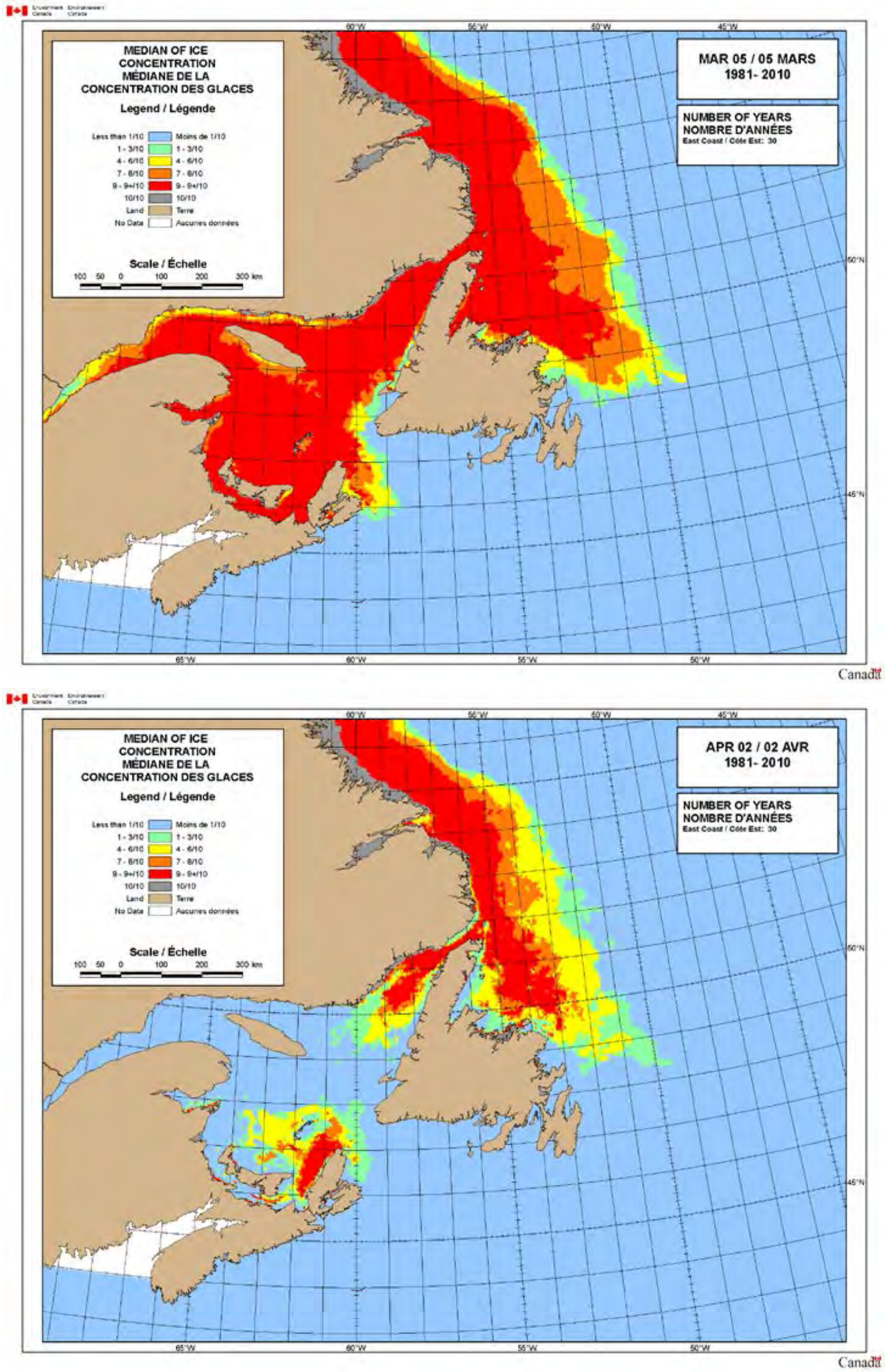


Figure 3.2 30-year Median of Ice Concentration in the Study Area, 1981- 2010.

Figure 3.2 (Continued)



Source: Canadian Ice Service 30-year Ice Atlas.
(http://iceweb1.cis.ec.gc.ca/30Atlas10/), accessed February 2014.

Figure 3.2 30-year Median of Ice Concentration in the Study Area, 1981-2010.

3.4.2 Icebergs

Icebergs are well known for causing concern with regards to navigation and offshore activities along the coast of Newfoundland and Labrador. The major source, contributing ~90% of icebergs in Canadian waters (including the Study Area), are from glaciers on the west coast of Greenland. Prevailing northwest winds and the strong Labrador Current move icebergs south along the coast of Labrador. Miller and Hotzel (1984) estimated the number of icebergs crossing a series of transects on the Labrador Shelf at a rate of 6-15 icebergs km^{-1} per year, with the total number of icebergs estimated at 1,400-3,000 per year. Major iceberg drift paths are shown in Robe (1980) *in* Petro-Canada (1996), and they branch in the northwest corner of the Study Area, flowing southward along the western border of the Study Area, and through the center from the northwest corner to the southeast. In general, in the Newfoundland offshore area, with the exception of the Flemish Pass, the highest numbers of icebergs are sighted along the northeast coast and numbers generally decrease to the east (LGL 2003). Environmental factors such as iceberg concentration, ocean currents, and wind determine how icebergs drift through the area. Iceberg scouring is relatively severe in the southwestern half of the Study Area where shallow shelf waters coincide with large numbers of icebergs carried on the inshore branch of the Labrador Current, e.g., up to 3,000-scours/km^2 just to the northeast of the Avalon Peninsula (Lewis et al. 1987 *in* Petro-Canada 1996). Scouring reduces to zero in deep water very large fast-moving icebergs may be present, at least in the central part of the Study Area.

Data from the International Ice Patrol (IIP) Iceberg Sightings Database for the period of May to November, 2001-2011, show a total of 6,736 icebergs observed in the Study Area (between approximately 43° and 51°N and 45° and 52°W; NSIDC 1995, updated annually; Table 3.9). These observed sightings may not include all icebergs passing through the Study Area but indicate the relative abundance by month and year. Of the 6,736 icebergs observed during the May to November periods, most were sighted in May (70.3%), followed by June (25.5%), and July (4.2%). Very few icebergs were observed in August, and none were observed from September to November. Additionally, there was a great deal of inter-annual variation in the numbers of observed icebergs. For example, during May to November of 2009, there were 2,275 icebergs observed in the Study Area, whereas for the same time period of 2010 and 2011, there were no icebergs observed. Iceberg size is typically characterized by waterline length, defined as the maximum dimension of the iceberg along the waterline, with small being defined as 16 – 60 m, medium as 61 – 122 m, and large or very large as > 123 m. About 40% of the 20,253 icebergs recorded during May to November, 2001-2011, were classified as medium, large or very large size.

Table 3.9 Number of Icebergs Observed in Study Area from May to November, 2001-2011.

Year	Month (Total Number of Icebergs Observed)							Total	% of Total
	May	Jun	Jul	Aug	Sep	Oct	Nov		
2001	33	44	2	-	-	-	-	79	1.17
2002	733	185	14	-	-	-	-	932	13.84
2003	1462	250	32	-	-	-	-	1744	25.89
2004	605	175	32	1	-	-	-	813	12.07
2005	2	-	-	-	-	-	-	2	0.03
2006	2	1	-	-	-	-	-	3	0.04
2007	113	362	104	-	-	-	-	579	8.60
2008	203	99	7	-	-	-	-	309	4.59
2009	1579	601	93	2	-	-	-	2275	33.77
2010	-	-	-	-	-	-	-	0	0.00
2011	-	-	-	-	-	-	-	0	0.00
Total	4732	1717	284	3	0	0	0	6736	
% of Total	70.25	25.49	4.22	0.04	0.00	0.00	0.00		

Source: NSIDC, IPP Iceberg Sightings Database (http://nsidc.org/data/docs/noaa/g00807_international_ iceberg_ sightings/index. html), accessed December 2013.

4.0 Biological Environment

The biological and socio-economic environments in and near the Study Area have been described in the Orphan Basin SEA (LGL 2003; Buchanan et al. 2004) and more recently, in exploration and drilling EAs and their amendments for Orphan Basin (Moulton et al. 2005a,b; LGL 2005, 2006a, 2009), Jeanne d'Arc Basin (Christian 2008; LGL 2006b, 2007a,b, 2008a,b, 2011a, 2012a), and Flemish Pass (LGL 2011b). In addition to updated information, summaries of relevant information from these documents are presented in the following subsections for fish and fish habitat, fisheries, seabirds, marine mammals and sea turtles, species at risk, and potentially sensitive areas.

4.1 Ecosystem

An ecosystem is an interrelated complex of physical, chemical, geological, and biological components that can be defined at scales ranging from a relatively small area, which may only contain one habitat type (e.g., a shelf), to a relatively large regional area ecosystem, which is topographically and oceanographically complex (e.g., the Northwest Atlantic). This EA focuses on components of the ecosystem, such as selected species and life stages of fish, seabirds, and marine mammals that are important ecologically, economically, and/or socially, and have the potential to interact with the Project. This is the Valued Environmental Component (VEC) approach to the EA detailed in Section 5.2. The VECs are discussed in the following subsections.

4.2 Fish and Fish Habitat

This subsection provides a description of the existing fish and fish habitat in the Study Area. Fish habitat in the Study Area is considered first, followed by a discussion of macroinvertebrate and fish species found in the Study Area.

4.2.1 Fish Habitat

For the purposes of this EA, fish habitat is considered to include physical, chemical, and biological aspects of the marine environment used by macroinvertebrate and fish species in the Study Area. The physical and chemical nature of the water column and bottom substrate is a critical factor affecting the characterization of associated marine biological communities. The biological component of fish habitat refers to phytoplankton, zooplankton, and benthos (i.e., infaunal and epibenthic invertebrates, such as polychaetes and echinoderms, not typically harvested during commercial fisheries in the Study Area).

4.2.2 Plankton

Plankton is composed of free-floating organisms that form the basis of the pelagic ecosystem. Members include bacteria, fungi, phytoplankton, and zooplankton (mostly invertebrates, but may also include eggs and larvae of fishes, known as ichthyoplankton). In simplest terms, phytoplankton (e.g., diatoms) produce carbon compounds through the utilization of sunlight, carbon dioxide, and nutrients (e.g., nitrogen, phosphorus, silicon); this process is called primary production.

Herbaceous zooplankton (e.g., calanoid copepods, the dominant component of Northwest Atlantic zooplankton) feed on phytoplankton, a growth process known as secondary production. The herbivores in turn are ingested by predators (i.e., tertiary production), such as predacious zooplankton (e.g., chaetognaths, jellyfish, etc.), all of which may be grazed by higher predators, such as fish, seabirds, and marine mammals. This food web also links to the benthic ecosystem through bacterial degradation processes, dissolved and particulate carbon, and direct predation. An understanding of plankton production is important because areas of enhanced production and/or biomass are areas where fish, seabirds, and marine mammals typically congregate to feed (LGL 2003).

Phytoplankton distribution, productivity, and growth regulation in high-latitude ecosystems constitute a complex system, with light, nutrients, and herbivore grazing being the principal factors limiting phytoplankton populations (Harrison and Li 2008). In the Northwest Atlantic, there is usually 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. Typically, the spring bloom of phytoplankton is the driving force of high-latitude marine ecosystem dynamics. Sunlight has been considered to be 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 high latitudes (Huntley et al. 1983; Head et al. 2000; Head and Pepin 2008). Zooplankton are the foremost link between primary production and higher-level organisms in the marine ecosystem. Zooplankton transfer organic carbon from phytoplankton to higher trophic levels including fish, birds, and marine mammals. Zooplankton are a food source for a broad spectrum of species, and they contribute carbon via faecal matter and dead zooplankton to the benthic food chains. Pepin et al. (2011) noted that plankton distribution in the Study Area is primarily influenced by local advective transport and mixing processes, and that several species of *Calanus* copepods act as key contributors to regional secondary production. More information on phytoplankton in and around the Study Area is available in Section 3.2.1 of the Orphan Basin SEA (LGL 2003) and the Husky New Drill Centre Construction and Operations Program EA (Section 5.4 *in* LGL 2006b).

Planktonic organisms are ubiquitous and abundant in the world's oceans and many have such rapid generation times, it logically follows that there will be essentially no or negligible effect on planktonic communities from the proposed CSEM Project. 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., shrimp, snow crab) and fish (e.g., cod) are described in following sections because of their VEC status.

4.2.3 Benthos

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

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

As indicated in the Orphan Basin SEA (LGL 2003) and the Husky New Drill Centre Construction and Operations Program EA (Subsection 5.4 *in* LGL 2006b), there are large gaps in the current knowledge of benthic ecosystems of the offshore waters of Newfoundland and Labrador. The existing literature, although extensive in appearance, tends to be spatially restricted and often species specific. Subsection 3.2.2 of LGL (2003) and Subsection 5.5.1.1 of LGL (2006b) include more general information on benthos in the vicinity of the Study Area. Deepwater corals and sponges have gained more focus in recent years. Some information on corals and sponges occurring within the Study Area is presented in the following subsection.

4.2.3.1 Deepwater Corals and Sponges

A variety of coral groups occur in Newfoundland and Labrador waters and include scleractinians (solitary stony corals), antipatharians (black wire corals), alcyonaceans (large and small gorgonians, and soft corals), and pennatulaceans (sea pens) (Wareham and Edinger 2007; Wareham 2009). Corals are largely distributed along the edge of the continental shelf and slope off Newfoundland and Labrador (Edinger et al. 2007; Wareham and Edinger 2007). Typically, they are found in canyons and along the edges of channels (Breeze et al. 1997), deeper than 200 m. Soft corals are distributed in both shallow and deep waters, while horny and stony corals (hard corals) are typically restricted to deep water areas. 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). In total, 30 species of corals have been documented for offshore Newfoundland and Labrador and include two antipatharians (black wire corals), 13 alcyonaceans (large gorgonians, small gorgonians, and soft corals), four scleractinians (solitary stony corals), and 11 pennatulaceans (sea pens).

Several recently published reports present knowledge on the ecology of deep cold-water corals of Newfoundland and Labrador waters, including information on biogeography, life history, biochemistry, and relation to fish (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). A DFO Science Advisory Report (DFO 2010a) also discusses the occurrence and ecological function of corals in Canadian waters.

According to distribution maps provided by Wareham (2009), there are ~22 species of corals occurring within the Study Area. The species identified include antipatharians (*Stauropathes arctica* and *Bathypathes* spp.), large gorgonians (*Keratoisis ornata*, *Paragorgia arborea*, and *Paramuricea* spp.), small gorgonians (*Acanella arbuscula*, *Acanthogorgia armata*, *Anthothela grandiflora*, and *Radicipes gracilis*), and soft corals (*Anthomastus grandiflorus*, *Duva florida*, *Gersemia rubiformis*, and *Nephtheid spp.*). One scleractinian species (*Flabellum alabastrum*) and eight pennatulacean species (*Anthoptilum grandiflorum*, *Distichoptilum gracile*, *Halipteris finmarchica*, *Pennatula grandis*, *Pennatula phosphorea*, *Umbellula lindahli*, *Funiculinia quadrangularis*, and *Pennatulacea* sp.) are also noted to occur there. According to Murillo et al. (2011), antipatharian species (*Leiopathes* sp.), one scleractinian species (*Desmophyllum dianthus*), and one pennatulacean species (*Pennatula aculeata*) also occur in the Flemish Pass region of the Study Area. The majority of coral species were observed to occur both on the continental slope and within Flemish Pass, with the exception of several soft corals (e.g., *Gersemia rubiformis* and *Duva florida*) found on the shelf of Jeanne d'Arc Basin. Based on DFO Research Vessel (RV) survey data collected in the Study Area from 2007 to 2011, most of the corals were caught at mean water depths of ~300 and ~675 m in the spring and fall surveys, respectively.

The patterns of association between deep-sea corals, fish, and invertebrate species, based on DFO scientific surveys and remotely operated vehicle (ROV) surveys are discussed by Edinger et al. (2009). Although there were no dramatic relationships between corals and abundance of the 10 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*), lantern fish (*Benthosema glaciale*) and greater eelpout (*Lycodes esmarkii*) in the Laurentian Channel and southern Grand Banks. This suggests that habitats supporting 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 fish. 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 exert 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 (DFO 2010a). Kenchington et al. (2013) noted the association of several demersal fish taxa with *Geodia*-dominated sponge grounds on the Grand Banks and Flemish Cap, although the precise nature of this association is unknown. According to the DFO RV survey data collected in the Study Area from

2007 to 2011, most of the sponges were collected in approximately 340 and 500 m depth in spring and fall, respectively.

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

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

In 2008 and 2009, the North Atlantic Fisheries Organization (NAFO) Scientific Council identified areas of significant coral and sponge concentrations within the NAFO Regulatory Area. NAFO Coral/Sponge Closure Area Five was updated in 2012. These areas that have been deemed closed to fishing with bottom gear are shown in Figure 4.36 in Section 4.7 (see also Potentially Sensitive Areas in DFO 2010a).

4.2.4 Fishes

For the purposes of this EA, the fishery VEC includes commercial fishery-targeted macroinvertebrate and fish species, incidental commercial fishery bycatch species, and macroinvertebrates and fish captured during DFO RV surveys in the Study Area.

4.2.4.1 Macroinvertebrates and Fishes Primarily Targeted in Commercial Fisheries

Two macroinvertebrate species, northern shrimp and snow crab, dominated the domestic harvest catch weight within the Study Area during 2005 to 2010. Percentage of average annual catch weights for northern shrimp and snow crab were ~66% and ~19%, respectively, followed by Greenland halibut (~5%), cockles (~4%), and yellowtail flounder (~3%) (see Table 4.1 in Section 4.2.4.3). Northern shrimp was harvested during every month between May and November, with peak harvesting in July and August. More than 99% of the snow crab catches occurred during the May to July period. Greenland halibut was also harvested during every month between May and November, with peak harvesting occurring in June and July. Cockles were harvested in each of the seven months being considered, with peak catches in October and November. In terms of catch value, northern shrimp and snow crab accounted for ~86% of the total catch value, followed by Greenland halibut (~7%) and cockles (~3%). Three other species, accounted for at least 1% of the total catch weights in each of the Study Area and the proposed 2014 Survey Block between May and November, 2005-2010. These species are also profiled below, with major commercial species presented first.

Northern Shrimp

The primary cold-water shrimp resource in the North Atlantic, the northern shrimp *(Pandalus borealis)* is distributed from Davis Strait to the Gulf of Maine. It typically occupies soft muddy substrates from depths of 150 to 600 m, in temperatures of 1°C to 6°C (DFO 2013a). Large individuals generally occur in deeper waters than small ones (DFO 2006). A diel vertical migration is undertaken with shrimp feeding on various prey, such as annelids, small crustaceans, and detritus, during the day and then migrating up the water column at night to feed on pelagic copepods and krill (DFO 2006). After insemination, gravid female shrimp may migrate to shallower areas where the water temperatures are most appropriate for embryonic development and subsequent larval hatch.

Northern shrimp are protandric hermaphrodites (Orr et al. 2009). They first mature as males, mate as males for one to several years, and then change to females for the remainder of their lives (DFO 2013a). Eggs are typically extruded in the summer and remain attached to the female until the following spring, when the female migrates to shallow coastal waters to spawn (Nicolajsen 1994 *in* Ollerhead et al. 2004). The hatched larvae float to the surface and commence feeding on planktonic organisms (DFO 2006). Northern shrimp are known to live for more than eight years in some areas and are large enough for recruitment to the fishery as early as three years of age (DFO 2013a).

As with most crustaceans, northern shrimp grow by moulting their shells. During this period, the new shell is soft, causing them to be highly vulnerable to predators, such as Greenland halibut, Atlantic cod, skates, wolffish, snow crab, and harp seals (DFO 2013a).

Georeferenced commercial catch location data for 2005–2010 and commercial catch data for 2011-2012 indicate that most northern shrimp catches within the Study Area occurred on the northeastern Newfoundland slope in areas with water depths between 200 and 500 m. Scattered shrimp catches were also reported on the slopes of the Jeanne d'Arc Basin and Flemish Pass. Based on DFO RV survey data collected in the Study Area from 2007 to 2011, the greatest proportion of northern shrimp was caught between the 200 and 500 m isobaths on the northeastern slope of Jeanne d'Arc Basin in the south-central portion of the Study Area. A smaller proportion of northern shrimp was caught in the northwestern portion of the Study Area.

Snow Crab

The snow crab *(Chionoecetes opilio)*, a decapod crustacean, occurs over a broad depth range in the Northwest Atlantic from Greenland to the Gulf of Maine (DFO 2013b). Snow crab distribution is widespread and continuous in waters off Newfoundland and southern Labrador. Large males are most common on mud or mud/sand, while smaller crabs are common on harder substrates.

After spring hatching, snow crab undergo a multi-stage life cycle featuring a 12 to 15 week planktonic larval period, before settlement. Benthic juveniles of both sexes moult frequently and at ~40 mm carapace width (~4 years of age) they become sexually mature. Female crabs carry the fertilized eggs for about two years (DFO 2013b).

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

Georeferenced commercial catch location data for 2005–2010 and commercial catch data for 2011-2012 indicate a wider distribution of catch locations for snow crab than for northern shrimp. Most snow crab catches were made between the 100 and 200 m isobaths of the Jeanne d'Arc Basin located in the western, central, and south-central portions of the Study Area. Scattered harvest locations were also reported for the shallower regions of the Jeanne d'Arc Basin and on the Flemish Pass in the western and central portions of the Study Area, respectively. Based on DFO RV survey data collected in the Study Area from 2007 to 2011, the greatest proportion of snow crab were caught between the 100 and 500 m isobaths on the northeastern slope of Jeanne d'Arc Basin.

Greenland Halibut

The Greenland halibut *(Reinhardtius hippoglossoides)* is distributed throughout cold, deep waters of the Labrador-eastern Newfoundland area, inhabiting the continental shelf and slope at depths of 200 to 2,200 m (Morgan et al 2013). The majority of the adult population is distributed in the deep and warm North Atlantic waters (e.g., Davis Strait, between Greenland and Baffin Island) where spawning occurs in winter or early spring (Templeman 1973; Bowering 1983; Bowering and Brodie 1995; Bowering and Nedreaas 2000). Larvae and juveniles are transported south by oceanic currents where they colonize the deep channels (Bowering 1983; Bowering and Brodie 1995). Greenland halibut are highly mobile and capable of travelling long distances (Boje 2002), and they typically move progressively offshore to the deep edges of the continental slope with increasing age and size (Bowering and Brodie 1995; Bowering and Nedreaas 2000). With increasing maturity, most Greenland halibut presumably migrate northward to areas such as Davis Strait to spawn (Templeman 1973; Chumakov 1975; Bowering and Brodie 1995). Movements and changes in distribution of Greenland halibut may also be due to fluctuations in oceanic temperatures (Morgan et al 2013). Small scale localized spawning may also occur along the deep slopes of the continental shelf throughout its range (Bowering and Brodie 1995).

In addition to shrimp, Greenland halibut feed on a variety of species, including small pelagic crustaceans, small fish (e.g., Arctic cod, capelin), larger fish (e.g., redfish, grenadier), and squid (DFO 2008a).

Georeferenced commercial catch location data for 2005–2010 and commercial catch data for 2011-2012 indicate Greenland halibut catch locations predominantly in the central-west and northwestern portions of the Study Area, in water depths ranging between 200 and 1,500 m. Based on DFO RV survey data collected in the Study Area from 2007 to 2011, the greatest proportion of Greenland halibut was caught on the northeastern Newfoundland slope and the northeastern slope of Jeanne d'Arc Basin between the 200 and 1,000 m isobaths.

Cockles

This bottom-dwelling bivalve occurs submerged just under the sediment surface in a variety of substrate types, ranging from soft mud to stony gravel (Franklin 1972). A non-selective filter-feeder, the cockle slightly projects two fleshy siphons through the sediment surface into the water, and directs a continuous flow of water through its body for respiration and feeding (Franklin 1972). Cockles fall prey to a variety of predators, such as various fish (including flounders and plaice), crabs, starfish, and even seabirds in shallower waters (Franklin 1972).

Cockles generally spawn in the spring, but spawning may extend into summer and fall (Franklin 1972). Eggs and sperm are shed freely into the water, and larvae are thought to remain planktonic for approximately three weeks before they settle on the sea bed.

Several species of cockle are known to occur in Northwest Atlantic waters. Of these, the Greenland cockle (*Serripes groenlandicus*) occurs in and around the Study Area and is a common bycatch species in the Stimpson's surf clam (*Mactromeris polynyma*) commercial fishery (DFO 2011a). As such, it is likely the cockle species in the georeferenced and ranged DFO commercial catch location data for the Study Area.

The Greenland cockle is widely distributed throughout the Arctic Ocean and southward in varying degrees (Golikov and Scarlato 1973 *in* Christian et al. 2010). In the Northwest Atlantic Ocean, this bivalve is found from Greenland to Cape Cod at subtidal depths >9 m. Barrie (1979 *in* Christian et al. 2010) found this cockle species on sandy substrates within a depth range of 6 to 18 m at various Labrador locations. It is ~100 mm in diameter at full growth (Gosner 1979 *in* Christian et al. 2010). The life history of the Greenland Cockle is poorly understood.

The Greenland cockle displays intense escape behaviour towards the sea stars, *Leptasterias polaris* and *Asterias rubens,* two of its primary predators (Legault and Himmelman 1993 *in* Christian et al. 2010). Other predators of the Greenland cockle include demersal fish (e.g., cod, haddock; Dolgov and Yaragina 1990 *in* Christian et al. 2010) and marine mammals (Fisher and Stewart 1997 and Born et al. 2003 *in* Christian et al. 2010).

Georeferenced commercial catch location data for 2005–2010 and commercial catch data for 2011-2012 indicate that most cockle catches occurred in the southwestern portion of the Study Area at locations with water depths <100 m.

Yellowtail Flounder

Yellowtail flounder *(Limanda ferruginea)* inhabit the continental shelf of the Northwest Atlantic from Labrador to Chesapeake Bay at depths ranging from 37 to 91 m (DFO 2013e) in water temperatures exceeding 2ºC (LGL 2006b). The northern limit of commercial concentrations reaches extend to the Grand Banks off the east coast of Newfoundland. Yellowtail spawning on the Grand Banks generally occurs between May and September with peaks during the latter part of June. The eggs, larvae and early juvenile stages of yellowtail are pelagic. Growth rates of flounder are slower in the northern range

(Grand Banks and Gulf of St. Lawrence) in comparison to the southern range (Georges Bank) and consequently sexual maturation is slower, with maturity occurring by age 4 to 6 in the northern range and age 2 to 3 in the southern range (DFO 2013e).

Juvenile and adult yellowtail are generally concentrated on the southern Grand Banks, on or near the Southeast Shoal where the substrate consists primarily of sand (Unit Area 3Nc, primarily) (Walsh et al. 2001 *in* LGL 2006b). Because of its small mouth size, yellowtail flounder is restricted in its choice of prey. The most common prey of yellowtail flounder include polychaetes, amphipods, shrimp, crustaceans, mollusks, isopods, and small fish. The most common predators of yellowtail flounder include cod and spiny dogfish; however, they are also preyed upon by skates, monkfish, bluefish, Atlantic halibut, American fourspot flounder, and seals (DFO 2013e).

Georeferenced commercial catch location data for 2005–2010 and commercial catch data for 2011-2012 indicate that most yellowtail flounder catches occurred in the southwest corner of the Study Area. Based on DFO RV survey data collected in the Study Area from 2007 to 2011, all yellowtail flounder catches occurred in the southwestern portion of the Study Area.

Stimpson's Surf Clam

This bivalve mollusc is a circumboreal species, inhabiting both the Atlantic and Pacific Oceans. It is the largest clam in the Northwestern Atlantic and occurs from Labrador to Rhode Island, often on medium to coarse sand substrate (Abbott 1974 *in* Christian et al. 2010). In the Canadian part of its range, this species occurs in commercial quantities in the offshore areas of the Scotian Shelf and Eastern Grand Banks, and inshore areas off southwest Nova Scotia and in the Gulf of St. Lawrence (DFO 1989a, 1999, 2004a *in* Christian et al. 2010). The Stimpson's surf clam (*Mactromeris polynyma)* appears to prefer medium to coarse sand substrate in which it burrows (DFO 2009 *in* Christian et al. 2010).

Surf clam spawning in offshore areas typically occurs during the fall (DFO 2009 *in* Christian et al. 2010). Davis and Shumway (1996 *in* Christian et al. 2010) report that larval hatch occurs within days of spawning, and that larvae remain planktonic for one to two months before settlement to the bottom substrate. Stimpson's surf clams are filter feeders with a microalgal diet (e.g., dinoflagellates; Smith and Wikfors 1992 *in* Christian et al. 2010). Predators of the surf clam include sea stars, whelk, crabs, and large groundfish (Himmelman and Hamel 1993; Rochette et al.1995; Morissette and Himmelman 2000 *in* Christian et al. 2010).

Georeferenced commercial catch location data for 2005–2010 and commercial catch data for 2011-2012 indicate that Stimpson's surf clams were caught in the southwestern portion of the Study Area, at locations with water depths <100 m.

Atlantic Herring

Atlantic herring (*Clupea harengus*) occur on both sides of the North Atlantic, ranging from western Greenland to Cape Hatteras in the Northwest Atlantic (Scott and Scott 1988). Typically a pelagic species, Atlantic herring generally inhabit relatively shallow waters, in depths <200 m. Immature fish and/or mature fish prior to spawning may form particularly large schools (Scott and Scott 1988). Atlantic herring stocks have been shown to undertake extensive annual migrations between spawning grounds, overwintering areas, and feeding areas (Scott and Scott 1988).

Spawning time and location varies with each herring stock. In Canadian waters, Atlantic herring spawning can occur between April and November, with the offshore stocks typically spawning in the fall (Scott and Scott 1988). Atlantic herring eggs remain on the seabed until the time of hatching. Upon hatching, the larvae are slender and light-sensitive and tend to seek deeper water on bright days (Graham and Sampson 1982 *in* Scott and Scott 1988). Egg and larval mortality is high, with relatively few fertilized eggs surviving to adult age (Scott and Scott 1988).

Atlantic herring are visual feeders (Blaxter 1966 *in* Scott and Scott 1988) and consume a variety of small organisms, including phytoplankton (the primary diet of young herring), euphausiids, copepods, fish eggs, pteropods, mollusc larvae, and the larvae of small fishes. Atlantic herring off Newfoundland have been known to eat very little during the winter months, instead surviving on accumulated fat (Hodder 1972 *in* Scott and Scott 1988). Atlantic herring make up the basic food source for numerous organisms, including many fish, marine bird, and marine mammal species.

Georeferenced commercial catch location data for 2005–2010 and commercial catch data for 2011-2012 indicate a few Atlantic herring catch locations in the northwestern portion of the Study Area, primarily in water depths <500 m. Based on DFO RV survey data collected in the Study Area from 2007 to 2011, most of the Atlantic herring were caught at a mean water depth of ~245 m during spring and fall surveys.

Mackerel

Mackerel (*Scomber scombrus*) is a fast swimming, pelagic, schooling species (NOAA 1999) distributed in both Northeast and Northwest Atlantic waters (DFO 2009b). In the Northwest Atlantic, it ranges from Newfoundland to North Carolina, occurring in coastal waters in spring and summer and deeper waters along the continental shelf edge in fall and winter (DFO 2009b). Mackerel is unique among most other pelagic species, such as capelin, in that it does not possess a swim bladder and must swim continuously or it will sink (DFO 2013d). Mackerel prefer water temperatures between 7 and 15ºC, and in the past several years a trend of migration to northerly regions has been observed in response to increased water temperature from climate change, with some mackerel ranging as far as the vicinity of the Arctic Circle at depths of around 20 m (DFO 2013d).

Most mackerel reach sexual maturity by two years of age (Sette 1943), with each female able to spawn repeatedly via batch spawning (Sette 1943; DFO 2009b). In Canadian waters, spawning occurs near the surface, day or night, primarily between June and July in the southern Gulf of St. Lawrence when sea surface temperatures reach 7 to 9ºC and peaks between 10 to 13ºC (Ware and Lambert 1985; DFO 2009b). Eggs, larvae, and juveniles are pelagic, ranging from near surface to 15 to 25 m depth (Sette 1943). Mackerel is an opportunistic feeder, preying on zooplankton (e.g., copepods, euphausiids, amphipods, and chaetognaths), crustaceans (including northern shrimp), molluscs, and fish (including capelin, yellowtail flounder, and other mackerel) (NOAA 1999; DFO 2009b). Mackerel, a muscular and fatty fish, falls prey to numerous cetaceans, pelagic and demersal fish, seals, and seabirds (Savenkoff et al. 2005; DFO 2009b).

Mackerel has traditionally been used as bait in lobster and crab traps, but has become popular commercially within the past several years due to the decline in traditionally harvested groundfish species (DFO 2013d). However, there are concerns regarding management of the mackerel fishery, owing to unreported catch (bait or recreational fishing), and to potentially unreliable biomass estimates from traditional egg surveys due to the climate-induced migrational trends seen in recent years (DFO 2009b, 2013d). As such, the fishery is being managed cautiously by DFO, with freezes in place for new mobile gear as of 2007, and the potential implementation of marine recreational fishing licences (DFO 2009b).

Georeferenced commercial catch location data for 2005–2010 indicate a few mackerel catches in the northwestern portion of the Study Area. No mackerel catches were reported in the commercial catch data for 2011-2012.

4.2.4.2 Other Fishes Caught in the Commercial Fishery

Other species that have been caught during commercial fisheries being prosecuted within the Study Area during recent years include the following:

- Redfish;
- Atlantic cod;
- American plaice;
- Thorny skate;
- Roughhead grenadier;
- Capelin;
- Blue hake;
- Witch flounder; and
- Wolffishes.

More fishery-related details for these species are included in Section 4.3 of this EA. These species are briefly profiled in this subsection.

<u>Redfish</u>

The Northwest Atlantic redfish consists of a complex of three species identified as Acadian redfish (*Sebastes fasciatus*), golden redfish (*S. marinus*), and deepwater redfish (*S. mentella*) (DFO 2008b). The deepwater redfish is the dominant species in northern areas, including the Study Area. The redfish distribution in the Northwest Atlantic ranges from the Gulf of Maine, northwards off Nova Scotia and southern Newfoundland banks, in the Gulf of St. Lawrence, and along the continental slope and deep channels from the southwestern Grand Banks to areas as far north as Baffin Island. Redfish are also present in the area of Flemish Cap and west of Greenland.

These species inhabit cool waters (3 to 8°C) along the slopes of banks and deep channels in depths of 100 to 700 m (Scott and Scott 1988; DFO 2010b). Redfish are generally slow growing and long lived fishes (DFO 2010b).

The reproductive cycle of redfish differs from that of other fish species. Unlike many other species, fertilization in redfish is internal and females bear live young. Mating takes place in the fall most likely between September and December, and females carry the developing embryos until they are extruded as free swimming larvae in spring. Larval extrusion takes place from April to July depending on the areas and species. Mating and larval extrusion do not necessarily occur in the same locations.

Generally found near the bottom, redfish have been observed to undertake diel vertical migrations, moving off the bottom at night to follow the migration of their prey (DFO 2010b). Redfish are pelagic or bathypelagic feeders, feeding primarily on zooplankton such as copepods, amphipods, and euphausiids. Fishes and crustaceans become more important in the diet of larger redfish (Scott and Scott 1988).

Based on DFO RV survey data collected in the Study Area from 2007 to 2011, most of the redfish caught were deepwater redfish. The highest catches of deepwater redfish occurred at a mean water depth of 400 m during both spring and fall surveys. In terms of total catch weight, the greatest proportion of deepwater redfish was caught between the 200 and 500 m isobaths in the northwestern, central, and south-central portions of the Study Area.

Deepwater redfish and the Atlantic population of Acadian redfish are currently designated as *threatened* under COSEWIC.

Atlantic Cod

The Atlantic cod *(Gadus morhua)* is a demersal fish that inhabits cold (10 to 15°C) and very cold (<0 to 5°C) waters in coastal areas and in offshore waters overlying the continental shelf throughout the Northwest and Northeast Atlantic Ocean (COSEWIC 2010a). The species is found contiguously along the east coast of Canada from Baffin Island to Georges Bank. Outside Canadian waters in the Northwest Atlantic, cod can be found on the northeast and southeast tips of the Grand Banks and on the Flemish Cap. During the first few weeks of life, cod eggs and larvae are found in the upper 50 m of the water column. As juveniles, cod are settled on the bottom and tend to occur in nearshore habitats with vertical structure such as eelgrass (*Zostera marina*) and macroalgae. As adults, the habitat requirements of cod are increasingly diverse.

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

Dispersal in Atlantic cod appears to be limited to the egg and larval phases of life, during which surface and near-surface water currents and turbulence are the primary determinants of horizontal and vertical displacement in the water column (COSEWIC 2010a). For some cod populations, eggs and larvae are capable of dispersing over very long distances. For example, cod eggs spawned off southeastern Labrador (NAFO Division 2J) may possibly disperse as far south as the Grand Banks (Helbig et al. 1992; Pepin and Helbig 1997). By contrast, eggs spawned by cod in inshore, coastal waters, especially at the heads of large bays, may experience dispersal distances of a few kilometres or less (Bradbury et al. 2000, 2002, 2008).

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

Two stocks of Atlantic cod occur within the Study Area: 2J3KL cod that occur off Labrador and eastern Newfoundland, and 3M cod that occur in the vicinity of the Flemish Cap and Flemish Pass. Recent DFO fall sampling of the 2J3KL stock indicates that length-at-age and weight-at-age have improved since the low values of the early 1990s, particularly in NAFO Divisions 3K and 3L (DFO 2013f). The condition of cod in 3K and 3L has also improved from that seen in the early 1980s, although it did decline between 2008 and 2009 (DFO 2013f). The NAFO Division 3M cod stock was on fishing moratorium from 1999 to 2009. Recent assessment results indicate a substantial increase in Spawning Stock Biomass, which should continue only if current post-moratorium fishing level is maintained (Gonzàlez-Troncoso et al. 2013).

Based on DFO RV survey data collected in the Study Area from 2007 to 2011, the greatest proportion of Atlantic cod was caught between the 200 and 500 m isobaths in the northwestern and south-central portions of the Study Area.

Atlantic cod as a species is currently designated as *special concern* under Schedule 3 of the *SARA*. The Newfoundland and Labrador population of Atlantic cod is currently designated as *endangered* under COSEWIC.

American Plaice

American plaice (*Hippoglossoides platessoides)* is a bottom-dwelling flatfish that resides on both sides of the Atlantic (COSEWIC 2009; DFO 2011b). American plaice that reside in the West Atlantic region range from the deep waters off Baffin Bay and Davis Strait, south to Labrador, the Grand Banks, and the Flemish Cap, and southwards to the Gulf of Maine and Rhode Island (DFO 2011b). In Newfoundland waters, American plaice occur both inshore and offshore over a wide variety of bottom types (Morgan

2000) but seem to prefer fine sand and gravel substrates (DFO 2011b). Adult and juvenile plaice typically inhabit the same areas over depths ranging from 20 to 700 m, but prefer depths from 100 to 300 m (DFO 2011b). It is tolerant of a wide range of salinities and has been observed in estuaries (Scott and Scott 1988; Jury et al. 1994). It is a cold water species, preferring water temperatures of -1.5°C to 13°C, but is most abundant at temperatures ranging from just below zero to -1.5°C (DFO 2011b). Tagging studies in Newfoundland waters suggest that, once settled, juveniles and adults are rather sedentary and do not undertake large scale migrations (DFO 2008c). However, older plaice have been known to move up to 160 km (Powles 1965). Migrations have been observed in Canadian waters to deeper offshore waters in the winter, returning to shallower water in the spring (Hebert and Wearing-Wilde 2002 *in* Johnson 2004).

In Newfoundland waters, American plaice spawn during the spring (Scott and Scott 1988). Within the Study Area, there are limited data with respect to the actual spawning times. American plaice in the Newfoundland Region have no specific spawning areas; rather spawning occurs over the entire area occupied (DFO 2008c) with the most intense spawning coincident with areas where the higher abundance of adults are found (Busby et al. 2007; DFO 2011b). American plaice are group synchronous, batch spawners that generally release and fertilize large quantities of eggs on the seabed over a period of days (Johnson 2004; DFO 2011b). Eggs are buoyant and drift into the upper water column where they are widely dispersed, allowing for some intermingling of stocks. Intermingling of adults is minimal. Hatching time is temperature dependent, occurring in 11 to 14 days at temperatures of 5°C (Scott and Scott 1988). Larvae are 4 to 6 mm in length when they hatch; they begin to settle to the seabed when they reach 18 to 34 mm in length and their body flattens (Fahay 1983).

Based on DFO RV survey data collected in the Study Area from 2007 to 2011, the greatest proportion of American plaice were caught at ~500 m depth in the central, south-central, and southwestern regions of the Study Area.

The Newfoundland and Labrador population of American plaice is currently designated as *threatened* under COSEWIC.

Skate

Skates are bottom-living fishes that can be found in temperate, arctic, or tropical waters worldwide (Scott and Scott 1988). At least 14 species have been found to occur in Canadian Atlantic waters (BIO and NAFC 2007), with thorny skates (*Amblyraja radiata*) and spinytail skates (*Raja spinicauda*) typically dominating those caught during research surveys in and around the Study Area (e.g., DFO 1998, 2009a; DFO RV survey data 2007–2011).

Skates lay eggs in rectangular, horny capsules known as 'sea- or mermaids' purses,' usually with one egg per capsule (Scott and Scott 1988). Eggs are presumed to be laid on the sea-bottom. Skates are carnivorous, generalists, and typically opportunistic feeders (BIO and NAFC 2007). They consume a wide variety of organisms, which may include crabs, shrimps, lobsters, amphipods, isopods, mysids, polychaetes, bivalve molluscs, small fish, and occasionally cephalopods (Scott and Scott 1988). Energy-rich skate eggs are preyed upon by gastropods and marine mammals such as seals and sea lions, while hatched skates are consumed by numerous predators including sharks, other skates and rays, and grey seals (BIO and NAFC 2007).

A common bycatch species in offshore trawler catches, skate was traditionally discarded and often not reported in catch statistics (Kulka and Miri 2007). However, with the decline in the groundfish resources in waters around Newfoundland, interest in skate began to increase in the early 1990s (Kulka and Miri 2003). Commercial catches of skates consist of several skate species; however, thorny skate dominates the catch composition. In Canadian commercial catches, about 95% of the skate catch is thorny skate (Kulka and Miri 2007; Kulka and Mowbray 1999 *in* Simpson and Miri 2012). Thus, the skate fishery on the Grand Banks can be considered a directed fishery for thorny skate, and this is likely the species in the georeferenced and ranged DFO commercial catch location data for the Study Area.

Thorny skate is a widely distributed species in temperate and arctic waters of the North Atlantic. In the western Atlantic, this skate is distributed from Greenland to South Carolina, with the center of distribution on the Grand Banks in NAFO Divisions 3LNO (Simpson and Miri 2012). Thorny skate occur on both hard and soft substrates (Kulka et al. 1996 *in* JW 2007), but are primarily associated with muddy, sandy and pebble substrates typical of Grand Banks sediment (Kulka and Miri 2003a *in* JW 2007).

The migration patterns of the thorny skate are not fully understood, but evidence suggests a seasonal migration between the continental shelf edge during December to June, and the top of the banks during the remainder of the year (Kulka and Mowbray 1998 *in* JW 2007). All available evidence suggests that thorny skates in Divisions 3LNOPs comprise a single population (Kulka and Miri 2007). Males mature at smaller sizes than females with size at maturity increasing from north to south. Ovaries of sexually mature females hold 10 to 12 pairs of eggs in various developmental stages (Kulka and Miri 2003a *in* JW 2007), and females deposit 6 to 40 egg cases per year (Templeman 1982, 1987). Larger thorny skate produce larger egg cases; it is not known if egg case size is related to survival rates (Kulka and Miri 2003a *in* JW 2007).

Based on DFO RV survey data collected in the Study Area from 2007 to 2011, most of the thorny skate catches occurred in the central, south-central, and southwestern regions, at mean water depths of ~300 m during both spring and fall surveys.

Roughhead Grenadier

The roughhead grenadier *(Macrourus berglax)* occurs in deep water along coasts in subarctic to temperate waters on both sides of the North Atlantic. In the Northwest Atlantic, this species of grenadier is abundant and widespread, and occurs from Davis Strait along the continental slope off Newfoundland, off Nova Scotia on Banquereau Bank, Sable Island, and Browns Bank, and on Georges Bank (Scott and Scott 1988). The roughhead grenadier is predominant at depths ranging from 800 to 1,500 m, although it may inhabit depths between 200 and 2,000 m (Murua and De Cardenas 2005 *in* González-Costas 2013) and has been found as deep as 2,700 m. Catches tend to be highest at water temperatures ranging between 2.0 and 3.5ºC (Scott and Scott 1988).

Spawning is thought to occur during the winter and early spring. Little is known about the spawning grounds of this fish off Newfoundland, although it is believed that some spawning occurs on the southern and southeastern slopes of the Grand Banks (Scott and Scott 1988; COSEWIC 2007). Food for the roughhead grenadier consists of a variety of benthic invertebrates including bivalve molluscs, shrimp, sea stars, polychaetes, and some fish. Roughhead grenadier has been found in the stomachs of Atlantic cod. This grenadier species is quickly becoming an important commercial fish in the Northwest Atlantic. The present roughhead grenadier fishery is unregulated since it is usually taken as bycatch in the Greenland halibut fishery (González-Costas 2012).

Based on DFO RV survey data collected in the Study Area from 2007 to 2011, the greatest proportion of roughhead grenadier was caught between the 500 and 2,000 m isobaths in the northwestern, central, and southwestern portions of the Study Area.

Roughhead grenadier is currently designated as *special concern* under COSEWIC.

Capelin

Capelin *(Mallotus villosus)* is a small pelagic species that has a circumpolar distribution in the northern hemisphere (DFO 2013c). Capelin are often found along the coasts during the spawning season and occur pre-dominantly in offshore waters (e.g., Grand Banks) while immature and maturing. Migration towards the coast precedes spawning on beaches or in deeper waters (Nakashima and Wheeler 2002; DFO 2013c). The preferred spawning substrate is usually fine to coarse gravels. Capelin beach spawning is more prevalent at night and typically occurs at a water temperature range of 5 to 8.5°C, but they have been observed to spawn at 4 to 10°C. On the bottom, spawning temperatures can be as low as 2°C as observed on the Southeast Shoal, located far south of the Study Area. Capelin are able to spawn at the age of two; males and most females usually die following spawning. Spawning commences in early June and may continue through July or August depending on tides, winds, and water temperatures (Scott and Scott 1988; Nakashima and Wheeler 2002; DFO 2013c). Incubation varies with ambient temperature and lasts ~15 days at 10°C (Scott and Scott 1988). Once hatched, larval capelin can be found at the surface to depths >40 m (Frank et al. 1993).

Capelin prey consists of planktonic organisms comprised primarily of euphausiids and copepods. Capelin feeding is seasonal with intense feeding in late winter and early spring leading up to the spawning cycle, when feeding ceases. Feeding recommences several weeks after cessation of spawning (Scott and Scott 1988).

Capelin are a major component in marine ecosystem dynamics as they are a key forage species that facilitate the transfer of energy between trophic levels, principally between primary and secondary producers to higher trophic levels (DFO 2013c). Capelin predators comprise most major fish species including Atlantic cod, haddock, herring, flatfish species, dogfish, and others. Several marine mammal species, including minke whales, fin whales, harp and ringed seals, as well as a variety of seabirds also prey on capelin.

Other than the fishery the primary cause of capelin mortality is predation, therefore variations in capelin abundances are directly linked to natural causes (DFO 2013c). Capelin have a short life span (usually five years or less), and abundances are linked to a few age classes. Management of capelin fisheries tends to be conservative as a result of the prominent role of capelin in the marine ecosystem.

Commercial fishery capelin catches during 2005–2010 were primarily concentrated in the west-central portion of the Study Area, at locations with water depths ranging from 200 to 500 m. A single capelin catch location was reported in the commercial catch data in July of 2011 at ~500 m depth. Based on DFO RV survey data collected in the Study Area from 2007 to 2011, most of the capelin was caught during springtime surveys at a mean water depth of 160 m. The fall survey mean catch depth was 200 m.

Blue Hake

Blue hake *(Antimora rostrata)* occur globally in all oceans and rank among the most commonly encountered of marine fish. Blue hake have been reported in varying concentrations in the Atlantic and Pacific Oceans, distributed mainly on continental slopes at depths of 400 to 3,000 m. In the Northwest Atlantic, blue hake generally inhabit the southern slope of Georges Bank and from the Scotian shelf north to the Labrador Shelf, and have been reported as far south as the Bahamas, off the Carolinas and Cape Hatteras (Kulka et al. 2003). From the Scotian Shelf to the continental slope south of David Strait, blue hake were found primarily below 500 m and their abundance peaked at or near the maximum sampling depth of 1,700 m. Smaller, and presumably younger, fish occurred at shallower depths (Kulka et al. 2003). Relatively little is known about the early life history and life cycle of blue hake, but they are presumed to migrate into deeper waters to spawn (DFO 2011c). Studies in both US and Canadian waters found no evidence of spawning; no eggs, larvae, or spawning fish were found. Given that the size of blue hake has been observed to increase with depth, it seems likely that spawning occurs beyond the depths sampled (Wenner and Musiak 1977; Kulka at al. 2003). Blue hake is not particularly attractive as a commercial fish (DFO 2011c).

Based on DFO RV survey data collected in the Study Area from 2007 to 2011, most of the blue hake were caught in the northeastern portion of the Study Area, during the fall at a mean water depth of 900 m. The mean catch depth during the spring surveys was 600 m.

Witch Flounder

Witch flounder *(Glyptocephalus cynoglossus)* range from the Hamilton Inlet Bank to North Carolina in the Northwest Atlantic (DFO 2013h). They preferentially inhabit deep holes and channels located between and along coastal banks (DFO 2013h), and gullies with clay, muddy sand or pure mud bottoms, and usually move from shallower, soft mud bottoms in the summer to deeper gullies in the winter, with bottom temperatures ranging from -1 to +11ºC (DFO 2013h). Evidence suggests that witch flounder are most abundant within a bottom temperature range of 2 to 6ºC. A deepwater species, witch flounder is most abundant at depths of 185 to 400 m, although some have been caught at depths >1,500 m (DFO 2013h). Witch flounder do not appear to undertake long distance migrations and are considered more or less sedentary, concentrating in areas favourable for spawning and moving in surrounding areas to feed (DFO 2013h).

Witch flounder form dense pre-spawning concentrations between winter and spring, and spawning occurs in shallow water and on the slopes of the Grand Banks area, in late spring to late summer or early fall (DFO 2013h). Eggs and larvae of witch flounder are pelagic, while juveniles can be either pelagic or deepwater fishes.

Witch flounder have a very small mouth, and their diet consists mainly of polychaetes, small crustaceans, and shellfish (DFO 2013h). Although a considerable portion of witch flounder catch occurs as bycatch of other fisheries, it has been a component of the Canadian Atlantic groundfisheries since the early 1940s (DFO 2013h).

There were few georeferenced commercial catch location data for witch flounder in the Study Area during 2005–2010. These were located in the west-central portion of the Study Area in water depths ~500 m. Based on DFO RV survey data collected in the Study Area from 2007 to 2011, most witch flounder were caught at mean water depths of 400 and 500 m during spring and fall surveys, respectively.

Spotted and Northern Wolffish

Spotted and northern wolffishes (*Anarhichas minor* and *A. denticulatus)* are profiled in Section 4.6 on Species at Risk. During DFO RV surveys conducted in the Study Area during 2007–2011, 430 spotted and 575 northern wolffish were caught during both spring and fall survey times. In terms of total catch weight, the greatest proportion of catches of these wolffish species in the Study Area occurred between the 100 and 500 m isobaths of the west- and south-central portions of the Study area. Catches also occurred along the northeastern Newfoundland slope in the northwestern portion of the Study Area.

Atlantic Wolffish

In Canadian waters, Atlantic wolfish *(A. lupus)* are distributed from the Canadian portion of the Gulf of Maine to offshore of Baffin Island, including the Bay of Fundy, Scotian Shelf, Grand Banks off Newfoundland, Gulf of St. Lawrence, northeastern Newfoundland and the Labrador Sea. Atlantic wolfish are most abundant off northeastern Newfoundland, on the Labrador Shelf, and in the southern Grand Banks (COSEWIC 2012a). Atlantic wolffish are primarily demersal and inhabit shallower areas than the northern and spotted wolffishes. This species has been observed from near shore to a depth of 918 m at water temperatures ranging from -1 to 10°C, but are most common at water depths of 150 to 350 m with water temperatures ranging from 1.5 to 4°C (Kulka et al. 2008). Unlike the northern and spotted wolffishes, Atlantic wolffish are often observed by divers close to shore, and they form dense concentrations offshore. During its feeding period, this wolffish species appears to prefer complex reliefs of rocks without algal growth and sand. Shelters in these rock reliefs are typically situated on 15-30° slopes with good water circulation. There is some indication that Atlantic wolffish form colonial settlements during the feeding period (Kulka et al. 2008).

Prey of Atlantic wolffish are primarily benthic invertebrates (>85%), typically including echinoderms (e.g., sea urchins), crustaceans (e.g., crabs), and molluscs (e.g., scallops) associated with both sandy and hard bottom substrates. Fish also constitutes part (<15%) of the Atlantic wolffish diet (e.g., redfish)

(Kulka et al. 2008; COSEWIC 2012a). Little is known of the predators of wolfish; however, juveniles have been found in the stomach contents of a variety of seal species, as well as Atlantic cod, Atlantic halibut, sea raven, spiny dogfish, longhorn sculpin, white hake, and haddock (COSEWIC 2012a). Migration by Atlantic wolffish is limited, with seasonal inshore movement in the spring when mature fish are found in areas with water depths <15 m. These wolffish seem to prefer stony bottom substrate for spawning in September and October in Newfoundland and Labrador waters. After internal fertilization, cohesive masses of eggs are deposited in crevices on the bottom, remaining unattached to the substrate. The egg mass is guarded and maintained by the male Atlantic wolffish for the 7 to 9 month incubation time, after which pelagic larvae hatch and commence to feed on crustaceans, fish larvae, and fish eggs within a few days of hatching (Kulka et al. 2008).

During DFO RV surveys conducted in the Study Area during 2007–2011, 2,788 Atlantic wolffish were caught, during both spring and fall survey times. Atlantic wolffish catches were most concentrated in the west- and south-central portions of the Study Area between the 200 and 500 m isobaths.

Atlantic wolffish is currently designated as *special concern* under Schedule 1 of the *SARA* and COSEWIC.

4.2.4.3 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 Macroinvertebrate and Fish Species Likely to Reproduce within or Near Study Area.

Species	Location(s) of Reproductive Events	Timing of Reproductive Events	Duration of Planktonic Stages
Northern shrimp	On banks and in channels over the extent of its distribution	Spawning in late summer, early 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
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
Greenland cockle	Eastern Grand Banks	Uncertain	Uncertain

Species	Location(s) of Reproductive Events	Timing of Reproductive Events	Duration of Planktonic Stages
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
Wolffishes	Along bottom in deeper water, typically along continental slope	Summer to early winter (species dependent)	Uncertain
Cusk	Uncertain	May to August Eggs are buoyant	Presumed to be 4 to 16 weeks
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
Sand lance	On sand in shallow water of the Grand Banks	November to January	Several weeks

4.3 Fisheries

This section describes the commercial fisheries and DFO RV survey fisheries that occur within the Study Area for EMGS's proposed CSEM program. There are no aboriginal or recreational fisheries in the Study Area.

4.3.1 Information Sources

Most of the data used in the following sections to characterize the fisheries is expressed as catch weight. Catch weight is considered a more consistent attribute than value which varies with market conditions. Where relevant, catch values are also reported for certain scenarios.

4.3.1.1 Data Sets

Commercial fisheries within the Study Area are managed by either Canada (DFO) or the international North Atlantic Fisheries Organization (NAFO). Both the domestic commercial fisheries and DFO RV surveys analysed in this subsection are based on DFO Newfoundland and Labrador Region databases. NAFO catch weight data are used to describe both domestic and foreign fisheries beyond the 200 nmi EEZ. More than half of the proposed Study Area is located outside of the 200 nmi limit. The NAFO data are derived from the STATLANT 21A data set for 2005 to 2012. The STATLANT reporting system of questionnaires is a long-standing standardized statistical inquiry for submission of national catch data to international fisheries agencies by national reporting offices. Rather than being georeferenced, these STATLANT data are geographically resolved at the NAFO Division level only. Thus the following analysis quantifies harvesting for portions of NAFO Divisions 3K, 3L, 3M, and 3N (Figure 4.1)[1]. The proposed Study Area overlaps with either all or portions of 18 NAFO Unit Areas (UAs), mostly in Divisions 3K and 3L. The southern part of the Study Area overlaps portions of four UAs in Division 3N and the eastern part of the Study Area overlaps portions of three UAs in Division 3M. Note that the data acquisition area proposed for 2014 (i.e., 2014 Survey Block) overlaps with portions of UAs 3Kgk, 3Lei and 3Ma. The western extreme of the proposed 2014 Survey Block extends slightly into UA 3Ld.

The DFO commercial fishery landings data used in this EA (DFO 2005 to 2012) represent all catches landed within the Newfoundland and Labrador region (whether managed by NAFO or DFO, as described above). The 2005-2010 DFO catch data for the Study Area are georeferenced (typically >95% of the harvest, by quantity) so most harvesting locations can be plotted. The positions provided in the datasets are those recorded in the vessels' fishing logs, and are reported in the database by degree and minute of latitude and longitude. For some gear, such as mobile gear towed over an extensive area, or for extended gear, such as longlines, the reference point does not represent the full distribution of the gear or activity on the water.

However, over many data entries, the reported locations create a relatively accurate indication of where fishing activities occur. The DFO catch data for 2011 and 2012 are cumulative catch weight ranges (defined by quartile values) within 6 min x 6 min cells. Maps based on these 2011 and 2012 commercial fishery databases are included in this EA.

In order to provide a historical perspective of catches in the general area of the Study Area, DFO data for UAs 3Kbcfgk, 3Ldehirt, 3Mabc, and 3Nabcd between 1986 and 2010 were also analyzed.

[1] For an indication of location of effort by Convention nations see maps in NAFO Ad Hoc Working Group report, 2009 at http://archive.nafo.int/open/fc/2009/fcdoc09-02.pdf.

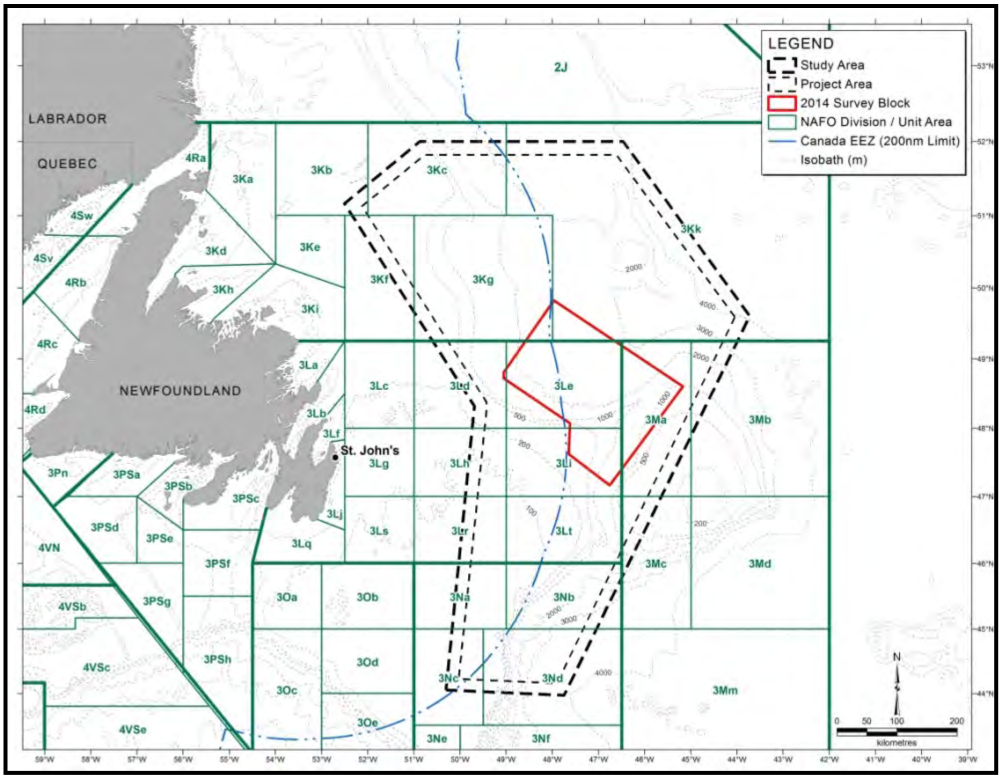


Figure 4.1 Locations of Study, Project and 2014 Survey Areas Relative to NAFO Unit Areas.

4.3.1.2 Consultations

A consultation meeting for EMGS's proposed 2014–2018 CSEM survey program was held with the FFAW and One Ocean on 14 January 2014. Fisheries-related information provided and any issues raised during the consultation process are reported in the discussions of the fisheries below. Details of the consultations are discussed in Section 5.1.1.

4.3.1.3 Other Sources

Other information sources used for this subsection include fisheries management plans, quota reports, and other DFO documents such as Science Advisory and Stock Status Reports.

4.3.2 Regional NAFO Fisheries

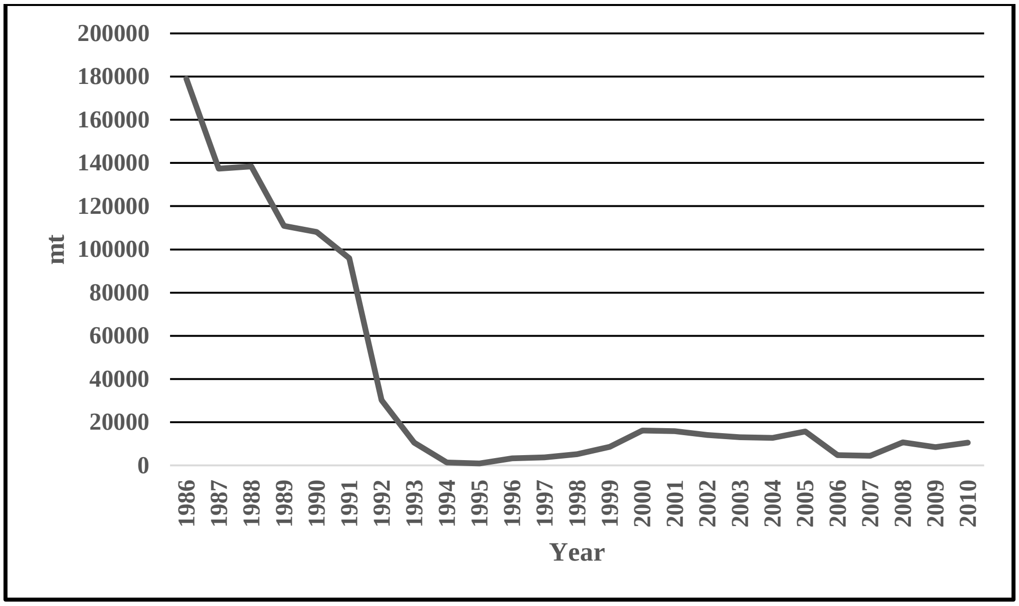
As noted above, more than half of the Study Area occurs outside of Canada's 200 nmi EEZ. The Study Area overlaps portions of NAFO Divisions 3K, 3L, 3M, and 3N (see Figure 4.1). NAFO manages 19 stocks comprised of 11 species: Atlantic cod (3L, 3M, 3NO stocks), redfish (3LN, 3M, 3O, Sub-area 2 and Div.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

During the 2005–2012 period, commercial harvesting beyond the 200 nmi EEZ, in terms of catch weight, was dominated by northern shrimp (35% of total catch weight) (primarily in NAFO Division 3K), snow crab (20%) (primarily in NAFO Division 3L), and capelin (12%) (primarily in NAFO Divisions 3L and 3K). Greenland halibut and Atlantic mackerel catches each accounted for 6% of the 2005–2012 commercial fishery catch weight outside of the EEZ (primarily in NAFO Divisions 3L and 3K, respectively). The highest catch weights during the eight-year period were taken in NAFO Divisions 3K (40%) and 3L (~38%), followed by 3M and 3N. Canadian vessels accounted for 77% of the commercial catch weight reported for this area during 2005–2012. Only in Division 3M did the foreign vessels dominate catches (>99% of total catch weight in this Division). Catches in 3M were dominated by northern shrimp, redfish, Atlantic cod, Greenland halibut, and blue shark. Percentage catches by weight in Division 3N were similar for Canadian and foreign vessels (~55 and 45%, respectively).

4.3.3 Domestic Fisheries

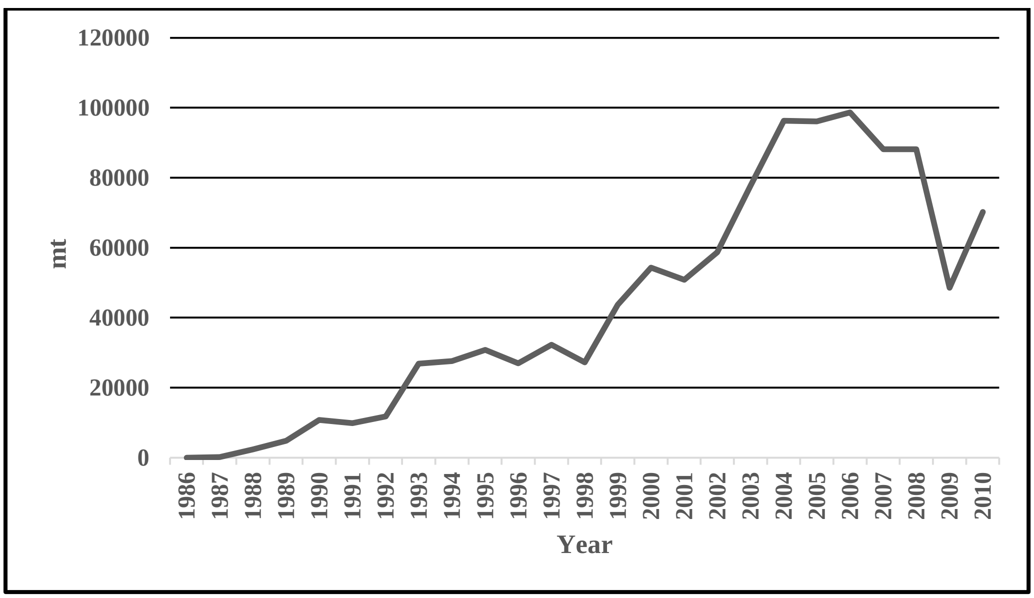
4.3.3.1 Historical (1986 to 2010) Catch Trends

From the late 1980s to the early 1990s, the Canadian fisheries in the northern Grand Banks area were dominated by groundfish harvesting using stern otter trawlers which primarily targeted Atlantic cod, American plaice, and a few other groundfish species. Landings of groundfish were quite high during this time. However, these record landings would not continue as groundfish stocks became severely depleted. With the acknowledgement of the collapse of several groundfish stocks in 1992, a harvesting moratorium was declared and directed fisheries for cod virtually vanished in this area. Since the collapse of these fisheries, formerly underutilized species, specifically snow crab and northern shrimp, replaced groundfish as the principal target species on the northern Grand Banks. Based on georeferenced DFO landings data, Figures 4.2 and 4.3 summarize the 1986-2010 catch weight data for the 18 UAs that overlap the Study Area. These figures illustrate the total groundfish harvest (Figure 4.2) and the total invertebrate harvest (Figure 4.3).



Source: DFO Newfoundland Commercial Fishery Landings Database, 1986-2010.

Figure 4.2 Annual Catch Weights of Groundfish within Study Area UAs, 1986-2010.



Source: DFO Newfoundland Commercial Fishery Landings Database, 1987-2010.

Figure 4.3 Annual Catch Weights of Invertebrates within Study Area UAs, 1987-2010.

4.3.3.2 Analysis of Recent Commercial Catches in the Study Area, 2005-2010

The average annual Newfoundland-landed commercial harvests from the Study Area during May to November, 2005 to 2010, are shown in Table 4.2. The domestic harvest catch weight in the Study Area was dominated by northern shrimp (~66%) and snow crab (~19%) during this period, followed by Greenland halibut (~5%), cockles (~4%), and yellowtail flounder (~3%) (Table 4.2). Northern shrimp was harvested during every month between May and November, with peak harvesting in July and

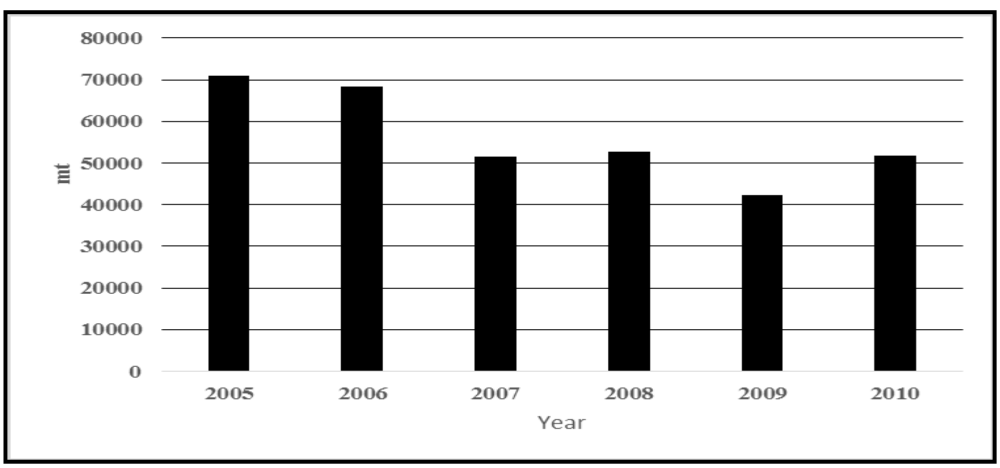
August. More than 99% of the snow crab catches occurred during the May to July period. Greenland halibut was also harvested during every month between May and November, with peak harvesting occurring in June and July. Cockles were harvested in each of the seven months being considered, with peak catches in October and November. In terms of catch value, northern shrimp and snow crab accounted for about 86% of the total catch value, followed by Greenland halibut (~7%) and cockles (~3%) (Table 4.2).

Figure 4.4 indicates the variability in annual average catch weight in the Study Area between May and November during the 2005 to 2010 period.

Table 4.2 Average Annual Catch Weights within Study Area, May to November, 2005 to 2010.

Species	Quantity (mt)	% of Overall Total	Value ($)	% of Overall Total
Northern Shrimp	29,234	66.0	33,576,128	49.3
Snow Crab	8,314	18.8	25,342,058	37.2
Greenland halibut	2,387	5.4	4,605,485	6.8
Cockles	1,673	3.8	1,857,953	2.7
Yellowtail flounder	1,261	2.8	768,665	1.1
Stimpson's surf clam	698	1.6	984231	1.4
American plaice	277	0.6	143,690	0.2
Iceland scallops	74	0.2	105,473	0.2
Redfish	77	0.2	40,822	<0.1
Atlantic halibut	19	<0.1	152,463	0.2
Striped wolffish	<0.1	<0.1	<0.1	<0.1
Overall Total	**44,289**	**99.4**	**68,069,323**	**99.1**

Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.



Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.4 Annual Catch Weights of All Species within the Study Area, May to November, 2005 to 2010.

4.3.3.3 Analysis of the Commercial Catches in the 2014 Survey Block, 2005-2010

The average annual Newfoundland-landed commercial harvests from the proposed 2014 Survey Block during May to November, 2005 to 2010, are shown in Table 4.3. The domestic harvest catch weight in the proposed 2014 Survey Block was dominated by northern shrimp (~51%) and snow crab (~39%) during this period, followed by herring (~5%), cockles (~4%), and Greenland halibut (~2%) (Table 4.3). While northern shrimp is harvested within the proposed 2014 Survey Block during every month between May and November, about 80% of the 2005-2010 catch weight was harvested in June to August period. Snow crab was harvested in the proposed 2014 Survey Block during May to August, 2005-2010. As for catch value, snow crab and northern shrimp accounted for more than 96% of the total catch value (Table 4.3).

Table 4.3 Average Annual Catch Weights in the Proposed 2014 Survey Block, May to November, 2005 to 2010.

Species	Quantity (mt)	% of Overall Total	Value ($)	% of Overall Total
Northern Shrimp	50	51.3	51,778	24.8
Snow Crab	45	39.1	149,216	71.5
Herring	6	5.0	1,164	0.6
Greenland halibut	3	2.3	5,360	2.5
Mackerel	2	2.0	1,042	0.5
Roughhead grenadier	<1	0.2	85	<0.1
Redfish	<1	<0.1	13	<0.1
Overall Total	**106**	**100.0**	**208,657**	**100.0**

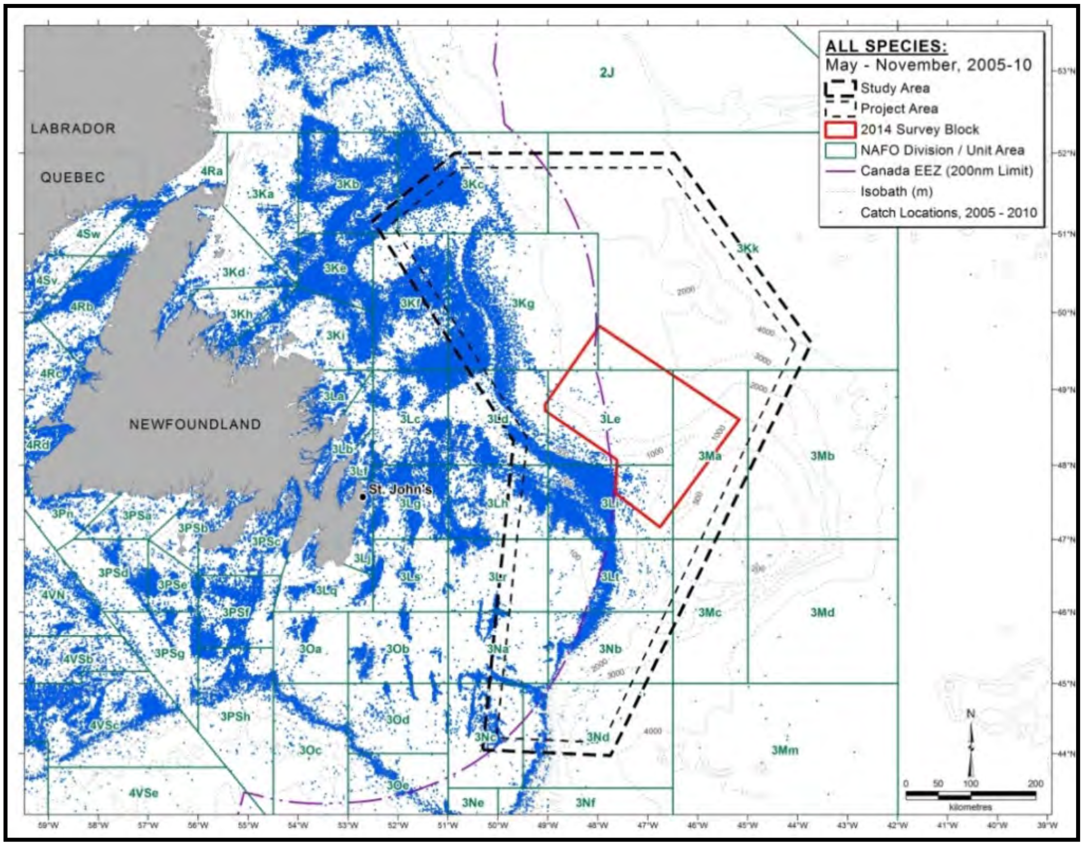
Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

4.3.3.4 Harvesting Locations

The georeferenced harvest locations in the Study Area for all species during 2005 to 2010 are presented in Figure 4.5. Most of total catch weight was harvested between May and August (~78%). As Figure 4.5 illustrates, most of the domestic fish harvesting in the Study Area during 2005-2010 was concentrated between the 100 and 1,000 m depth contours. Except for UAs 3Lt, 3Nb and 3Nd, most of the Study Area commercial fishery harvest locations are inside the 200 nmi EEZ. There were relatively few harvest locations indicated within the proposed 2014 Survey Block (Figure 4.5). In recent years, the pattern of harvesting locations has been consistent from year to year.

The distributions of harvesting locations of the species accounting for at least 1% of the total catch weights in each of the Study Area and the proposed 2014 Survey Block between May and November, 2005-2010, are presented in Figures 4.6 to 4.15.

In the following sections, shrimp and crab landings data are presented in two ways: (1) pre-2011 data are georeferenced, and (2) 2011 and later data are presented in "cell" format. The 2011-2012 data used in the following maps are the result of the 'new format' commercial fishery landings database that is now distributed by DFO to outside users. A coloured cell in these maps indicates that there was at least one catch record for that cell. Unlike the georeferenced pre-2011 data, there is no indication of the amount of catch for any particular cell.



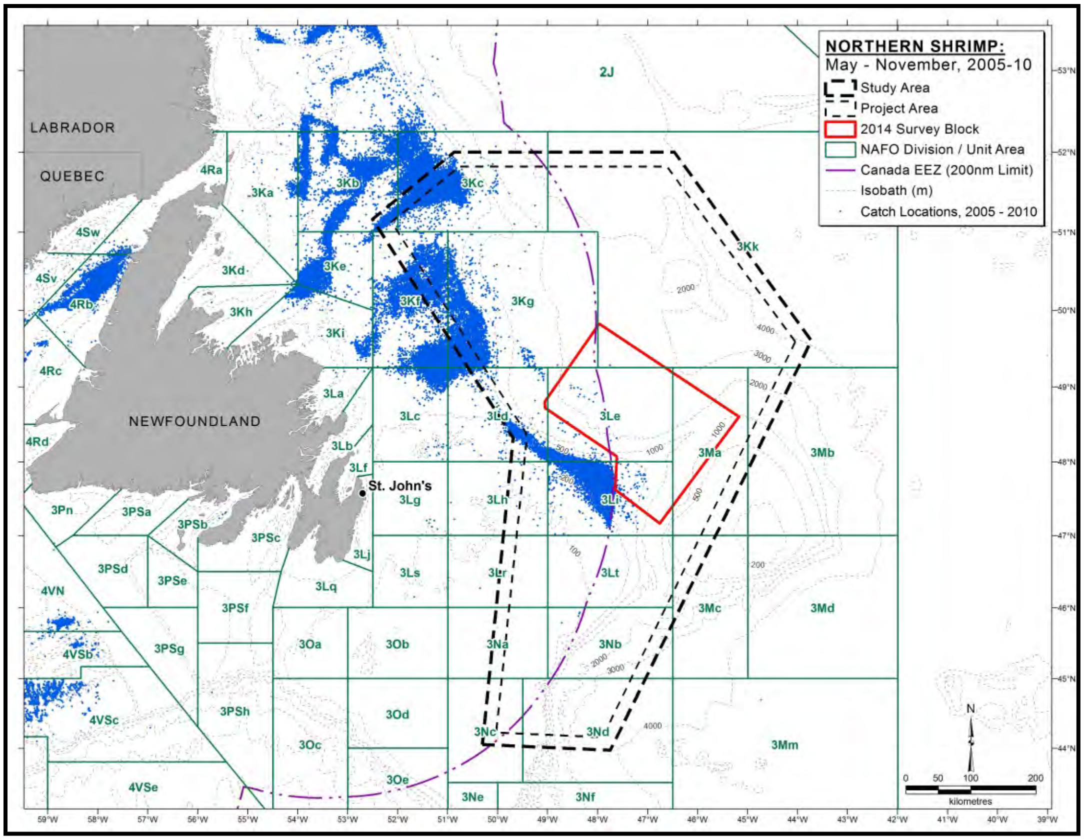
Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.5 Harvest Locations of All Species in the Study Area, May to November, 2005-2010.

Northern Shrimp

During 2005-2010, northern shrimp catches in the Study Area occurred primarily in the northwestern portion of the Study Area inside the Canadian EEZ and in the east-central portion of the Study Area (known locally as the "shrimp triangle") (Figure 4.6). Some northern shrimp catches were reported within the proposed 2014 Survey Block, both inside and outside the Canadian EEZ (Figure 4.6).

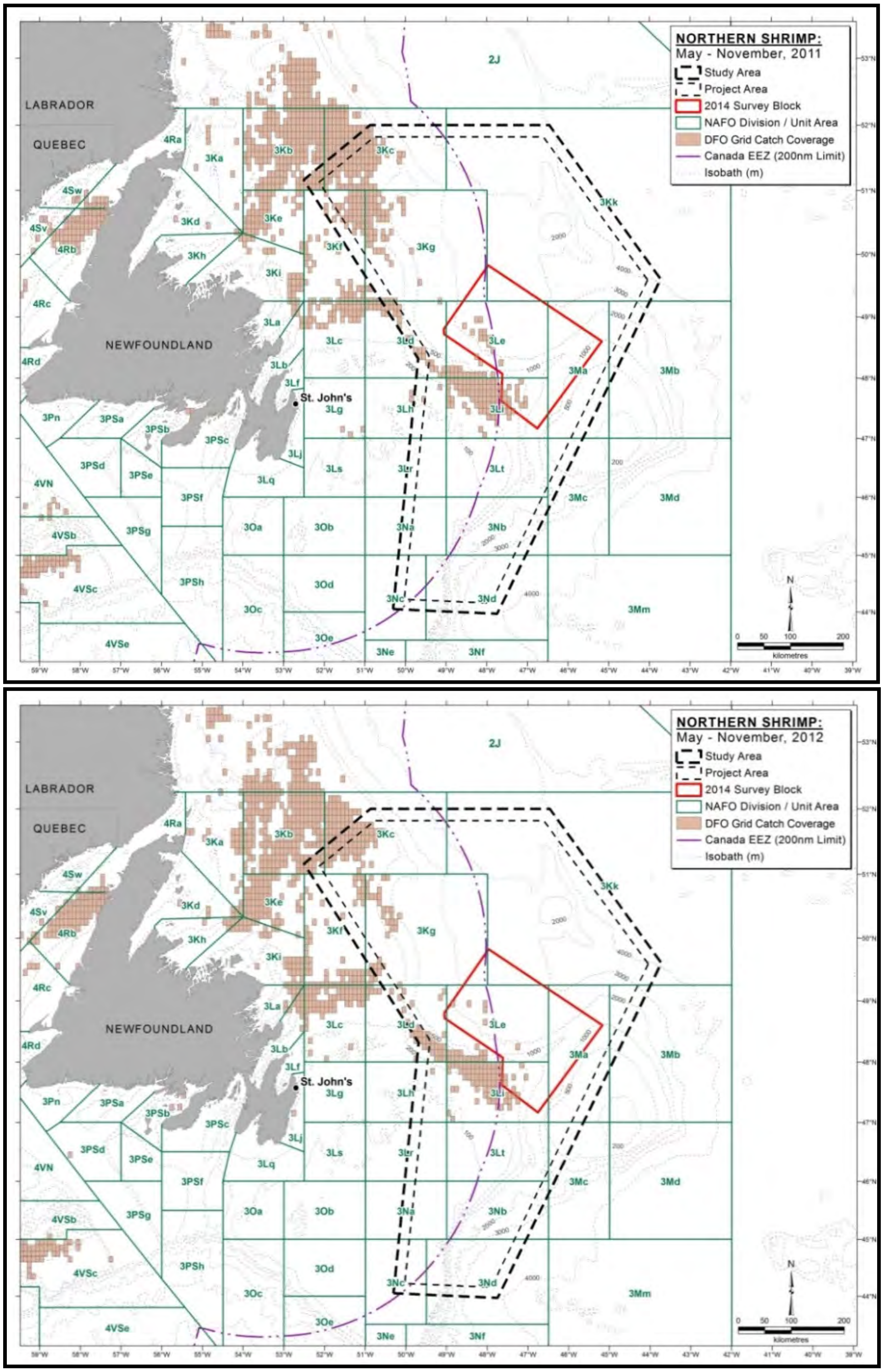
Most of the shrimp harvested within the Study Area during 2005-2010 were caught in NAFO UAs 3Kc, 3Kf, 3Kg and 3Li, in areas where water depth ranged between 200 and 500 m (Figure 4.6).



Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.6 Harvesting Locations of Northern Shrimp in the Study Area, May to November, 2005-2010.

The same harvest patterns for northern shrimp within the Study Area were seen for 2011 and 2012 (Figure 4.7). Note that the data used to produce Figure 4.7 represent the 'new format' commercial fishery landings database that is now distributed by DFO to outside users. A coloured cell in the following maps indicates that there was at least one catch record for that cell. Unlike the georeferenced pre-2011 data, there is no indication of the amount of catch for any particular cell.



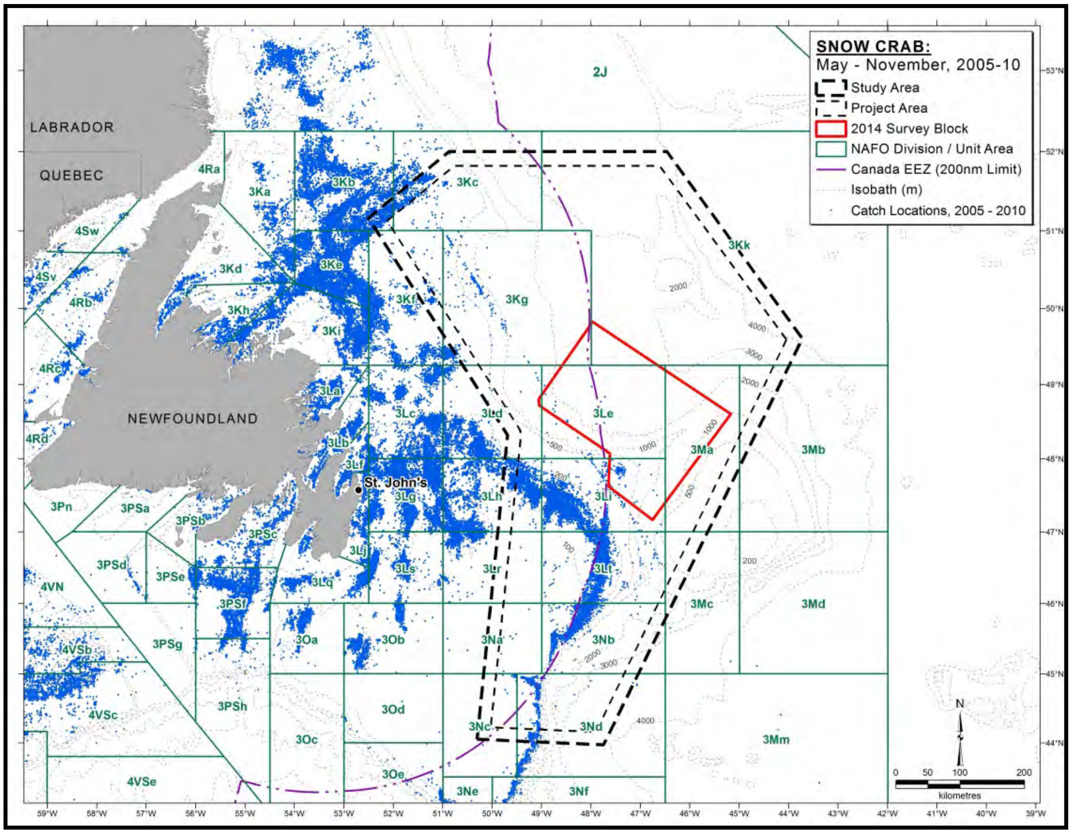
Source: DFO Newfoundland Commercial Fishery Landings Database, 2011-2012.

Figure 4.7 Harvesting Locations of Northern Shrimp in the Study Area, May to November, 2011 (top) and 2012 (bottom).

Snow Crab

During 2005-2010, snow crab catches in the Study Area occurred primarily in the southern portion of the Study Area both inside and outside the Canadian EEZ (Figure 4.8). Some snow crab catches were reported in the southern portion of the proposed 2014 Survey Block outside the Canadian EEZ (Figure 4.8).

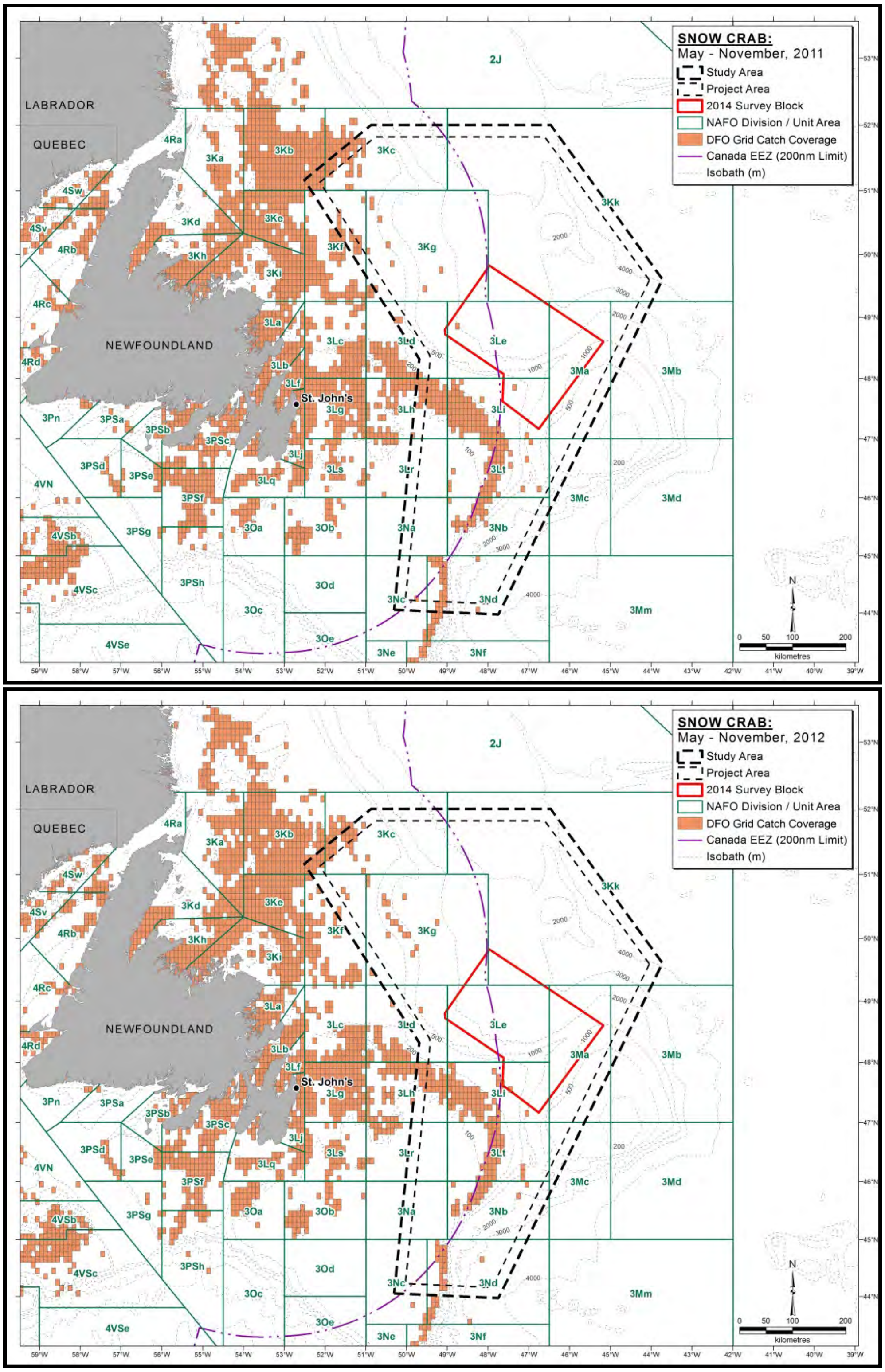
Most of the snow crab harvested within the Study Area during 2005-2010 were caught in NAFO UAs 3Kb, 3Kc, 3Lh, 3Li, 3Lt, 3Nb and 3Nd, in areas where water depths were less than 200 m (Figure 4.8).



Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.8 Harvesting Locations of Snow Crab in the Study Area, May to November, 2005-2010.

The same harvest patterns for snow crab within the Study Area were seen for 2011 and 2012 (Figure 4.9). Note that the data used to produce Figure 4.9 represent the 'new format' commercial fishery landings database that is now distributed by DFO to outside users. A coloured cell in this figure indicates that there was at least one catch record for that cell. There is no indication of the amount of catch for any particular cell.



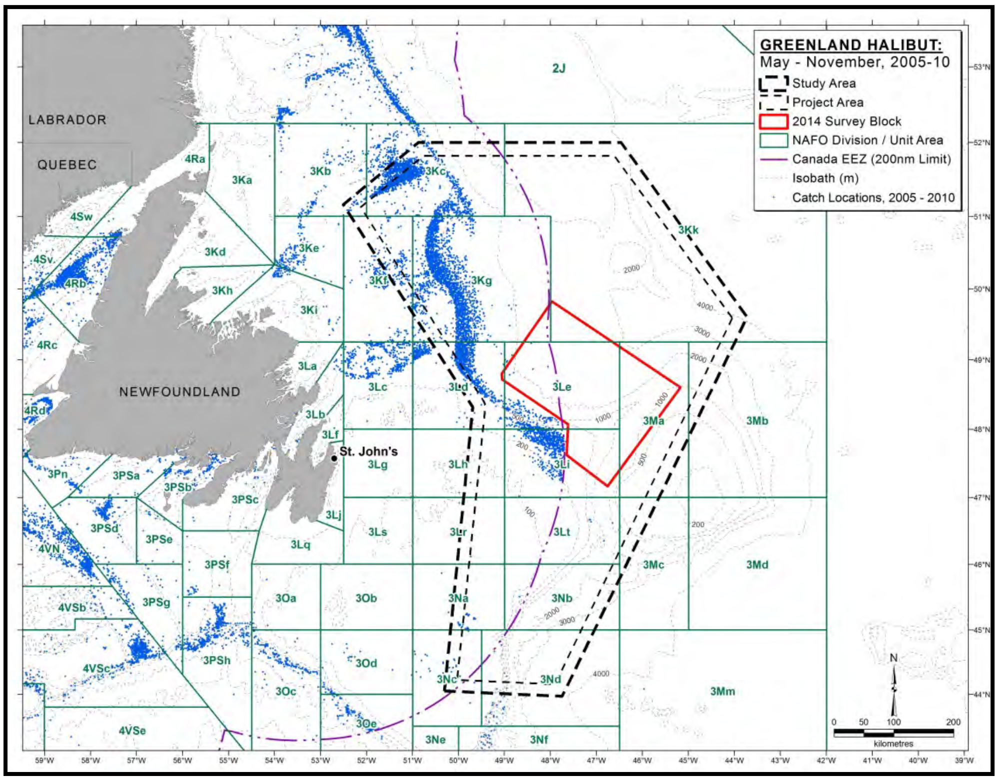
Source: DFO Newfoundland Commercial Fishery Landings Database, 2011-2012.

Figure 4.9 Harvesting Locations of Snow Crab in the Study Area, May to November, 2011 (top) and 2012 (bottom).

Greenland Halibut

During 2005-2010, Greenland halibut catches in the Study Area occurred primarily in the central and northwestern portions of the Study Area inside the Canadian EEZ (Figure 4.10). Very few Greenland halibut catches were reported in the proposed 2014 Survey Block (Figure 4.10).

Most of the Greenland halibut harvested within the Study Area during 2005-2010 were caught in NAFO UAs 3Kc, 3Kg, 3Ld and 3Li. Other than UA 3Li, most catches were made in areas where water depths ranged from 500 to 1,000 m. In UA 3Li, most Greenland halibut were caught in areas where water depths ranged from 200 to 500 m (Figure 4.10).



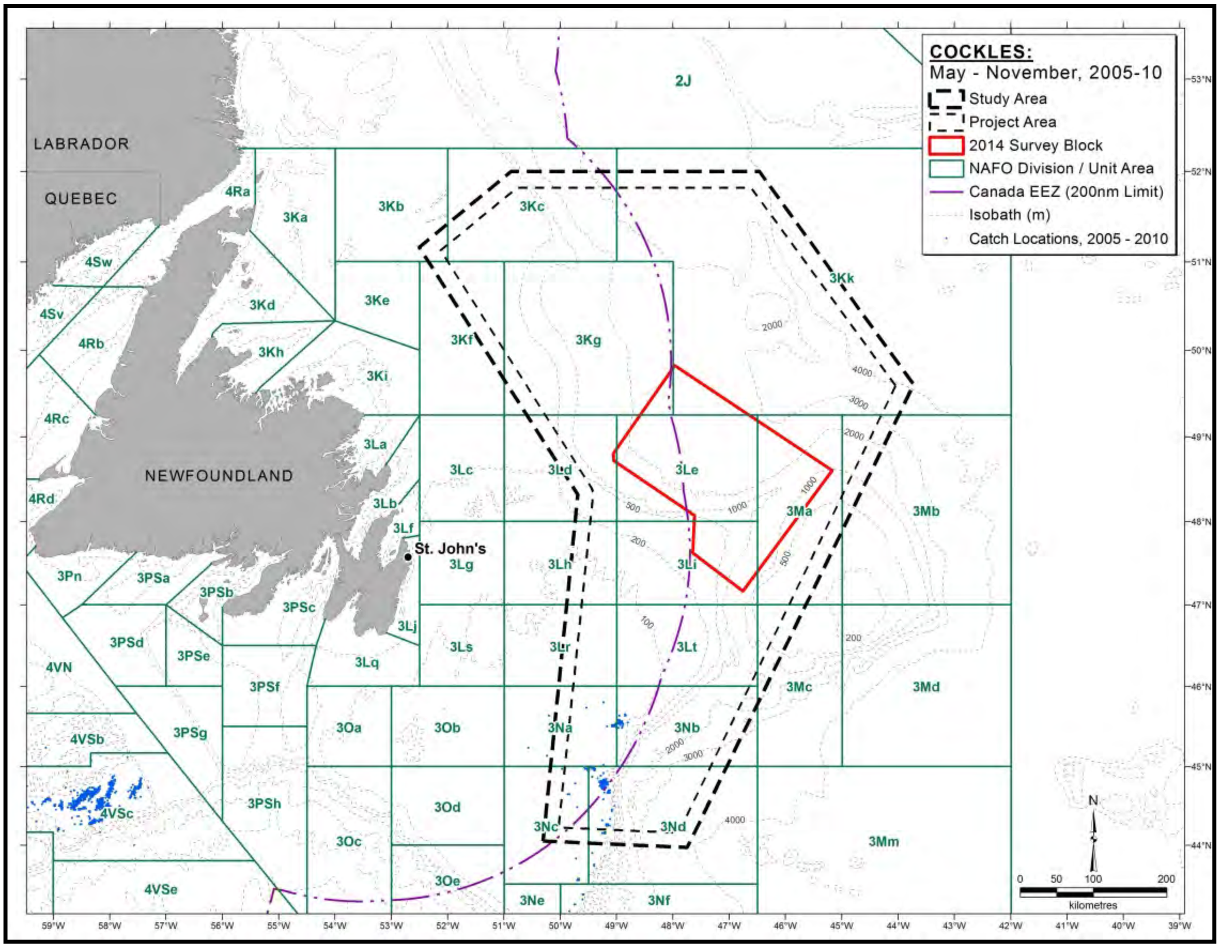
Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.10 Harvesting Locations of Greenland Halibut in the Study Area, May to November, 2005-2010.

Cockles

During 2005-2010, cockle catches in the Study Area occurred in the southern portion of the Study Area both inside and outside the Canadian EEZ (Figure 4.11). No cockle catches were reported in the proposed 2014 Survey Block (Figure 4.11).

Most of the cockles harvested within the Study Area during 2005-2010 were taken in NAFO UAs 3Nb and 3Nd, in areas where water depths were less than 100 m (Figure 4.11).



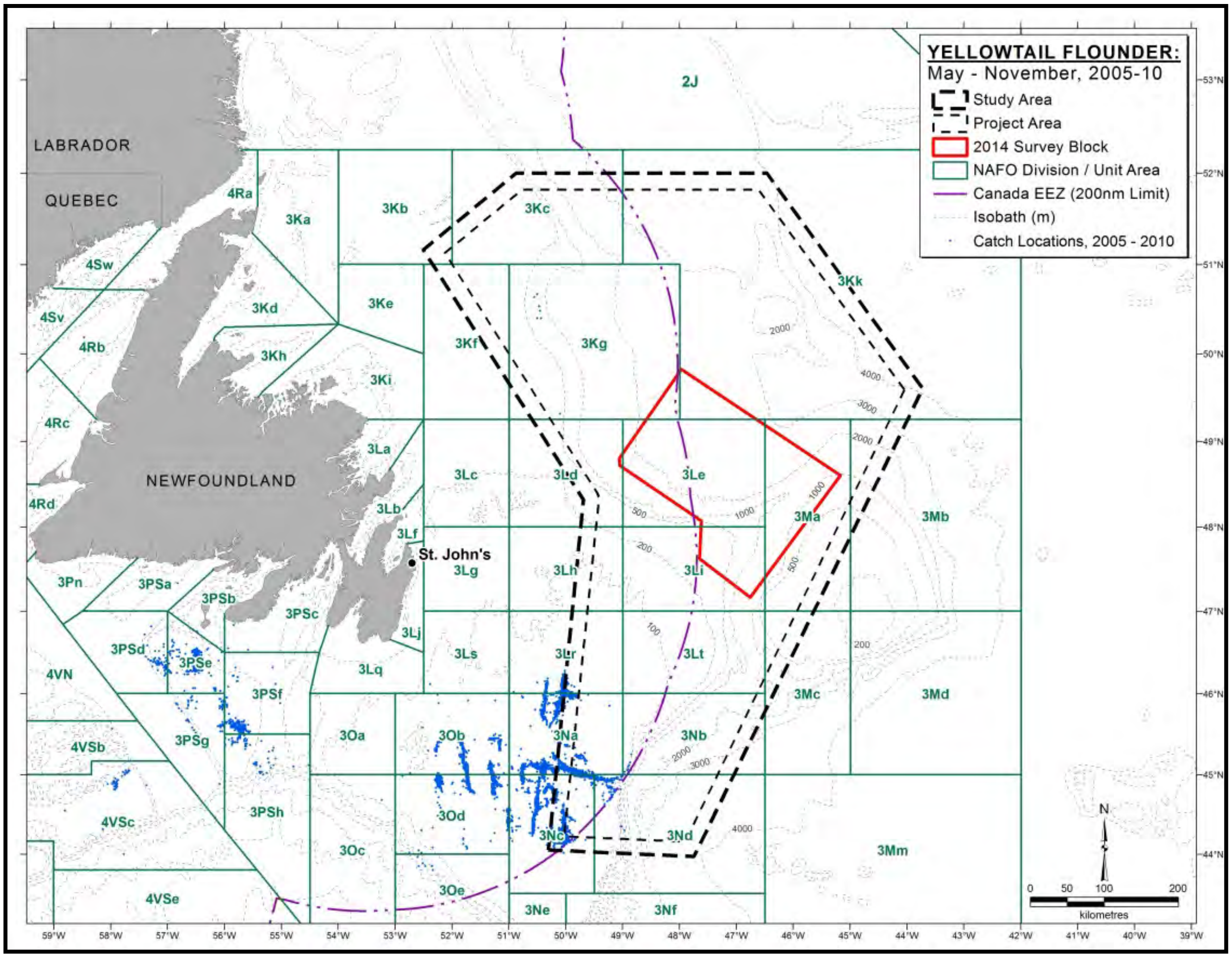
Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.11 Harvesting Locations of Cockles in the Study Area, May to November, 2005-2010.

Yellowtail Flounder

During 2005-2010, yellowtail flounder catches in the Study Area occurred in the southwestern portion of the Study Area, primarily inside the Canadian EEZ (Figure 4.12). No yellowtail flounder catches were reported in the proposed 2014 Survey Block (Figure 4.12).

Most of the yellowtail flounder harvested within the Study Area during 2005-2010 were taken in NAFO UAs 3Na, 3Nc and 3Nd, in areas where water depths were less than 100 m (Figure 4.12).



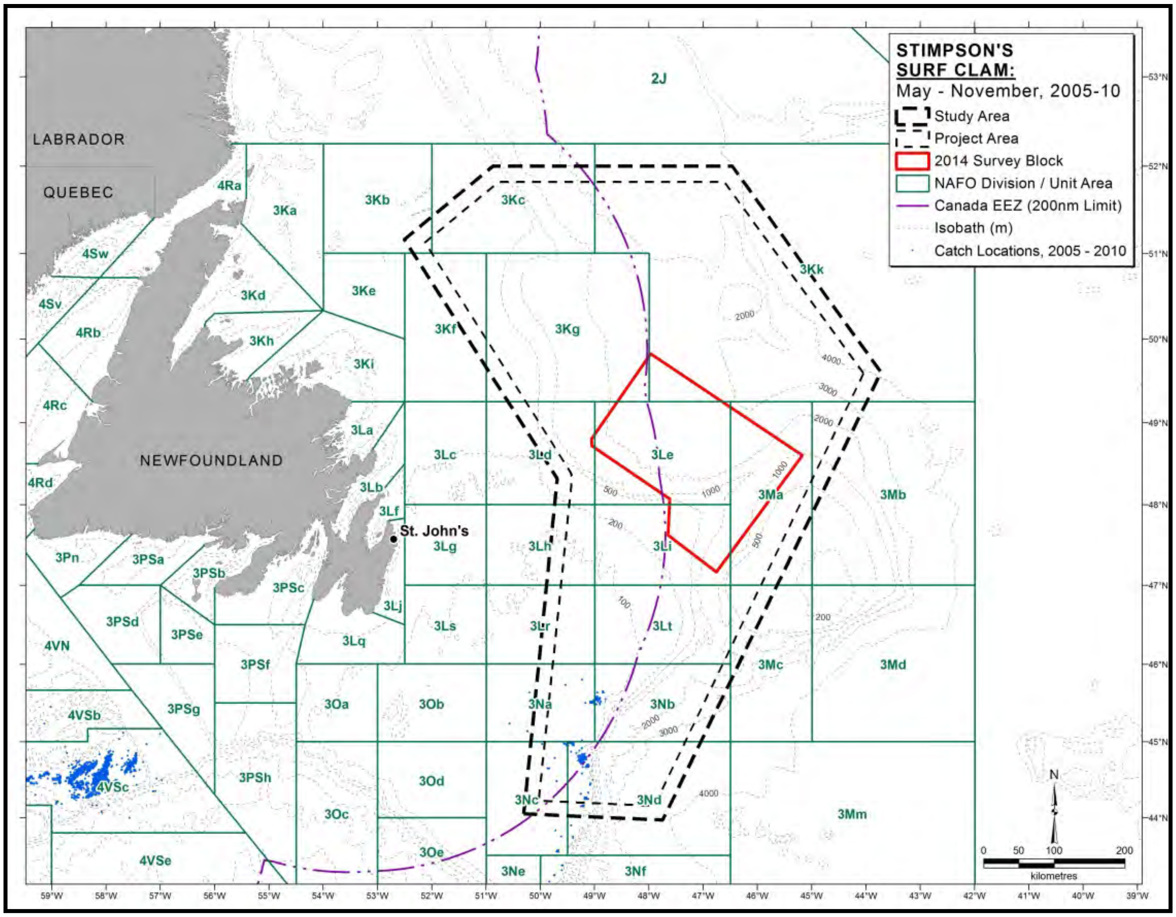
Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.12 Harvesting Locations of Yellowtail Flounder in the Study Area, May to November, 2005-2010.

Stimpson's Surf Clam

During 2005-2010, Stimpson's surf clam catches in the Study Area occurred in the southern portion of the Study Area, primarily inside the Canadian EEZ (Figure 4.13). No surf clam catches were reported in the proposed 2014 Survey Block (Figure 4.13).

Most of the Stimpson's surf clams harvested within the Study Area during 2005-2010 were taken in NAFO UAs 3Na, 3Nb and 3Nd, in areas where water depths were less than 100 m (Figure 4.13).



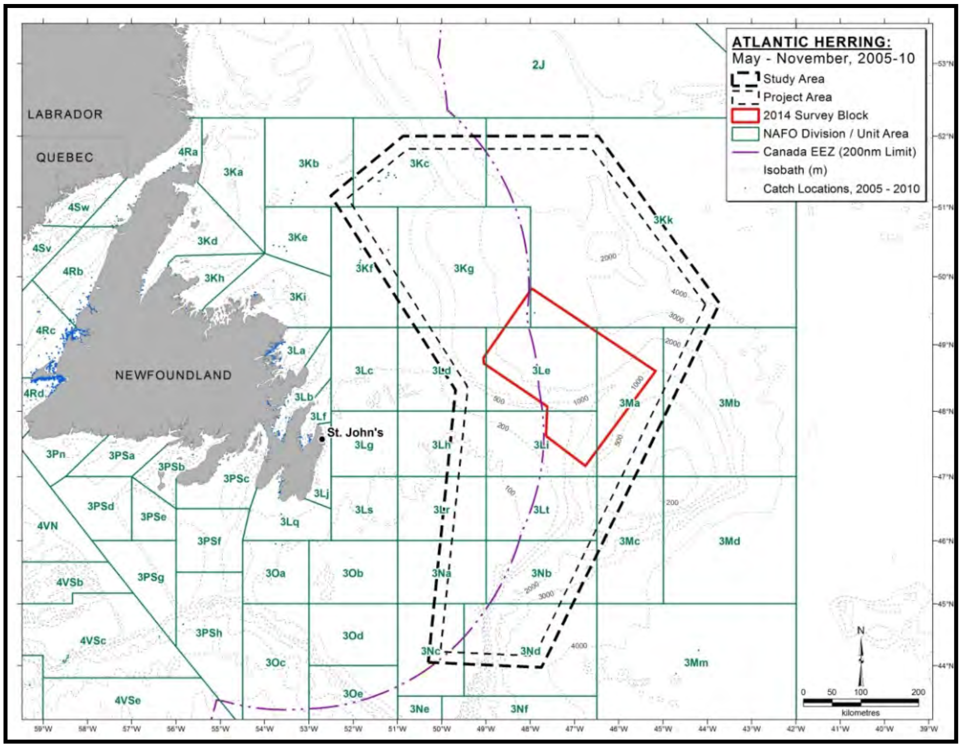
Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.13 Harvesting Locations of Stimpson's Surf Clam in the Study Area, May to November, 2005-2010.

<u>Herring and Mackerel</u>

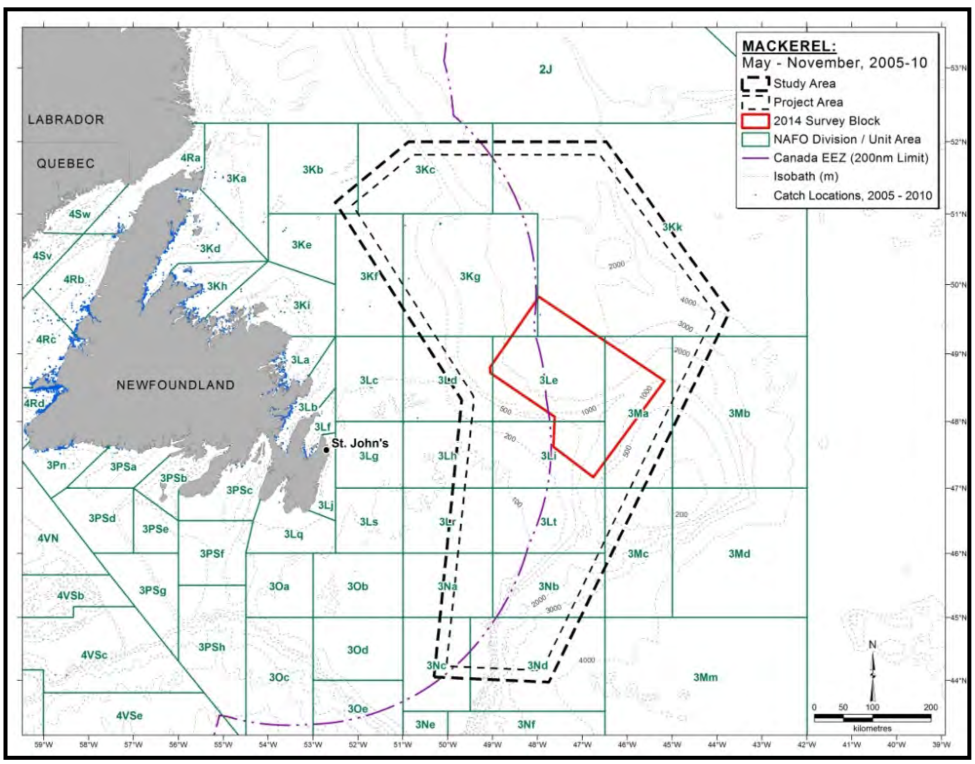
During 2005-2010, most herring and mackerel catches in the Study Area occurred in the northwestern portion of the Study Area, inside the Canadian EEZ (Figures 4.14 and 4.15). Some herring and mackerel catches were reported in the northern portion of the proposed 2014 Survey Block (Figures 4.14 and 4.15).

Herring and mackerel harvested within the Study Area during 2005-2010 were taken in NAFO UAs 3Kc, 3Kg and 3Kk (Figures 4.14 and 4.15).



Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.14 Harvesting Locations of Herring in the Study Area, May to November, 2005-2010.



Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

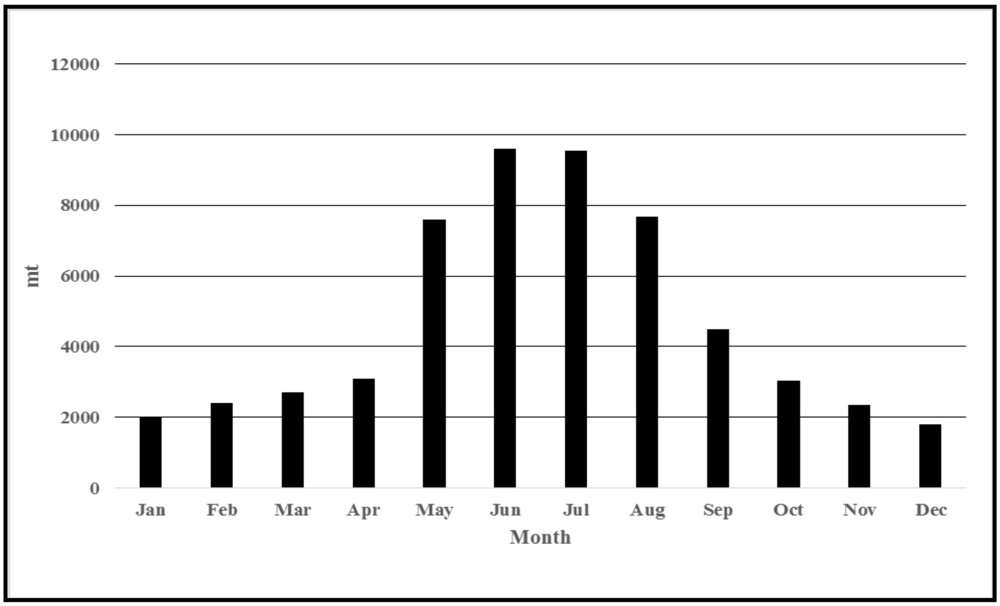
Figure 4.15 Harvesting Locations of Mackerel in the Study Area, May to November, 2005-2010.

4.3.3.5 Timing of Commercial Fisheries

Study Area

Figure 4.16 indicates the average monthly catch weight within the Study Area for all species during the 2005-2010 period. The May to August period had the highest catch weights during the six-year period. Based on the 2005-2010 DFO landings database, about 79% of the annual catch weight harvested within the Study Area is taken during the May to November period.

In the Study Area, northern shrimp was harvested during every month between May and November, with peak harvesting in July and August. More than 99% of the snow crab catches occurred during the May to July period. Greenland halibut was also harvested during every month between May and November, with peak harvesting occurring in June and July. Cockles were harvested in each of the seven months being considered, with peak catches in October and November.



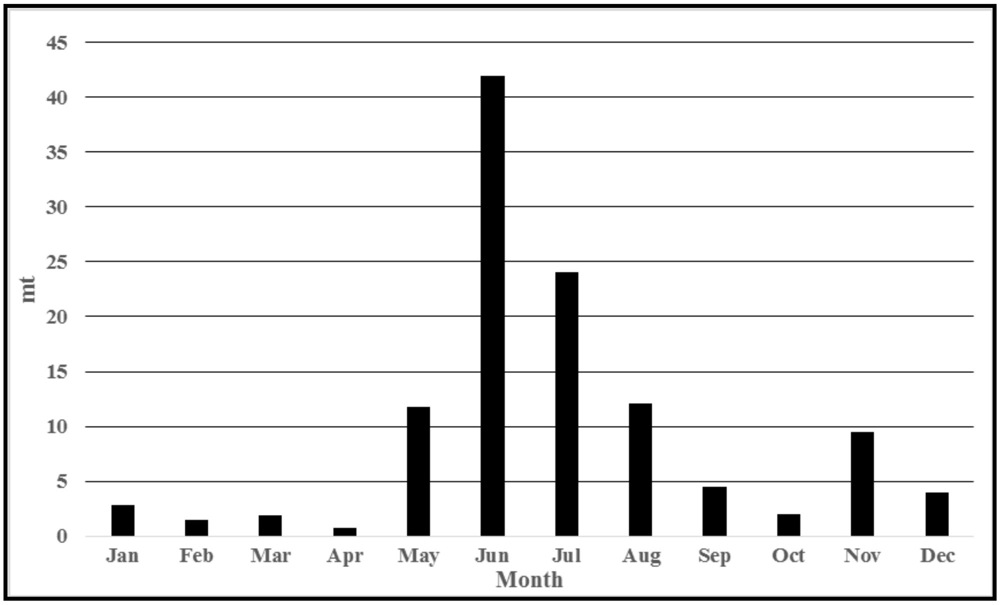
Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.16 Average Monthly Catch Weights of All Species within the Study Area, 2005 to 2010

Proposed 2014 Survey Block

Figure 4.17 indicates the average monthly catch weight within the proposed 2014 Survey Block for all species during the 2005-2010 period. The May to August period had the highest catch weights during the six-year period. Based on the 2005-2010 DFO landings database, about 91% of the annual catch weight harvested within the 2014 Survey Block is taken during the May to November period.

In the proposed 2014 Survey Block, northern shrimp was harvested during every month between May and November, with peak harvesting in June, July and August. More than 96% of the snow crab catches occurred during the May to July period. All Greenland halibut harvesting in the 2014 Survey Block occurred in July (~5%) and August (~95%). All herring and mackerel harvesting in this area occurred in November and September, respectively.



Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.17 Average Monthly Catch Weights of All Species within the Proposed 2014 Survey Block, 2005 to 2010

4.3.3.6 Fishing Gear

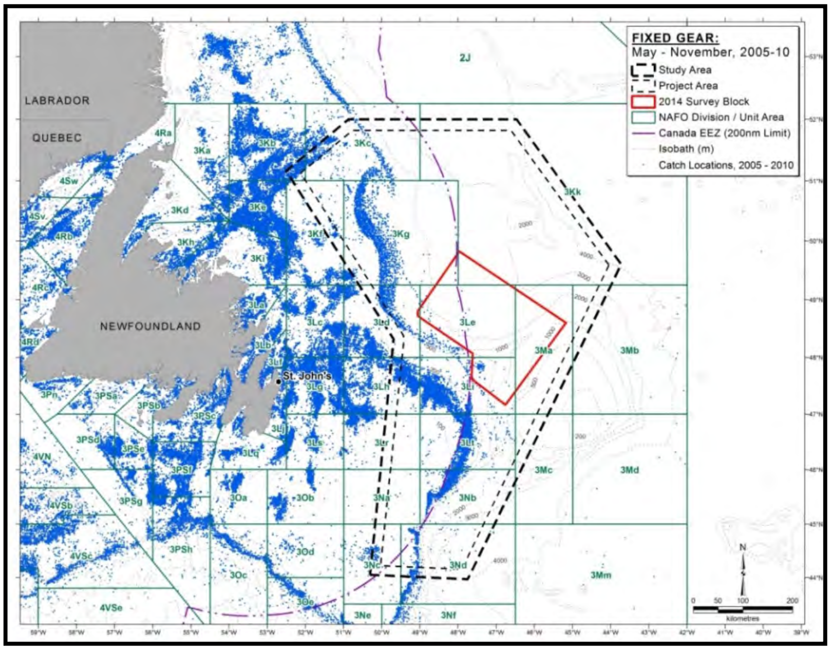
In terms of catch weight differences between gear types, mobile gear accounted for approximately three times the catch weight in the Study Area than fixed gear (Table 4.4). Northern shrimp accounted for about 86% of the mobile gear catch weight while snow crab and Greenland halibut accounted for almost 99% of the fixed gear catch weight.

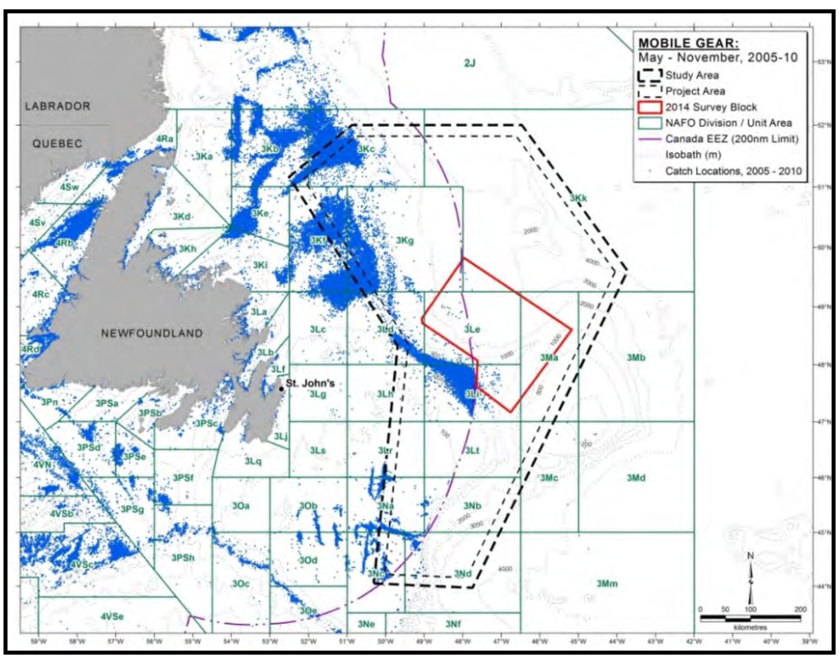
Table 4.4 Average Annual Study Area Catch Weight by Gear Type, May to November, 2005 to 2010.

Species	Fixed Gear (mt) [specific gear]	% of Species Total	Mobile Gear (mt) [specific gear]	% of Species Total
Northern shrimp	0	0.0	29,234 [ST]	100.0
Snow crab	8,314 [P]	100.0	0	0.0
Greenland halibut	1,895 [G]	79.4	492 [BOT, LL]	20.6
Cockles	0	0.0	1,673 [D]	100.0
Yellowtail flounder	<0.1 [G]	<0.1	1,261 [BOT]	>99.9
Stimpson’s surf clam	0	0.0	698 [D]	100.0
American plaice	1 [G]	0.4	276 [BOT, LL]	99.6
Iceland scallops	0	0.0	76 [D]	100.0
Redfish	19 [G]	24.0	59 [BOT]	76.0
Atlantic halibut	19 [G]	98.4	<1 [BOT, LL, ST]	1.6

Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.
‘ST’ denotes shrimp trawl; ‘P’ denotes pot; ‘G’ denotes gillnet; ‘BOT’ denotes bottom otter trawl; ‘LL’ denotes longline;
‘D’ denotes dredge

Approximately 77% of the commercial catch weight in the Study Area during May to November, 2005-2010 was harvested with mobile gear, principally shrimp trawls (Figure 4.18). Other mobile gear types used include bottom otter trawls (Greenland halibut, yellowtail flounder, American plaice, redfish and Atlantic halibut), longlines (Greenland halibut, American plaice and Atlantic halibut) and boat dredges (cockles, Stimpson's surf clams and Iceland scallops). The principal fixed gear type in terms of catch weight was crab pot (Figure 4.18). Gill nets were also used, principally for Greenland halibut but also in the harvesting of redfish and Atlantic halibut.





Source: DFO Newfoundland Commercial Fishery Landings Database, 2005-2010.

Figure 4.18 Fixed (top) and Mobile (bottom) Harvesting Locations, May to November, 2005-2010

4.3.4 Macroinvertebrates and Fishes Collected during DFO RV Surveys

Fisheries and Oceans undertakes annual fisheries surveys (DFO RV Surveys) using a statistical study design. These are described for recent years in the following sections.

4.3.4.1 Predominant Species/Groups and Catch Location Distributions

Data collected during 2007 to 2011 spring/summer (March, May, June and July) and fall (September, October, November and December) DFO RV surveys in the Study Area were analyzed, and catch weights and catch numbers of species/groups with combined catch weights of at least 100 kg are presented in Table 4.5.

Deepwater redfish accounted for 35.3% of the total 2007-2011 catch weight, followed by yellowtail flounder (7.1%), Atlantic cod (6.3%), sponges (5.7%) northern shrimp (5.2%), American plaice (4.6%) shrimp (Natantia) (4.1%), thorny skate (3.9%), Greenland halibut (3.3%), roughhead grenadier (2.9%) and sand lance (2.8%). The remaining species/groups with total catch weights exceeding 100 kg are indicated in Table 4.5. The distribution of georeferenced catch locations for all species/groups reported during the 2007 to 2011 DFO RV surveys within the Study Area are shown in Figure 4.19.

Table 4.5 Catch Weights and Numbers of Invertebrate and Fish Species/Groups Collected within the Study Area during DFO RV Surveys, 2007-2011.

Species	Weight (kg)	Number
Redfishes (*Sebastes* spp.)	136,256	714,467
Yellowtail flounder (*Limanda ferruginea*)	27,305	86,967
Atlantic cod (*Gadus morhua*)	24,378	33,431
Sponges (Porifera)	21,804	-
Northern shrimp (*Pandalus borealis*)	19,984	4,077,602
American plaice (*Hippoglossoides platessoides*)	17,864	64,631
Shrimp (Natantia)	15,970	-
Thorny skate (*Raja radiata*)	14,961	8,317
Greenland halibut (*Reinhardtius hippoglossoides*)	12,836	29,058
Roughhead grenadier (*Macrourus berglax*)	11,356	24,564
Sand lance (*Ammodytes dubius*)	10,700	857,583
Capelin (*Mallotus villosus*)	8,348	520,306
Sea cucumbers (Holothuroidea)	5,697	17,947
Blue hake (*Antimora rostrata*)	4,599	28,339
Sea anemones (Actiniaria)	4,107	-
Sea stars (Asteroidea)	3,645	-
Basket stars (Ophiuroidea)	2,728	-
Snow crab [males] (*Chionoecetes opilio*)	2,634	9,592
Jellyfish (Scyphozoa)	2,622	-
Witch flounder (*Glyptocephalus cynoglossus*) Eel pout	2,466	6,271
Greenland shark (*Somniosus microcephalus*)	2,000	2
Roundnose grenadier (*Coryphaenoides rupestris*)	1,949	16,213
Atlantic wolffish (*Anarhichas lupus*)	1,919	2,788

Species	Weight (kg)	Number
Longnose eel (*Synaphobranchus kaupi*)	1,873	18,165
Marlin spike (*Nezumia bairdi*)	1,778	20,702
Sculpins (Cottidae)	1,720	90,309
Comb jellies (Ctenophora)	1,664	-
Northern wolffish (*Anarhichas denticulatus*)	1,636	515
Sea urchins (Echinoidea)	1,201	-
Black dogfish (*Centroscyllium fabricii*)	1,179	971
Spotted wolffish (*Anarhichas minor*)	1,052	430
Vahl's eelpout (*Lycodes vahlii*)	913	8,851
Tunicates (Tunicata)	900	-
Sand dollars (Clypeasteroida)	699	-
Iceland scallop (*Chlamys islandica*)	630	6,443
Toad crab (*Hyas* spp.)	605	20,586
Spinytail skate (*Raja* [*Bathraja*] *spinicauda*)	597	71
Lanternfishes (Myctophidae)	556	93,918
Large scale tapirfish (*Notacanthus nasus*)	541	891
Arctic eelpout (*Lycodes reticulatus*)	521	2,273
Longfin hake (*Urophycis chesteri*)	465	3,859
Threebeard rockling (*Gaidropsarus* spp.)	390	1,737
Eelpout (*Lycodes* sp.)	385	3,358
Jensen's skate (*Raja jenseni*)	349	133
Striped shrimp (*Pandalus montagui*)	314	51,011
Shrimp (*Sergestes arcticus*)	288	277,501
Corals (Anthozoa)	285	3,739
Eelpout (Zoarcidae)	206	3,481
Brittle stars (Ophiuroidea)	200	-
Alligatorfish (Scorpaeniformes)	179	26,753
Shrimp (*Acanthephyra pelagica*)	178	29,591
Octopuses (Octopoda)	174	462
Deepsea cat shark (*Apristurus profundorum*)	156	87
Barracudinas (Paralepididae)	148	3,774
Blennies (*Lumpenus* spp.)	147	6,823
Deepwater chimaera (*Hydrolagus affinis*)	139	24
Atlantic halibut (*Hippoglossus hippoglossus*)	104	11
Shrimp (*Argis dentata*)	102	18,889

Source: DFO RV Survey Data 2007-2011.

Figure 4.19 shows the catch location distribution for all species in the Study Area during DFO RV surveys conducted between 2007 and 2011. The catch location distributions of species/groups that accounted for at least 10 mt catch weight in the Study Area during DFO RV surveys conducted between 2007 and 2011 are shown in Figures 4.20 to 4.34.

Redfishes were caught primarily in areas where water depths ranged from 100 to 1,000 m. Largest catches were distributed somewhat evenly along the south-north dimension of the Study Area, including the southern part of the proposed 2014 Survey Block (Figure 4.20).

Yellowtail flounder were caught primarily in the southwestern portion of the Study Area in areas where water depths were less than 100 m (Figure 4.21).

Atlantic cod were caught primarily in areas where water depths were less than 500 m. Largest catches occurred in the northwestern and southern portions of the Study Area (Figure 4.22).

Sponges were caught in areas where water depths ranged from 200 to 2,000 m. Largest catches occurred in the southern portion of the Study Area at the southern end of the Flemish Pass (UAs 3Lt and 3Nb), and within the proposed 2014 Survey Block (Figure 4.23).

Northern shrimp were caught primarily in areas where water depths ranged from 200 to 500 m along the entire north-south dimension of the Study Area. Largest catches occurred in the northwestern and central portions of the Study Area, including the southwestern part of the proposed 2014 Survey Block (Figure 4.24).

American plaice were caught primarily in the central and southern portions of the Study Area where water depths ranged from 100 to 1,000 m. Catch sizes in the 2014 Survey Block were relatively small (Figure 4.25).

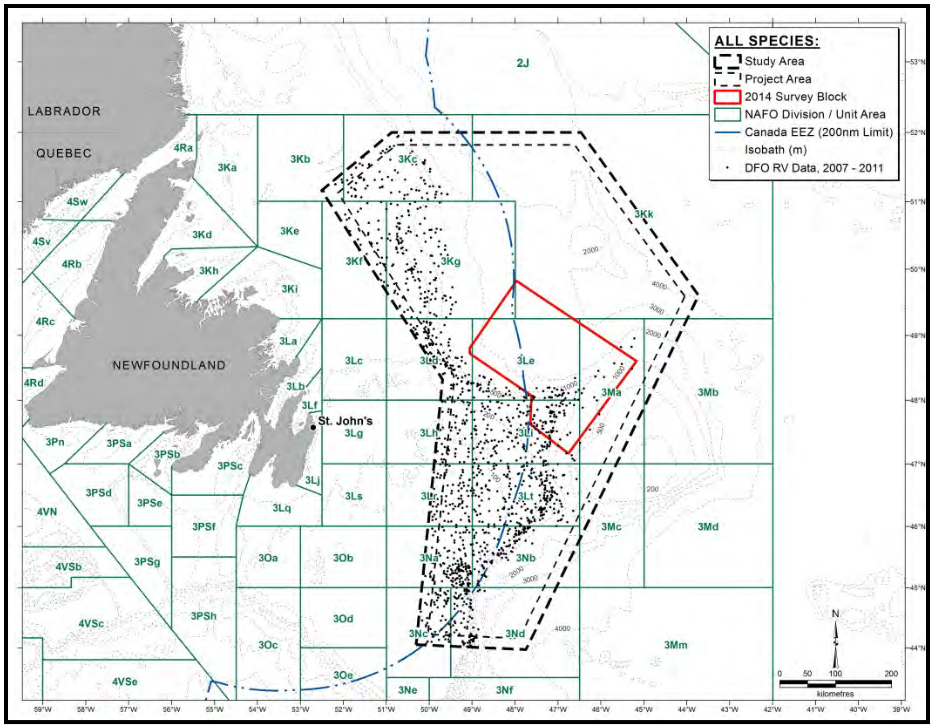
Shrimp (Natantia) were caught primarily in the northwestern and central portions of the Study Area where water depths ranged from 200 to 500 m. Largest catches occurred in the central portion of the Study Area, including the southwestern part of the proposed 2014 Survey Block (Figure 4.26).

Thorny skate were caught primarily in the central and southern portions of the Study Area where water depths ranged from 200 to 500 m. Largest catches occurred in the southern portion of the Study Area in UAs 3Lt, 3Nc and 3Nd (Figure 4.27).

Greenland halibut were caught throughout the Study Area where water depths ranged from 200 to 2,000 m. Largest catches were distributed somewhat evenly along the south-north dimension of the Study Area, including the southern part of the proposed 2014 Survey Block (Figure 4.28).

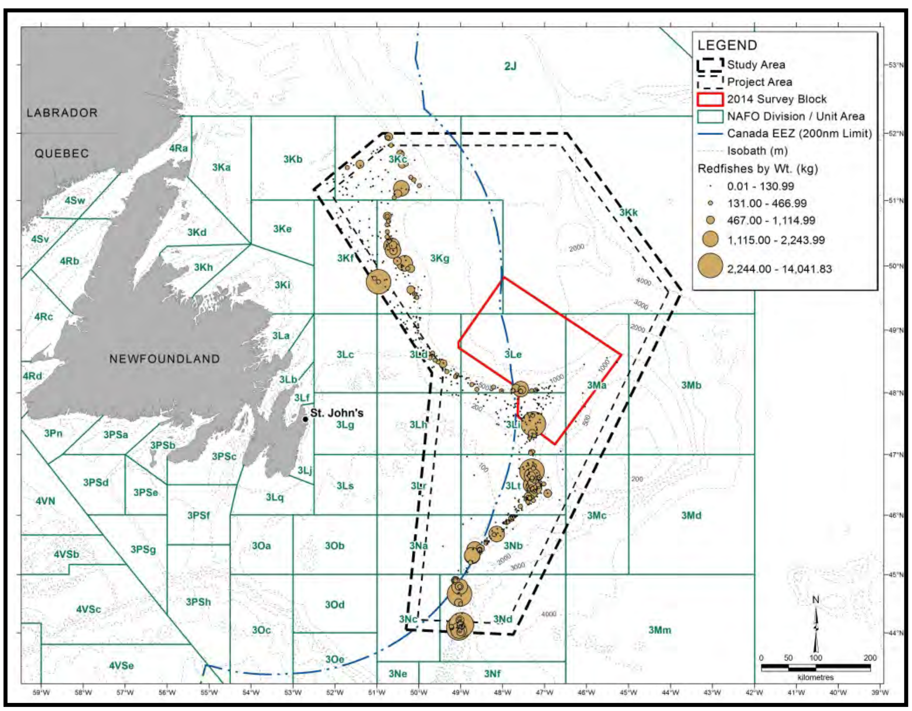
Roughhead grenadier were caught throughout the Study Area, primarily where water depths ranged from 500 to 2,000 m. Largest catches were made in the central and southern portions of the Study Area, including the proposed 2014 Survey Block (Figure 4.29).

Sand lance were caught primarily in the southern portion of the Study Area where water depths were less than 200 m (Figure 4.30).



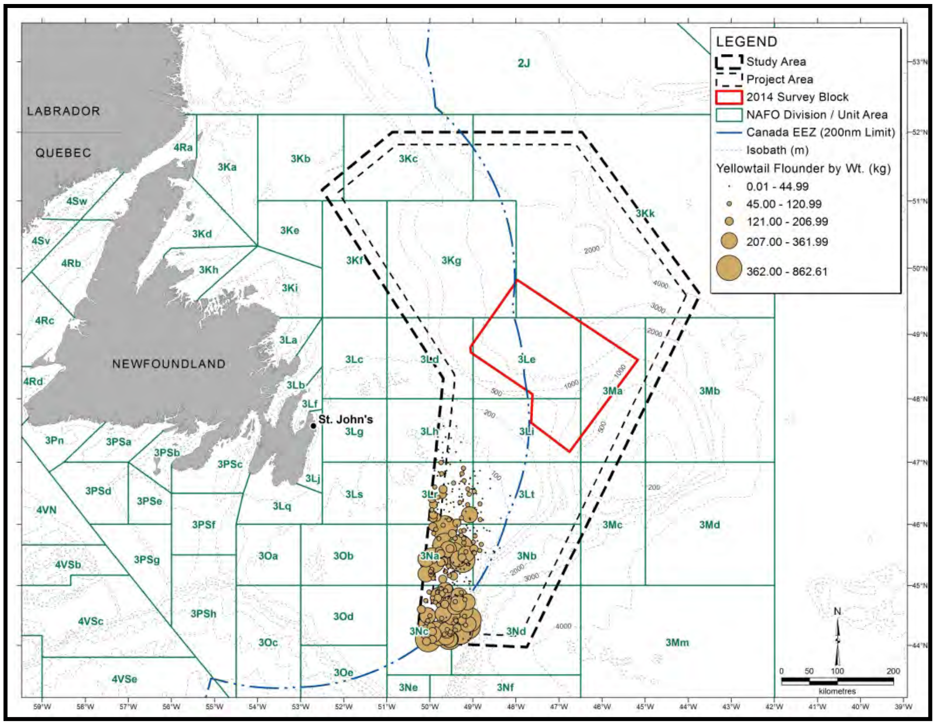
Source: DFO RV Survey Data, 2007-2011.

Figure 4.19 RV Survey Catch Locations of All Species within the Study Area, 2007 to 2011.



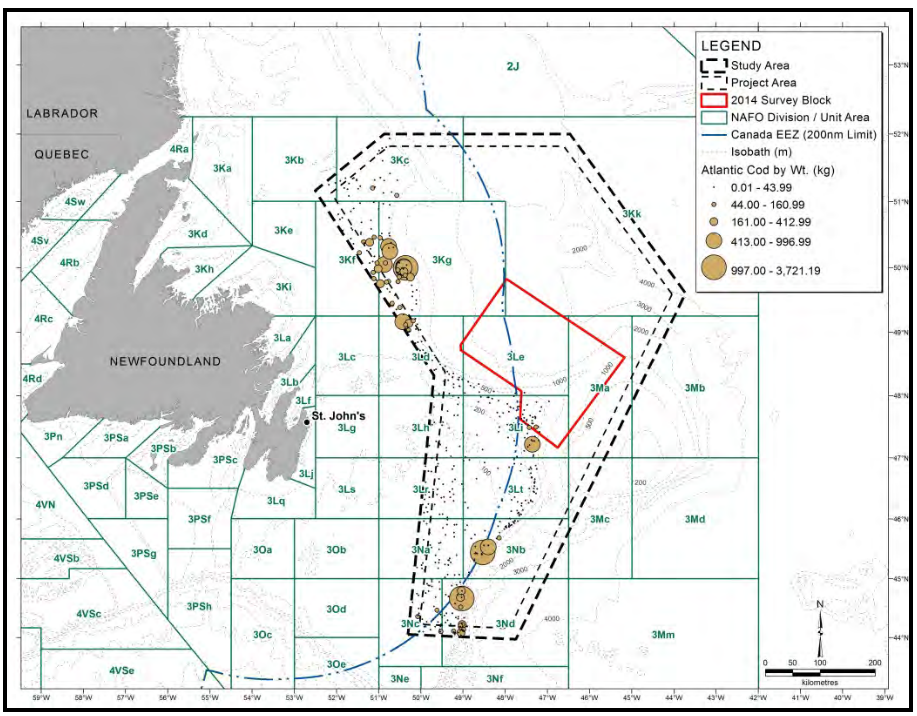
Source: DFO RV Survey Data, 2007-2011.

Figure 4.20 RV Survey Catch Locations of Redfishes within the Study Area, 2007 to 2011.



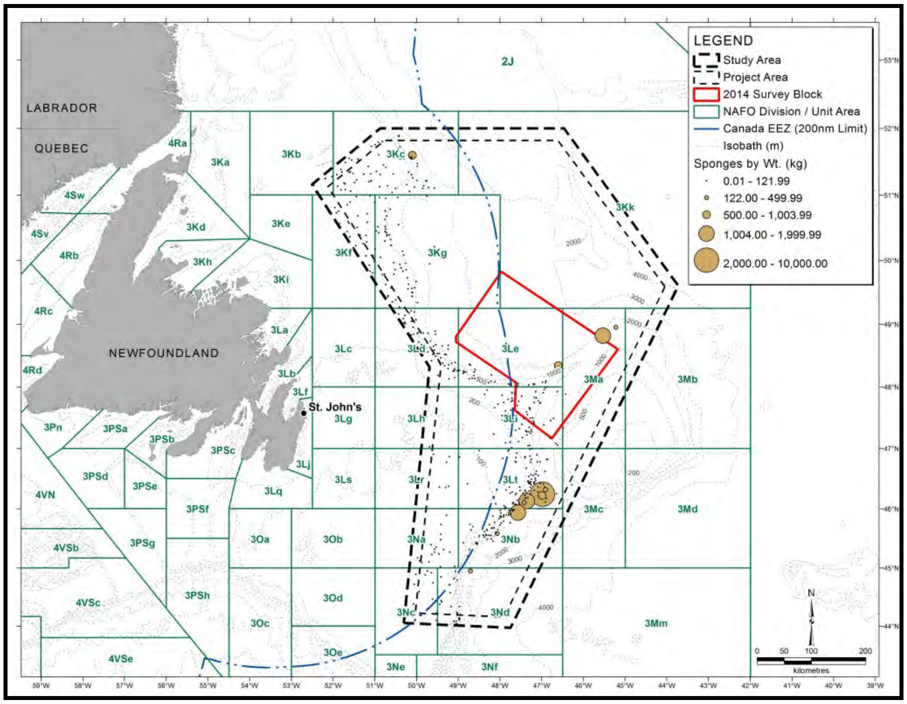
Source: DFO RV Survey Data, 2007-2011.

Figure 4.21 RV Survey Catch Locations of Yellowtail Flounder within the Study Area, 2007 to 2011.



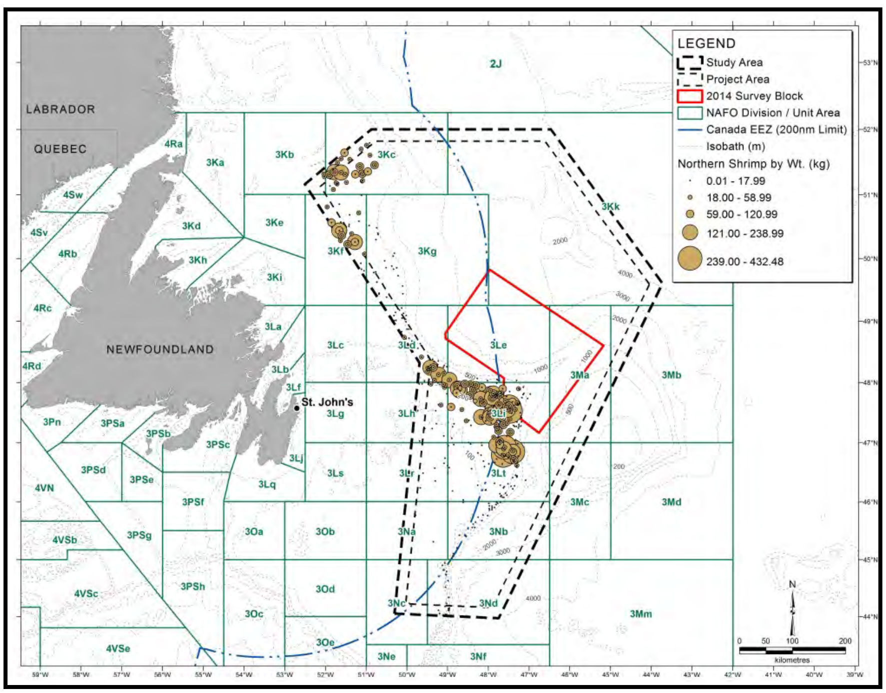
Source: DFO RV Survey Data, 2007-2011.

Figure 4.22 RV Survey Catch Locations of Atlantic Cod within the Study Area, 2007 to 2011.



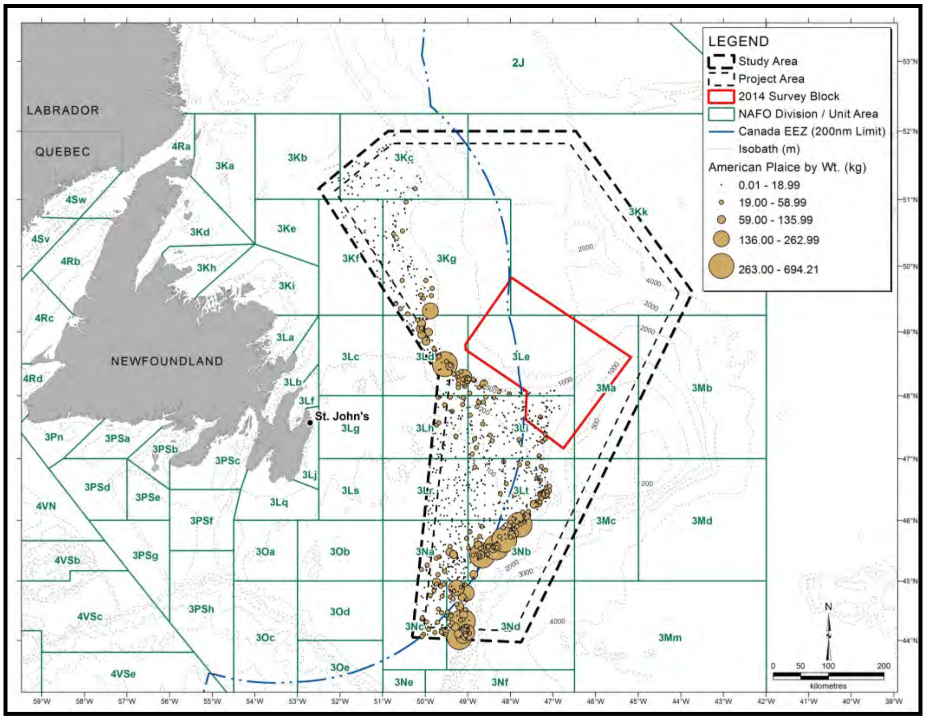
Source: DFO RV Survey Data, 2007-2011.

Figure 4.23 RV Survey Catch Locations of Sponges within the Study Area, 2007 to 2011.



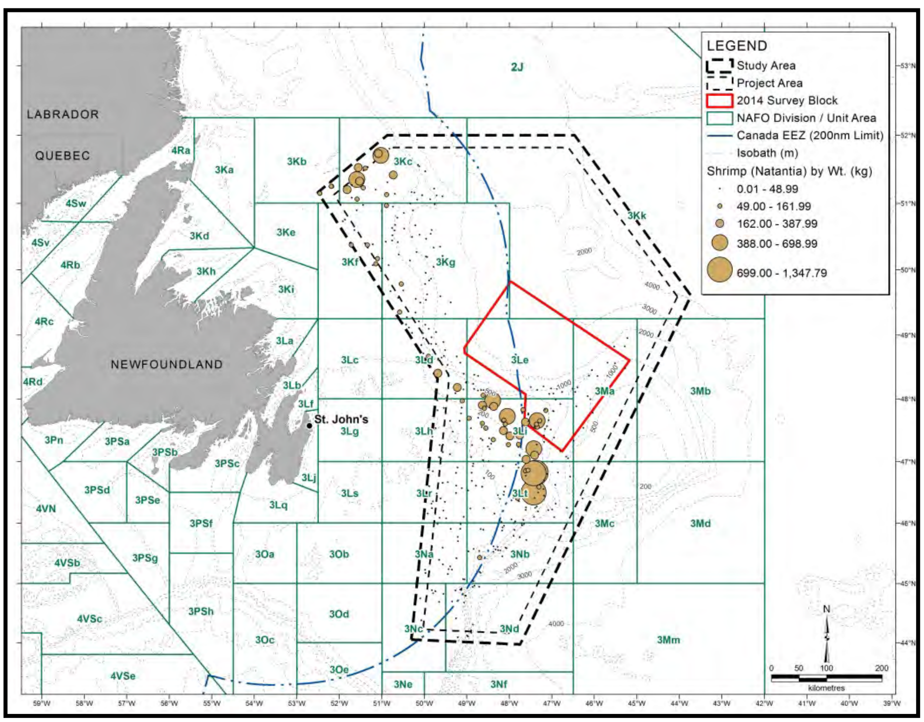
Source: DFO RV Survey Data, 2007-2011.

Figure 4.24 RV Survey Catch Locations of Northern Shrimp within the Study Area, 2007 to 2011.



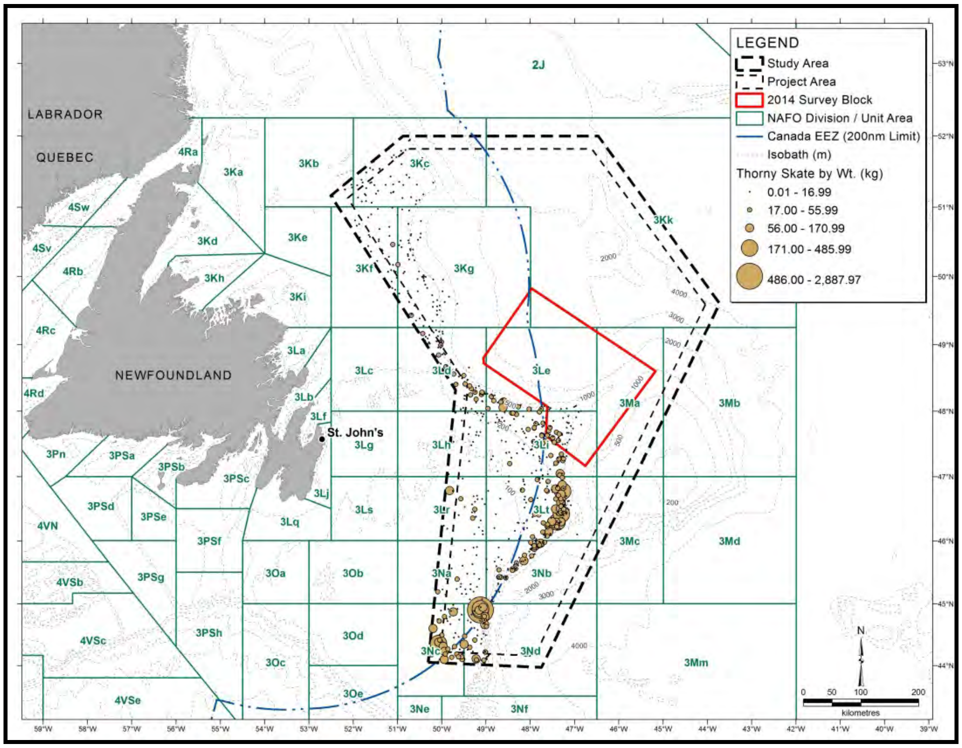
Source: DFO RV Survey Data, 2007-2011.

Figure 4.25 RV Survey Catch Locations of American Plaice within the Study Area, 2007 to 2011.



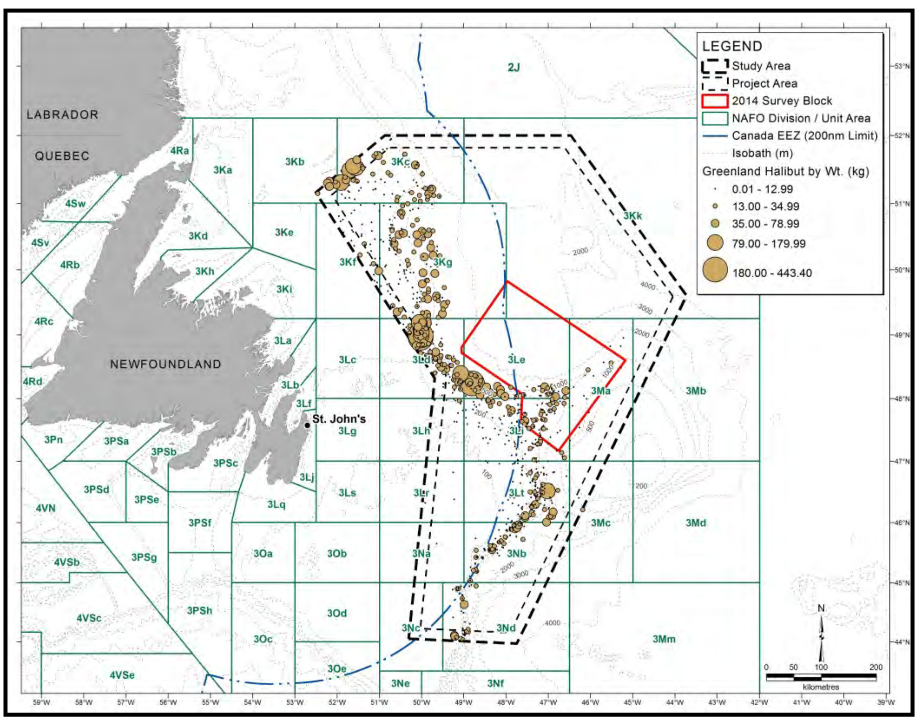
Source: DFO RV Survey Data, 2007-2011.

Figure 4.26 RV Survey Catch Locations of Shrimp (Natantia) within the Study Area, 2007 to 2011.



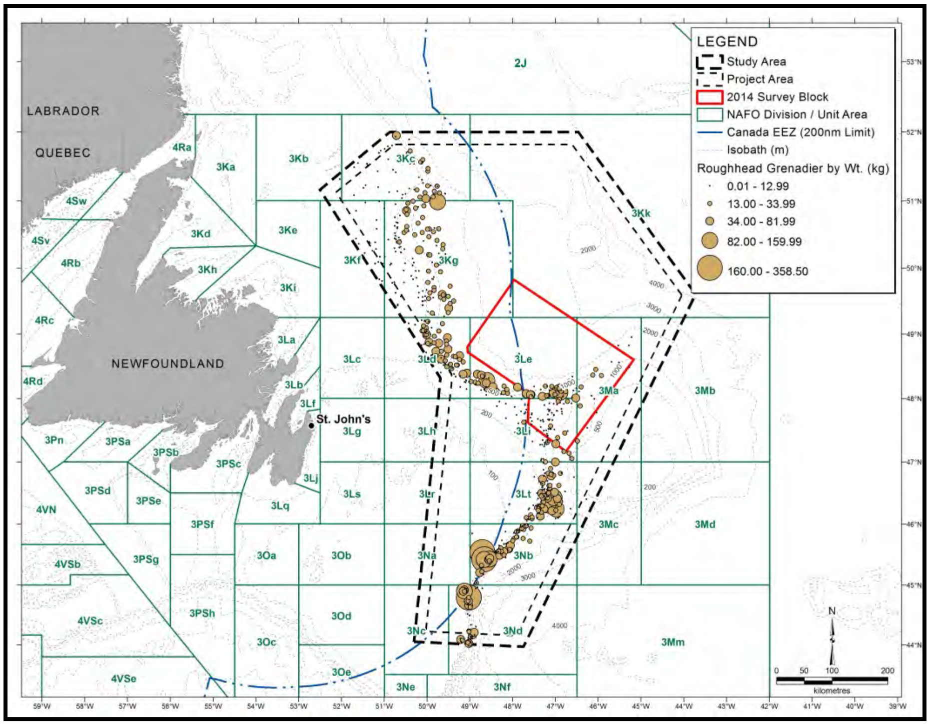
Source: DFO RV Survey Data, 2007-2011.

Figure 4.27 RV Survey Catch Locations of Thorny Skate within the Study Area, 2007 to 2011.



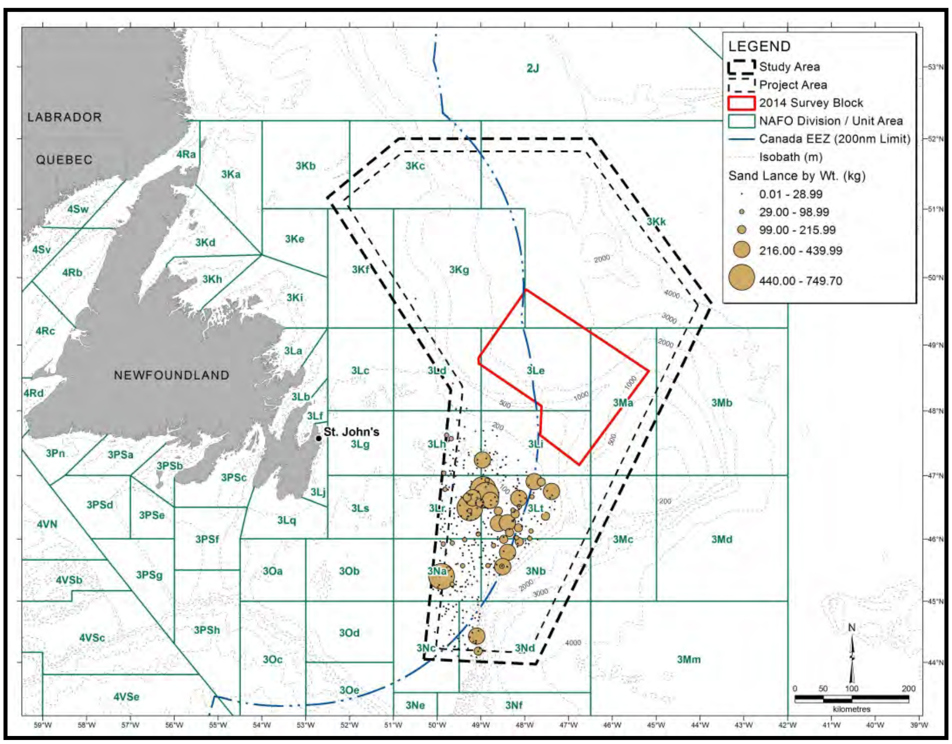
Source: DFO RV Survey Data, 2007-2011.

Figure 4.28 RV Survey Catches of Greenland Halibut within the Study Area, 2007 to 2011.



Source: DFO RV Survey Data, 2007-2011.

Figure 4.29 RV Survey Catches of Roughhead Grenadier within the Study Area, 2007 to 2011.



Source: DFO RV Survey Data, 2007-2011.

Figure 4.30 RV Survey Catches of Sand Lance within the Study Area, 2007 to 2011.

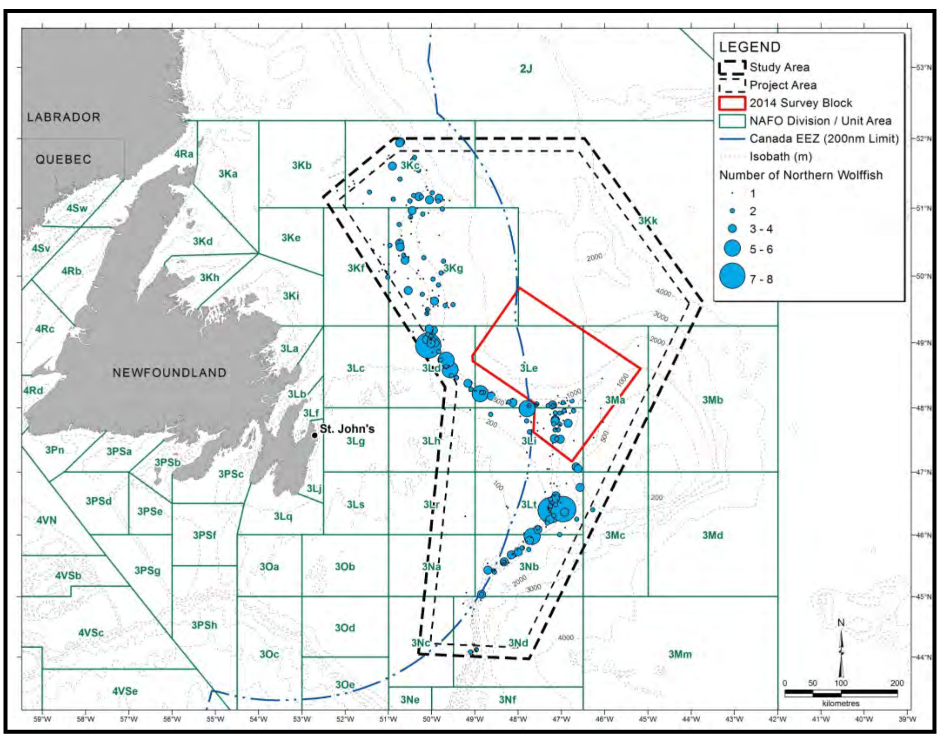
The DFO RV survey catch location distributions within the Study Area during the same five year period for the three wolffish species with status under Schedule 1 of *SARA* and for corals are shown in Figures 4.31 to 4.34.

Northern wolffish catches occurred throughout the Study Area where water depths ranged from 200 to 1,000 m. The largest catches were made in the central and southern portions of the Study Area where water depths range between 500 and 1,000 m, including the 2014 proposed Survey Block (Figure 4.31).

Atlantic wolffish catches occurred primarily in the central portion of the Study Area where water depths ranged from 200 to 500 m. The largest catches were made along the entire length of the slope extending from UA 3Ld to UA 3Nb. A few catches were reported along the southwestern boundary of the proposed 2014 Survey Block (Figure 4.32).

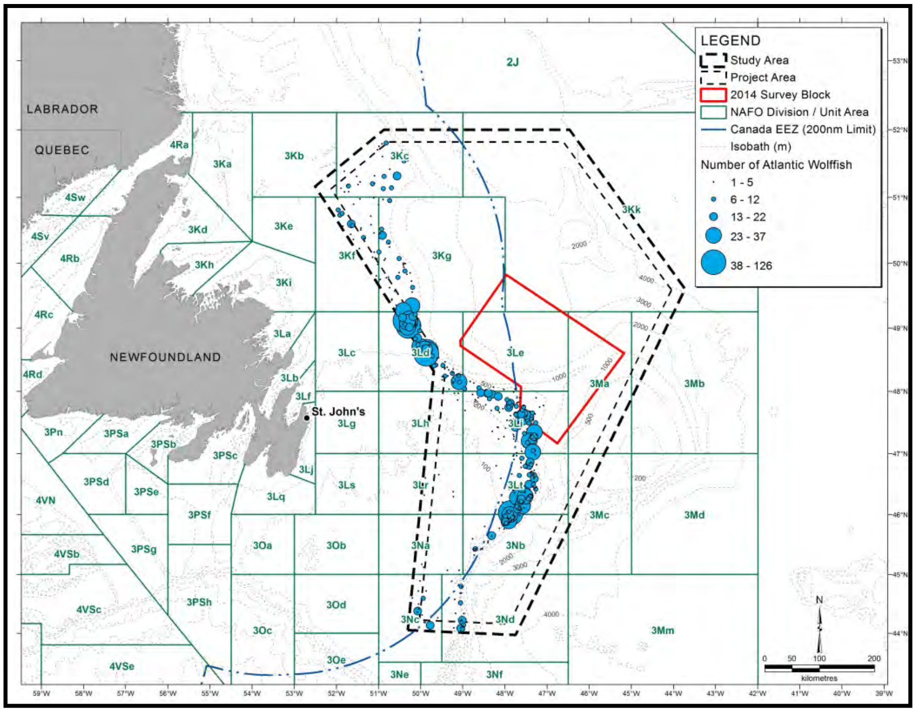
Spotted wolffish catches occurred primarily in the northwestern and central portions of the Study Area where water depths ranged from 200 to 500 m. The largest catches were made in UAs 3Kc, 3Ld and 3Lt. A few catches were reported along the southwestern boundary of the proposed 2014 Survey Block (Figure 4.33).

Coral catches occurred primarily in the central and southern portions of the Study Area where water depths ranged from <100 to >1,000 m. The largest catches were made in UA 3Lt, followed by UAs 3Le and 3Li, including the southern portion of the proposed 2014 Survey Block (Figure 4.34).



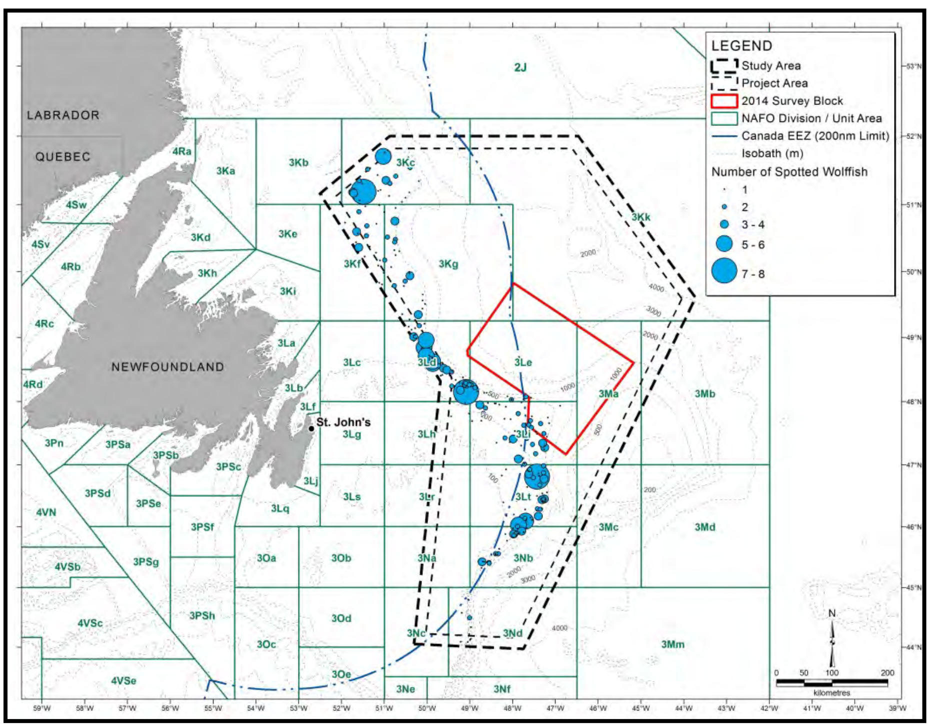
Source: DFO RV Survey Data, 2007-2011.

Figure 4.31 RV Survey Catches of Northern Wolffish within the Study Area, 2007 to 2011.



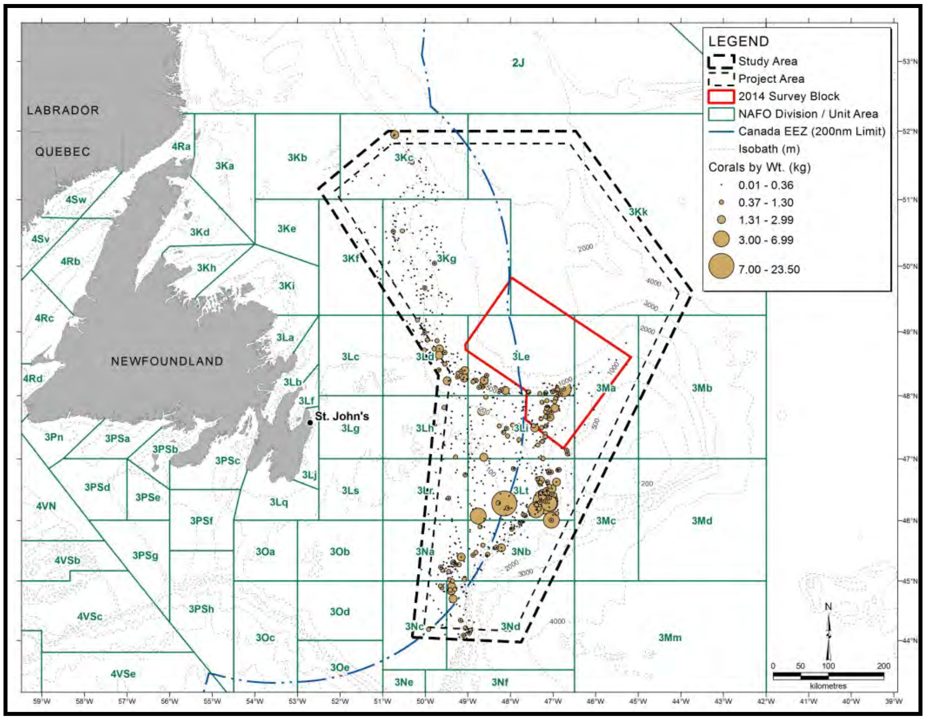
Source: DFO RV Survey Data, 2007-2011.

Figure 4.32 RV Survey Catches of Atlantic Wolffish within the Study Area, 2007 to 2011.



Source: DFO RV Survey Data, 2007-2011.

Figure 4.33 RV Survey Catches of Spotted Wolffish within the Study Area, 2007 to 2011.



Source: DFO RV Survey Data, 2007-2011.

Figure 4.34 RV Survey Catches of Corals within the Study Area, 2007 to 2011.

4.3.4.2 Catches by Survey Season and Depth

Catches of the species/groups included in Table 4.5 are divided into spring/summer and fall survey catch weights in Table 4.6. Also included in Table 4.6 are the ranges of mean catch depth for each species/group during each survey time. Spring/summer surveys accounted for 36.6% of the total catch weight, and fall surveys accounted for 63.4% of the total catch weight in the Study Area during 2007-2011.

Species/groups that were caught predominantly during the spring/summer surveys (i.e., >75% of the total catch weight for that species/group) included capelin, basket stars, sand dollars, and shrimp (*Sergestes arcticus*) (Table 4.6). Species/groups that were caught predominantly during the fall surveys included sponges, roughhead grenadier, blue hake, sea stars, jellyfish, roundnose grenadier, longnose eel, marlin spike, black dogfish, Iceland scallop, toad crab, spinytail skate, lanternfishes, large scale tapirfish, threebeard rockling, eelpout, Jensen's skate, octopuses, and deepwater chimaera (Table 4.6). The differences in predominant species/group between the spring/summer and fall surveys are largely due to differences in fishing depth.

Table 4.6 Percentage Catch and Mean Catch Depth by Survey Season for Invertebrates and Fishes Caught during RV Surveys within the Study Area, 2007 to 2011.

Species/Groups	Percent Catch in Spring/Summer Surveys (%)	Spring/Summer Survey Mean Catch Depth Range (m)	Percent Catch in Fall Surveys (%)	Fall Survey Mean Catch Depth Range (m)
Redfishes (*Sebastes* spp.)	35.6	63-723	64.4	49-1442
Yellowtail flounder (*Limanda ferruginea*)	51.0	39-406	49.0	38-205
Atlantic cod (*Gadus morhua*)	56.3	39-631	43.7	38-657
Sponges (Porifera)	2.3	45-715	97.7	40-1,448
Northern shrimp (*Pandalus borealis*)	46.3	66-641	53.7	46-784
American plaice (*Hippoglossoides platessoides*)	41.2	39-723	58.8	38-1,201
Shrimp (Natantia)	35.3	49-702	64.7	49-1,429
Thorny skate (*Raja radiata*)	34.2	39-715	65.8	38-1,315
Greenland halibut (*Reinhardtius hippoglossoides*)	32.5	67-723	67.5	52-1,448
Roughhead grenadier (*Macrourus berglax*)	21.7	64-723	78.3	62-1,448
Sand lance (*Ammodytes dubius*)	42.4	20-438	57.6	40-414
Capelin (*Mallotus villosus*)	91.5	39-723	8.5	55-637
Sea cucumbers (Holothuroidea)	44.8	39-472	55.2	38-1,448
Blue hake (*Antimora rostrata*)	5.5	263-723	94.5	245-1,448
Sea anemones (Actiniaria)	27.2	48-701	72.8	57-1,448
Sea stars (Asteroidea)	7.6	39-715	92.4	38-1,448
Basket stars (Ophiuroidea)	94.7	40-598	5.3	42-1,448
Snow crab [males] (*Chionoecetes opilio*)	33.3	57-631	66.7	51-652
Jellyfish (Scyphozoa)	18.8	82-723	81.2	43-1,448
Witch flounder (*Glyptocephalus cynoglossus*) Eel pout	25.3	49-723	74.7	79-1,442
Greenland shark (*Somniosus microcephalus*)	50.0	458	50.0	389
Roundnose grenadier (*Coryphaenoides rupestris*)	1.5	439-723	98.5	106-1,448
Atlantic wolffish (*Anarhichas lupus*)	59.3	40-622	40.7	44-673
Longnose eel (*Synaphobranchus kaupi*)	5.7	196-723	94.3	311-1448
Marlin spike (*Nezumia bairdi*)	21.9	60-723	78.1	73-1,448
Sculpins (Cottidae)	39.2	40-723	60.8	38-1,365
Comb jellies (Ctenophora)	34.4	20-109	65.6	38-97
Northern wolffish (*Anarhichas denticulatus*)	26.6	97-723	73.4	63-1,448
Sea urchins (Echinoidea)	32.5	40-603	67.5	38-1,448
Black dogfish (*Centroscyllium fabricii*)	3.4	629-694	96.6	619-1,424
Spotted wolffish (*Anarhichas minor*)	38.8	100-694	61.2	59-1,369
Vahl's eelpout (*Lycodes vahlii*)	30.8	80-702	69.2	49-960
Tunicates (Tunicata)	29.4	46-585	70.6	44-1,442
Sand dollars (Clypeasteroida)	83.0	39-694	17.0	38-1,402
Iceland scallop (*Chlamys islandica*)	3.7	48-471	96.3	45-643
Toad crab (*Hyas* spp.)	22.7	39-452	77.3	38-1,149
Spinytail skate (*Raja* [*Bathraja*] *spinicauda*)	24.6	290-701	75.4	288-1,412
Lanternfishes (Myctophidae)	15.3	254-723	84.7	69-1,448
Large scale tapirfish (*Notacanthus nasus*)	10.5	406-723	89.5	115-1,448
Arctic eelpout (*Lycodes reticulatus*)	35.1	42-402	64.9	47-627
Longfin hake (*Urophycis chesteri*)	45.2	283-682	54.8	222-1,243

Species/Groups	Percent Catch in Spring/Summer Surveys (%)	Spring/Summer Survey Mean Catch Depth Range (m)	Percent Catch in Fall Surveys (%)	Fall Survey Mean Catch Depth Range (m)
Threebeard rockling (*Gaidropsarus* spp.)	8.5	205-715	91.5	63-1,448
Eelpout (*Lycodes* sp.)	3.4	199-340	96.6	73-1,377
Jensen's skate (*Raja jenseni*)	2.0	653-715	98.0	289-1,442
Striped shrimp (*Pandalus montagui*)	43.0	40-421	57.0	47-601
Shrimp (*Sergestes arcticus*)	95.1	254-723	4.9	193-1,448
Corals (Anthozoa)	42.1	39-715	57.9	41-1,448
Eelpout (Zoarcidae)	35.4	44-667	64.6	64-1,332
Brittle stars (Ophiuroidea)	28.5	50-602	71.5	46-1,436
Alligatorfish (Scorpaeniformes)	35.2	49-694	64.8	45-601
Shrimp (*Acanthephyra pelagica*)	23.0	351-723	77.0	119-1,448
Octopuses (Octopoda)	5.2	82-701	94.8	44-1,448
Deepsea cat shark (*Apristurus profundorum*)	0.0	-	100.0	871-1,448
Barracudinas (Paralepididae)	52.3	210-723	47.7	193-1,424
Blennies (*Lumpenus* spp.)	51.7	134-406	48.3	119-460
Deepwater chimaera (*Hydrolagus affinis*)	0.0	-	100.0	1,055-1,448
Atlantic halibut (*Hippoglossus hippoglossus*)	37.5	309-453	62.5	296-627
Shrimp (*Argis dentata*)	39.2	55-452	60.8	59-1,442

Source: DFO RV Survey Data 2007-2011.

DFO RV survey catch weights in the Study Area from 2007 to 2011 were also analyzed for 11 mean catch depth ranges and results are presented in Table 4.7. For each mean catch depth range, the number of individuals and the total catch weight for corals, sponges and the three wolfish species are also presented. Corals and sponges were caught in all mean catch depth ranges. The types of corals most commonly caught were sea broccoli coral and bubblegum coral. Other types reported include sea strawberry coral, sea pens, mushroom coral and blackwire coral. The latter three types were only reported caught at depths exceeding 700 m. Unlike northern and spotted wolffishes, Atlantic wolffish were not caught below 700 m. See Section 4.3.4.1 for more information on distribution of catches, including water depth ranges within which most of the catches occurred.

Table 4.7 Total Catch Weights and Predominant Species Caught at Various Mean Catch Depth Ranges, 2007 to 2011 RV Surveys Combined.

Mean Catch Depth (m)Range	Total Catch Weight (kg)	Predominant Species
<100 m	61,806	Yellowtail flounder (44%) Sand lance (13%) Sea cucumbers (9%) American plaice (8%) Sea stars (6%) Thorny skate (4%) Corals [211 indiv.; 47 kg] Sponges [52 indiv.; 167 kg] N wolffish [4 indiv.; 9 kg] A wolffish [27 indiv.; 581 kg] S wolffish [2 indiv.; 4 kg]
≥100 m to <200 m	24,282	Northern shrimp (14%) Shrimp (Natantia) (13%) Basket stars (11%) Sand lance (11%) American plaice (11%) Capelin (9%) Thorny skate (4%) Male snow crab (4%) Redfishes (4%) Corals [124 indiv.; 38 kg] Sponges [36 indiv.; 104 kg] N wolffish [9 indiv.; 25 kg] A wolffish [53 indiv.; 145 kg] S wolffish [42 indiv.; 204 kg]
≥200 m to <300 m	90,902	Redfishes (52%) Northern shrimp (14%) Shrimp (Natantia; 10%) Atlantic cod (6%) Capelin (4%) American plaice (4%) Thorny skate (3%) Corals [107 indiv.; 17 kg] Sponges [112 indiv.; 325 kg] N wolffish [22 indiv.; 77 kg] A wolffish [158 indiv.; 706 kg] S wolffish [96 indiv.; 263 kg]
≥300 m to <400 m	84,792	Redfishes (55%) Atlantic cod (17%) Thorny skate (5%) Shrimp (Natantia) (4%) Northern shrimp (4%) American plaice (2%) Greenland halibut (2%) Corals [127 indiv.; 22 kg] Sponges [118 indiv.; 188 kg] N wolffish [47 indiv.; 251 kg] A wolffish [127 indiv.; 433 kg] S wolffish [76 indiv.; 259 kg]

Mean Catch Depth (m)Range	Total Catch Weight (kg)	Predominant Species
≥400 m to <500 m	49,598	Redfishes (58%) Thorny skate (8%) Atlantic cod (6%) American plaice (5%) Sea anemone (4%) Roughhead grenadier (3%) Greenland halibut (3%) Corals [109 indiv.; 21 kg] Sponges [72 indiv.; 167 kg] N wolffish [57 indiv.; 310 kg] A wolffish [23 indiv.; 42 kg] S wolffish [36 indiv.; 193 kg]
≥500 m to <600 m	12,330	Redfishes (64%) American plaice (6%) Roughhead grenadier (4%) Greenland halibut (3%) Witch flounder (3%) Corals [48 indiv.; 23 kg] Sponges [25 indiv.; 165 kg] N wolffish [25 indiv.; 146 kg] A wolffish [1 indiv.; 1 kg] S wolffish [7 indiv.; 74 kg]
≥600 m to <700 m	16,425	Redfishes (22%) Greenland halibut (17%) Roughhead grenadier (12%) American plaice (8%) Witch flounder (8%) Blue hake (4%) Marlin spike (4%) Sea anemones (3%) Jellyfish (3%) Corals [108 indiv.; 31 kg] Sponges [49 indiv.; 264 kg] N wolffish [58 indiv.; 338 kg] A wolffish [5 indiv.; 11 kg] S wolffish [7 indiv.; 47 kg]
≥700 m to <800 m	2,301	Greenland halibut (29%) Roughhead grenadier (19%) Blue hake (9%) Redfishes (6%) Northern wolfish (4%) Roundnose grenadier (4%) Black dogfish (4%) Marlin spike (4%) Jellyfish (3%) Corals [31 indiv.; 33 kg] Sponges [7 indiv.; 41 kg] N wolffish [12 indiv.; 90 kg]

Mean Catch Depth (m)Range	Total Catch Weight (kg)	Predominant Species
≥800 m to <900 m	7,395	Sponges (38%) Greenland halibut (12%) Roughhead grenadier (10%) Blue hake (8%) American plaice (8%) Jellyfish (4%) Roundnose grenadier (3%) Longnose eel (3%) Northern wolfish (2%) Corals [85 indiv.; 13 kg] Sponges [14 indiv.; 2,799 kg] N wolffish [20 indiv.; 150 kg]
≥900 m to < 1,000 m	3,149	Roughhead grenadier (21%) Blue hake (14%) Roundnose grenadier (13%) Greenland halibut (12%) Longnose eel (8%) Black dogfish (8%) Jellyfish (5%) Marlin spike (4%) Northern wolfish (3%) Corals [66 indiv.; 6 kg] Sponges [10 indiv.; 28 kg] N wolffish [14 indiv.; 85 kg]
≥1,000 m	32,737	Sponges (54%) Roughhead grenadier (9%) Blue hake (8%) Greenland halibut (8%) Roundnose grenadier (4%) Longnose eel (3%) Jellyfish (3%) Black dogfish (2%) Corals [279 indiv.; 37 kg] Sponges [59 indiv.; 17,555 kg] N wolffish [27 indiv.; 156 kg] S wolffish [1 indiv.; 9 kg]

Source: DFO RV Survey Data 2007-2011.

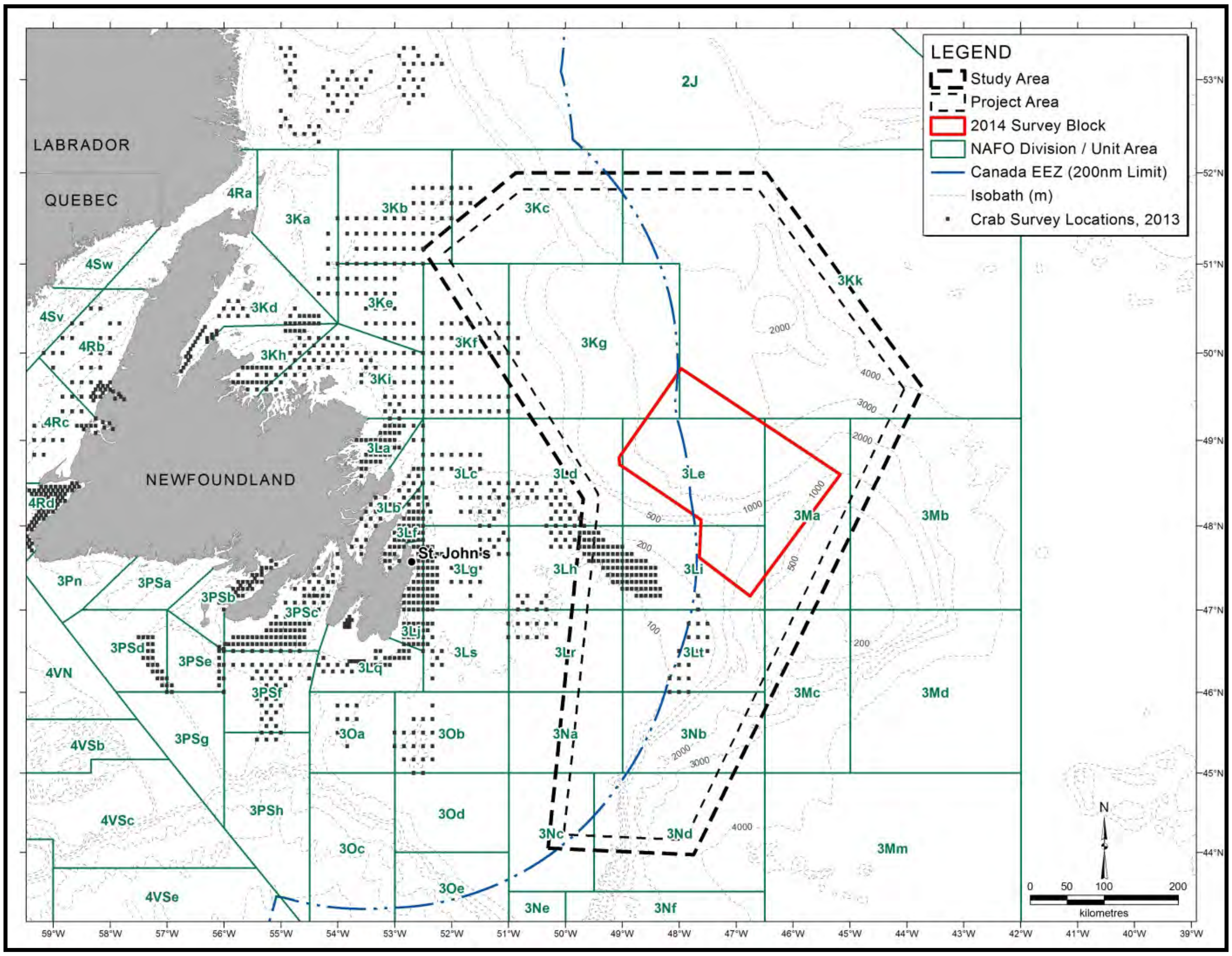
4.3.5 Aboriginal and Recreational Fisheries

There are no Aboriginal or recreational fisheries in the Study Area.

4.3.6 Industry and DFO Science Surveys

Fisheries research surveys conducted by DFO, and sometimes by the fishing industry, are important to the commercial fisheries to determine stock status, as well as for scientific investigation. In any year, there may be overlap between the Study Area and DFO research surveys in NAFO 3LM, depending on the timing in a particular year. Typically, DFO conducts a spring survey in sections of 3LNOPs (April to July), and a fall survey of 2HJ3KLMNO (September or October to December). The fall survey may employ two vessels. The deeper waters of 3L (slope areas) are typically surveyed in October, and the shallower areas in November or December. There is also an annual spring acoustic survey for capelin in NAFO Division 3L. In 2013, DFO multispecies research science surveys were conducted from March to December; fall survey vessels included the Coast Guard Vessels *Alfred Needler* and *Teleost*. The 2014 survey schedule is currently in draft form (G. Sheppard, December 2013, pers. comm.).

Members of the FFAW have been involved in the snow crab DFO-industry collaborative post-season trap survey in various offshore harvesting locations over the last ten years or so. This survey is conducted every year. It starts around September 1 and may continue until November before it is completed. The set locations are determined by DFO and do not change from year to year (Figure 4.35).



Source: DFO 2014.

Figure 4.35 Joint DFO-Industry Post-season Crab Survey Locations, 2014.

4.4 Marine Mammals and Sea Turtles

Marine mammals and sea turtles that may occur in the Study Area are described below. Some of these species are *SARA* species and these are further discussed in Section 4.6.

4.4.1 Marine Mammals

A total of 21 marine mammals, including 18 cetacean and three seal species are known or expected to occur in the Study Area (Table 4.8). Most marine mammals use the Study Area seasonally, and the region likely represents important foraging areas for many.

4.4.1.1 Information Sources

A large database of cetacean sightings in Newfoundland and Labrador waters has been compiled by DFO in St. John's (J. Lawson, DFO, pers. comm., 2013) and has been made available for the purposes of describing cetacean sightings within the Study Area. These data can be used to indicate what species have occurred in the region, but cannot provide fine-scale descriptions or predictions of abundance, distribution, or habitat use.

As noted by DFO, a number of *caveats* should be considered when using the DFO cetacean sighting data, and include:

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

The DFO database includes sightings collected as part of the marine mammal monitoring programs for seismic and controlled source electromagnetic surveys in Orphan and Jeanne d'Arc basins (e.g., Moulton et al. 2005, 2006; Abgrall et al. 2008a,b, 2009). The Orphan Basin SEA (see Section 3.2.5 *in* LGL 2003) provides summaries of marine mammal species and previously available sighting data for the Study Area and adjacent waters. Exploration and drilling EAs and their amendments for Orphan Basin (Buchanan et al. 2004; Moulton et al. 2005; LGL 2005, 2009, 2012b, 2013a), Jeanne d'Arc Basin (LGL 2008a, 2011a, 2012a, 2013b), and the northern Grand Banks (LGL 2011b) have also provided information on marine mammals. As requested in the Scoping Document, the following overview of marine mammal species likely to occur in the Study Area summarizes and updates relevant information with particular focus on spatial and temporal distribution and life history parameters.

4.4.1.2 Overview of Marine Mammals

As noted earlier, a total of 21 marine mammals, including 18 cetacean and three seal species are known or expected to occur in the Study Area (Table 4.8). Several cetaceans are considered *at risk* by COSEWIC and listed under *SARA*. Those species listed under Schedule 1 of *SARA* are described in Section 4.6.

A summary of the prey of marine mammals that occur in the Study Area is provided in LGL (2008a—see Table 4.14 in that report). For most species of marine mammals, there are no reliable population estimates for Atlantic Canada and most estimates are based on data collected in northeastern U.S. waters. Thus, Waring et al. (2013) was reviewed to acquire updated population estimates for cetaceans considered part of the Western North Atlantic stock.

Table 4.9 summarizes the cetacean sightings from the DFO Cetacean Database for the Study Area. The data sources include historical and new sightings from commercial whaling, fisheries observers, MMOs aboard seismic vessels, and the general public.

Table 4.8 Marine Mammals Known or Expected to Occur in the Study Area.

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Baleen Whales (Mysticetes)					
Blue Whale *(Balaenoptera musculus)*	Rare	Year-round, mostly spring to summer	Coastal, pelagic	Schedule 1: E	E
North Atlantic Right Whale *(Eubalaena glacialis)*	Extremely Rare	Summer?	Coastal, shelf	Schedule 1: E	E
Fin Whale *(Balaenoptera physalus)*	Common	Year-round, mostly summer	Pelagic, slope	Schedule 1: SC	SC
Sei Whale *(Balaenoptera borealis)*	Uncommon	May-Sep	Pelagic, offshore	NS	DD
Humpback Whale *(Megaptera movaeangliae)*	Common	Year-round, mostly May-Oct	Coastal, banks	Schedule 3: SC	NR
Minke Whale *(Balaenoptera acutorostrata)*	Common	Year-round, mostly May-Oct	Shelf, banks, coastal	NS	NR
Toothed Whales (Odontocetes)					
Sperm Whale *(Physeter macrocephalus)*	Uncommon to Common	Year-round, mostly summer	Pelagic, slope, canyons	NS	NR, LPC
Northern Bottlenose Whale *(Hyperoodon ampullatus)* Scotian Shelf population	Uncommon	Year-round, mostly May-Oct	Pelagic, slope, canyons	Schedule 1: E	E
Northern Bottlenose Whale *(Hyperoodon ampullatus)* Davis Strait-Baffin Bay-Labrador Sea population	Uncommon	Year-round, mostly May-Oct	Pelagic, slope, canyons	NS	SC
Sowerby's Beaked Whale *(Mesoplodon bidens)*	Rare	Summer?	Pelagic, deep slope, canyons	Schedule 1: SC	SC
Killer Whale *(Orcinus orca)*	Uncommon	Year-round, mostly Jun-Oct	Widely distributed	NS	SC
Cuvier's Beaked Whale *(Ziphius cavirostris)*	Rare	Year-round?	Slope, offshore	NS	NR, MPC
Long-finned Pilot Whale *(Globicephala melas)*	Common	May-Sep	Mostly pelagic	NS	NR
***Dolphins/Porpoises* (Delphinids/Phocoenids)**					

Species	Study Area		Habitat	*SARA* Status[a]	COSEWIC Status[b]
	Occurrence	Season			
Atlantic White-sided Dolphin *(Lagenorhynchus acutus)*	Common	Year-round, mostly Jun-Oct	Shelf, slope	NS	NR
Short-beaked Common Dolphin *(Delphinus delphis)*	Common	Jun-Oct	Nearshore, pelagic	NS	NR
White-beaked Dolphin *(Lagenorhynchus albirostris)*	Uncommon	Year-round, mostly Jun-Sep	Shelf	NS	NR
Common Bottlenose Dolphin *(Tursiops truncates)*	Rare	Summer?	Shelf, coastal, pelagic (occasionally)	NS	NR
Striped Dolphin *(Stenella coeruleoalba)*	Uncommon	Summer	Offshore convergence zones and upwelling	NS	NR
Harbour Porpoise *(Phocoena phocoena)*	Uncommon	Year-round, mostly spring to fall	Shelf, coastal, pelagic (occasionally)	Schedule 2: T	SC
True Seals (Phocids)					
Harp Seal *(Pagophilus groenlandicus)*	Common	Year-round	Pack ice, pelagic	NS	NC, MPC
Hooded Seal *(Cystophora cristata)*	Common	Year-round	Pack ice, pelagic	NS	NR, MPC
Grey Seal *(Halichoerus grypus)*	Rare	Winter?	Coastal, shelf	NS	NR

Notes: E=Endangered, T=Threatened, SC=Special Concern, NR=Not at Risk, NC=Not Considered, DD=Data Deficient, NS=No Status, LPC=Low Priority Candidate, MPC=Mid Priority Candidate. ? indicates uncertainty.
[a]www.sararegistry.gc.ca/default_e.cfm, accessed January 2014.
[b]www.cosewic.gc.ca/eng/sct5/index_e.cfm, accessed January 2014.

Table 4.9 Cetacean Sightings within the Study Area, 1961 to 2009.

Species	Number of Sightings	Minimum Number of Individuals	Months Observed
Baleen Whales (Mysticetes)			
Blue Whale	2	2	Apr; Jun
North Atlantic Right Whale	1	2	Jun
Humpback Whale	683	2254	Year-round
Fin Whale	217	383	Mar-Dec
Fin/Sei Whale	18	30	Jun-Sep
Sei Whale	36	61	Feb; May-Sep
Minke Whale	153	285	Jan; Apr-Dec
Toothed Whales (Odontocetes)			
Sperm Whale	135	308	Year-round
Killer Whale	30	168	Jan; May-Nov
Long-finned Pilot Whale	264	4714	Jan-Mar; May-Dec
False Killer Whale[a]	1	2	Jun
Northern Bottlenose Whale	28	103	Mar; May-Oct
Sowerby's Beaked Whale	1	4	Sep
Beluga[b]	1	1	Jul
Dolphins/Porpoises			
Common Bottlenose Dolphin	1	15	Sep
Short-beaked Common Dolphin	43	1010	Mar; Jul-Oct
Atlantic White-sided Dolphin	48	870	Feb; May-Oct
White-beaked Dolphin	36	170	Feb-Mar; May-Aug; Oct
Striped Dolphin	4	19	Aug-Sep
Harbour Porpoise	39	261	Feb-Mar; May-Oct
Unidentified Cetaceans			
Unidentified Baleen Whale	35	55	May-Oct
Unidentified Toothed Whale	4	20	Jul-Sep
Unidentified Dolphin	243	3024	Year-round
Unidentified Cetacean	483	464	Year-round

[a]extralimital record. [b]dead; this species is unlikely to occur in the Study Area.

4.4.1.3 Baleen Whales (Mysticetes)

Six species of baleen whales occur in the Study Area, four of which are considered regular visitors (see Table 4.9). Within the Study Area, blue whales are considered rare and North Atlantic right whales are considered extremely rare, and these species are described in the Species at Risk section (Section 4.6). 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.

Fin Whale

Fin whales are distributed throughout the world's oceans, but are most common in temperate and polar regions (Jefferson et al. 2008). The Atlantic fin whale population is currently designated as *special concern* under Schedule 1 of *SARA* and by COSEWIC (see Table 4.8). Fin whales were heavily targeted by commercial whalers in Newfoundland and Labrador, but continue to regularly occur offshore Newfoundland particularly during summer months. The current estimate for the western North Atlantic stock is 3,522 individuals (CV = 0.27; Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 890 fin whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coasts. The abundance corrected for perception and availability biases was estimated at 1,555 fin whales (Lawson and Gosselin, unpublished data). Based on the DFO cetacean sightings database, fin whales are the second most commonly recorded mysticete in the DFO sightings database, with sightings throughout the western part of the Study Area from March to December (see Table 4.9). Fin whales were commonly observed in Orphan Basin during the 2004 and 2005 seismic monitoring programs (Moulton et al. 2005a, 2006) and were also sighted during the Statoil/Husky seismic monitoring program in Jeanne d'Arc Basin (Abgrall et al. 2009). Fin whales feed on small schooling fish and krill and tend to be found in areas where these prey concentrate, such as areas of upwelling, shelf breaks, and banks (COSEWIC 2005). It is likely that fin whales commonly occur in the Study Area from spring to fall.

Humpback Whale

Humpback whales are cosmopolitan in distribution and are most common over the continental shelf and in coastal areas (Jefferson et al. 2008). Humpback whales migrate annually from high-latitude summer foraging areas to Caribbean breeding grounds in the winter. Clapham et al. (1993) noted that not all individuals migrate to the tropics each year; some presumably remain near their foraging grounds in high and mid-latitudes during the winter. Primary feeding areas in the North Atlantic, described using genetic and individual identification data, include the Gulf of Maine, eastern Canada, west Greenland, and the Northeast Atlantic (Stevick et al. 2006). The western North Atlantic population of humpback whale is considered *special concern* on Schedule 3 of *SARA* and *not at risk* by COSEWIC. There are an estimated 11,570 individuals in the North Atlantic (Stevick et al. 2003). Lawson and Gosselin (2009) provided an abundance estimate of 1,427 humpback whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coasts. The abundance corrected for perception and availability biases was estimated at 3,712 whales (Lawson and Gosselin, unpublished data). Most large whale entanglements in Newfoundland and Labrador involve humpback whales (Benjamins et al. 2012).

Humpback whales are common over the banks and nearshore areas of Newfoundland and Labrador from June through September, sometimes forming large aggregations to feed primarily on spawning capelin, sand lance, and krill. Davoren (2013) reported several humpback whale hotspots off northeastern Newfoundland that were associated with capelin spawning. Humpbacks are the most commonly recorded mysticete in the Study Area, with sightings occurring year-round (see Table 4.9) but predominantly during summer.

Sei Whale

The distribution of sei whales is poorly known, but they occur in all oceans and appear to prefer mid-latitude temperate waters (Jefferson et al. 2008). In the North Atlantic, sei whales have no status under *SARA* and are considered *data deficient* by COSEWIC. Two stocks of sei whales are currently considered to occur in eastern Canada, on the Scotian Shelf and in the Labrador Sea, although there is limited evidence supporting the definition of the Labrador Sea stock (COSEWIC 2003a). The best estimate of abundance for the Scotian Shelf stock of sei whales is 357 (CV=0.52; Waring et al. 2013). Satellite telemetry data showed that sei whales migrate from the southeast North Atlantic to the Labrador Sea, suggesting a productive feeding ground for sei whales in that area (Olsen et al. 2009; Prieto et al. 2010). A tagged individual sei whale spent up to 96 h in the northwest corner of the Study Area en route to the Labrador Sea (Prieto et al. 2010). Sei whales were regularly sighted in the Orphan Basin during the seismic monitoring programs in 2004 and 2005 (6 and 15 sightings, respectively; Moulton et al. 2005a, 2006), and one sei whale sighting was recorded in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). Based on the DFO cetacean sightings database, at least 36 sei whale sightings have been reported in the Study Area (see Table 4.9). Sei whales appear to prefer offshore, pelagic, deep areas that are often associated with the shelf edge, and feed primarily on copepods (COSEWIC 2003a).

Minke Whale

The smallest of the baleen whales, the minke whale has a cosmopolitan distribution and is found in polar, temperate, and tropical regions (Jefferson et al. 2008). Minke whales have no status under *SARA* and are considered *not at risk* in the North Atlantic by COSEWIC. There are four populations recognized in the North Atlantic based on feeding areas, including the Canadian east coast, west Greenland, central North Atlantic, and Northeast Atlantic stocks (Donovan 1991). However, DNA data suggest that there may be as few as two different stocks in the North Atlantic (Anderwald et al. 2011). There are an estimated 20,741 individuals (CV=0.30) in the Canadian east coast stock, which ranges from the continental shelf of the northeastern United States to Davis Strait (Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 1,315 minke whales for Newfoundland, based on aerial surveys conducted off the southern and eastern coasts. The abundance corrected for perception and availability biases was estimated at 4,691 whales (Lawson and Gosselin, unpublished data). Minke whales are common over the banks and coastal regions of Newfoundland and Labrador from early spring to fall, arriving as early as April and remaining as late as October and November. Within the Study Area, minke whales are the third most commonly recorded mysticete in the DFO sightings database, with sightings predominantly recorded during summer months (see Table 4.9). Thirty-one sightings of minke whales were recorded in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). Minke whales tend to forage in continental shelf waters on small schooling fish like capelin and sand lance, making relatively short duration dives (Stewart and Leatherwood 1985).

4.4.1.4 Toothed Whales (Odontocetes)

Twelve species of toothed whales may occur in the Project Area (see Table 4.8), ranging from the largest of odontocetes, the sperm whale, to the one of the smallest, the harbour porpoise. Many of these species appear to be present in the Study Area only seasonally, but there is generally little information on the distribution and abundance of these species.

Sperm Whale

Sperm whales are most common in tropical and temperate waters, but are widely distributed and occur from the edge of the polar pack ice to the equator (Jefferson et al. 2008). Sperm whales have no status under *SARA* and are designated *not at risk* by COSEWIC. They are currently considered a *low priority candidate* species by COSEWIC. Whitehead (2002) estimated a total of 13,190 sperm whales for the Iceland-Faroes area, the area north of it, and the east coast of North America combined. Waring et al. (2013) reported an estimate of 1,593 animals (CV=0.36) for the U.S. North Atlantic. Since males tend to range further north (Whitehead 2003), sperm whales encountered in the Study Area are more likely to be single males. However, mixed groups with females and juveniles have occasionally been observed in higher latitudes, and males can still form large same-sex aggregations (Whitehead and Weilgart 2000; Whitehead 2003). Sperm whales appear to prefer deep waters off the continental shelf, particularly areas with high secondary productivity, steep slopes, and canyons that may concentrate their primary prey of large-bodied squid (Jaquet and Whitehead 1996; Waring et al. 2001). Sperm whales are deep divers, routinely diving to hundreds of metres, sometimes to depths over 1,000 m, and remaining submerged up to an hour (Whitehead and Weilgart 2000). Sperm whales were regularly sighted in the deep waters of Orphan Basin during the summers of 2004–2007 (Moulton et al. 2005a, 2006; 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). There have been 135 sightings of sperm whales in the Study Area reported in the DFO cetacean sightings database and sightings occurred year-round (see Table 4.9).

Northern Bottlenose Whale

The northern bottlenose whale is profiled in Section 4.6 on Species at Risk.

Sowerby's Beaked Whale

Sowerby's beaked whale is a small beaked whale found only in the North Atlantic, primarily in deep, offshore temperate to subarctic waters (COSEWIC 2006a). Designated as *special concern* under Schedule 1 of *SARA* and by COSEWIC, it is unclear if Sowerby's beaked whales are rare or poorly surveyed due to their deep-diving behaviour, small size, and offshore habitat. It is the most northerly distributed of the *Mesoplodon* spp., with all but one record occurring in the Northwest Atlantic between New England and Labrador (MacLeod 2000; MacLeod et al. 2006). There are an unknown number of Sowerby's beaked whales in the North Atlantic, but they are occasionally encountered offshore of eastern Newfoundland and Labrador. They are most often observed in deep water, along the shelf edge and slope. Based on analysis of stomach contents, their main prey type appears to be mid- to deep-water fish, with squid making up a small portion of the diet (MacLeod et al. 2003; Pereira et al. 2011). Despite the paucity of confirmed sightings, Sowerby's beaked whales may occur in low densities in deep areas in the Study Area. Based on the DFO cetacean sightings database, there has been one sighting of four Sowerby's beaked whales in the Study Area in September 2005 (see Table 4.9).

Killer Whale

Killer whales have a cosmopolitan distribution and occur in all oceans from polar pack ice to the equator, but they appear to be most common in coastal areas of higher latitudes (Jefferson et al. 2008). The Northwest Atlantic/Eastern Arctic population is categorized as *special concern* by COSEWIC but has no status under *SARA*. The number of killer whales in the Northwest Atlantic/Eastern Arctic population is unknown (COSEWIC 2008), but at least 67 individuals have been identified in the Northwest Atlantic (Lawson and Stevens 2013). Killer whale movements are generally related to the distribution and abundance of their primary prey, which can include fish, other marine mammals, seabirds, and cephalopods (Ford et al. 2000). In Newfoundland and Labrador, killer whales have been observed approaching, attacking, and/or consuming other cetaceans, seals, seabirds, and several species of fish; however, it is not known if there is any prey specialization among killer whale groups or individuals (Lawson et al. 2007). Stable isotope analysis of samples from seven killer whales suggests that killer whales off Newfoundland and Labrador mainly feed on fish, although one individual was found to have fed mostly on baleen whales (Matthews and Ferguson 2011). Observed group sizes range from 1 to 30 individuals (rarely more than 15), averaging 5.2 whales (Lawson and Stevens 2013).

Although they occur at relatively low densities, killer whales are considered year-round residents of Newfoundland and Labrador (Lien et al. 1988; Lawson et al. 2007; Lawson and Stevens 2013). Sightings appear to have increased in recent years, but it is unclear if this is due to increased abundance or observer effort. There have been 30 killer whale sightings in the Study Area based on the DFO cetacean sightings database, and these sightings occurred mainly from May through November (see Table 4.9). Four sightings of killer whales were recorded in Jeanne d'Arc Basin during the Statoil/Husky seismic monitoring program in 2008 (Abgrall et al. 2009). A killer whale outfitted with a satellite tag at Admiralty Inlet, Baffin Island, on 15 August 2009, was tracked moving into the North Atlantic in mid-November, where it traveled just to the east of Flemish Cap and the proposed Study Area (Matthews et al. 2011). However, it is uncertain whether killer whales from populations in other areas, such as the Canadian Arctic, Greenland, or Iceland interact with whales off Newfoundland and Labrador (Lawson and Stevens 2013).

Cuvier's Beaked Whale

Cuvier's beaked whale is probably the most widespread of the beaked whales, although it is not found in polar waters (Jefferson et al. 2008). It is occasionally observed at sea and is mostly known from strandings. Its inconspicuous blows, deep-diving behavior, and tendency to avoid vessels help to explain the infrequent sightings (Barlow and Gisiner 2006). Cuvier's beaked whale is not listed under *SARA*, but is considered a *mid-priority candidate* species by COSEWIC (see Table 4.8). Abundance estimates of Cuvier's beaked whale for the Northwest Atlantic are not available.

Cuvier's beaked whale is an offshore, deep-diving species that feeds almost exclusively on large-bodied squid (MacLeod et al. 2003). Deep dives last a median duration of 28.6 min followed by surfacings lasting a median duration of 126 s (MacLeod and D'Amico 2006). Adult males of this species usually travel alone, but these whales can be seen in groups of up to 15, with a mean group size of 2.3 (MacLeod and D'Amico 2006).

In the Northwest Atlantic, Cuvier's beaked whales have stranded and been sighted as far north as the Scotian Shelf, but occur most commonly from Massachusetts to Florida (MacLeod et al. 2006). Cuvier's beaked whales were not reported within the Study Area in the DFO cetacean sightings database; sightings of Cuvier's beaked whales in the Study Area are not expected.

Long-finned Pilot Whale

Long-finned pilot whales are widespread in the North Atlantic and considered to be abundant year-round residents of Newfoundland and Labrador (Nelson and Lien 1996). Long-finned pilot whales have no status under *SARA* and are considered *not at risk* by COSEWIC (see Table 4.8). An estimated 12,619 individuals (CV=0.37) occur in the Northwest Atlantic (Waring et al. 2013). Long-finned pilot whales were the most commonly recorded toothed whale in the DFO cetacean database, with sightings recorded for most months of the year (see Table 4.9) and primarily in waters >600 m deep in the Study Area. Pilot whales studied near Nova Scotia had an average group size of 20 individuals, but groups ranged in size from 2 to 135 animals (Ottensmeyer and Whitehead 2003). Pilot whale distribution is linked with areas of high relief, the shelf break, or slope, and they often exhibit inshore-offshore movements coinciding with the movements of their prey (Jefferson et al. 2008). Short-finned squid have historically been the primary prey item in Newfoundland, but pilot whales also consume other cephalopods and fish (Nelson and Lien 1996).

Atlantic White-sided Dolphin

The Atlantic white-sided dolphin occurs in temperate and sub-Arctic regions of the North Atlantic (Jefferson et al. 2008). This species has no status under *SARA* and is considered *not at risk* by COSEWIC (see Table 4.8). There may be at least three distinct stocks in the North Atlantic, including the Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea, which combined are estimated to total ~48,819 animals (CV=0.61) in the Northwest Atlantic (Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 1,507 white-sided dolphins for Newfoundland, based on aerial surveys conducted off the southern and eastern coasts. The abundance corrected for perception and availability biases was estimated at 3,384 dolphins (Lawson and Gosselin, unpublished data). Atlantic white-sided dolphins occur regularly from spring to fall in offshore areas of Newfoundland, but less is known of their winter distribution. Sightings in the North Atlantic seem to coincide with the 100-m depth contour and areas of high relief. There have been 48 sightings of Atlantic white-sided dolphins recorded in the DFO cetacean sightings database, mainly from May to October (see Table 4.9). Prey items range from cephalopods to pelagic or benthopelagic fishes, such as capelin, herring, hake, sand lance, and cod (Selzer and Payne 1988). Atlantic white-sided dolphins tend to occur in large groups ranging from 2 to 2,500 individuals, with an average of 52.4 (Weinrich et al. 2001).

Short-beaked Common Dolphin

The short-beaked common dolphin is an oceanic species that is widely distributed in temperate to tropical waters of the Atlantic and Pacific Oceans (Jefferson et al. 2008). This species has no status under *SARA* and is considered *not at risk* by COSEWIC (see Table 4.8). An estimated 67,191 individuals (CV=0.29) occur in the Northwest Atlantic (Waring et al. 2013). Lawson and Gosselin (2009) provided an abundance estimate of 576 common dolphins for Newfoundland, based on aerial surveys conducted off the southern and eastern coasts. The abundance corrected for perception and availability biases was estimated at 1,806 dolphins (Lawson and Gosselin, unpublished data). Short-beaked common dolphins form groups ranging in size from several dozens to over 10,000, often moving rapidly and displaying many aerial behaviours, such as porpoising and bowriding (Jefferson et al. 2008). They are found in a variety of habitats, ranging from 100 to 2,000 m deep, but appear to prefer areas with high seafloor relief (Selzer and Payne 1988), and are often associated with features of the Gulf Stream (Hamazaki 2002). The abundance and distribution of short-beaked common dolphins also coincides with peaks in abundance of mackerel, butterfish, and squid (Selzer and Payne 1988). Gaskin (1992) indicated that common dolphins can be abundant off the coast of Nova Scotia and Newfoundland for a few months during the summer. There have been 43 sightings of common dolphins recorded in the Study Area in the DFO cetaceans database, mainly from July to October (see Table 4.9). Most sightings were in waters >500 m deep.

White-beaked Dolphin

White-beaked dolphins have a more northerly distribution than most dolphin species, occurring in cold temperate and sub-Arctic waters of the North Atlantic (Jefferson et al. 2008). This species has no status under *SARA* and is considered *not at risk* by COSEWIC (see Table 4.8). Waring et al. (2013) reported a total of 2003 individuals (CV=0.94) in the Northwest Atlantic. Lawson and Gosselin (2009) provided an abundance estimate of 1,842 white-beaked dolphins for Newfoundland, based on aerial surveys conducted off the southern and eastern coasts. The abundance corrected for perception and availability biases was estimated at 15,625 dolphins (Lawson and Gosselin, unpublished data). Sightings of white-beaked dolphins are considered uncommon in the Study Area. Based on the DFO cetacean sightings database, there have been 36 sightings recorded in the Study Area (see Table 4.9) in both shelf and slope waters. White-beaked dolphins are thought to remain at high latitudes year-round and are generally observed in continental shelf and slope areas, although they also occur in shallow coastal areas (Lien et al. 1997). They typically occur in groups of less than 30 animals, but group sizes up to the low hundreds have also been reported (Lien et al. 1997). White-beaked dolphins have a range of prey items, including squid, crustaceans, and a number of small mesopelagic and schooling fishes like herring, haddock, hake, and cod (Jefferson et al. 2008).

Common Bottlenose Dolphin

The common bottlenose dolphin is widely distributed and found most commonly in coastal and continental shelf waters of tropical and temperate regions (Jefferson et al. 2008). Bottlenose dolphins have no status under *SARA* and are considered *not at risk* by COSEWIC (see Table 4.8). An estimated 81,588 individuals (CV=0.17) occur in offshore waters of the Northwest Atlantic (Waring et al. 2013).

Bottlenose dolphins are considered rare in the Study Area. There has been only one sighting of 15 individuals of bottlenose dolphin recorded in the DFO cetacean sightings database (see Table 4.9). This sighting occurred in September 2005 during Chevron's seismic monitoring program in the Orphan Basin (Moulton et al. 2006).

Striped Dolphin

The preferred habitat of the striped dolphin seems to be deep water along the edge and seaward of the continental shelf, particularly in areas with warm currents (Baird et al. 1993). This species has no status under *SARA* and is considered *not at risk* by COSEWIC (see Table 4.8). Offshore waters of Newfoundland are thought to be at the northern limit of its range. An estimated 46,882 individuals (CV=0.33) occur in the Northwest Atlantic (Waring et al. 2013). There have been only four sightings of this species recorded in the Study Area based on the DFO cetacean sightings database, and these sightings occurred in August and September (see Table 4.9).

Harbour Porpoise

Harbour porpoises occur in continental shelf regions of the northern hemisphere, from Baffin Island to New England in the Northwest Atlantic (Jefferson et al. 2008). There are at least three populations recognized in the Northwest Atlantic: eastern Newfoundland and Labrador, the Gulf of St. Lawrence, and the Gulf of Maine/Bay of Fundy (Palka et al. 1996). Lawson and Gosselin (2009) provided an abundance estimate of 1,195 harbour porpoises for Newfoundland, based on aerial surveys conducted off the southern and eastern coasts. The abundance corrected for perception and availability biases was estimated at 3,326 porpoises (Lawson and Gosselin, unpublished data). In the Atlantic, harbour porpoises are considered *threatened* under Schedule 2 of *SARA* and *special concern* by COSEWIC (see Table 4.8) Limited information is available regarding distribution and movements of harbour porpoises in Newfoundland and Labrador. Data on harbour porpoises incidentally caught in groundfish gillnets suggest that they occur around the entire island of Newfoundland and in southern Labrador (Lawson et al. 2004). Bycatch data also indicate that harbour porpoises occur as far north as Nain, and in deep water (>2000 m) in the Newfoundland Basin and Labrador Sea (Stenson and Reddin 1990 *in* COSEWIC 2006b; Stenson et al. 2011). Harbour porpoises are primarily observed over continental shelves and in areas with coastal fronts or upwellings that concentrate small schooling fish, although sightings also occasionally occur in deeper waters (Read 1999). Bycaught porpoises in Newfoundland appear to primarily consume capelin, Atlantic herring, sand lance, and lantern fish (COSEWIC 2006b). Harbour porpoises typically occur singly or in small groups of up to three individuals, occasionally occurring in larger groups (COSEWIC 2006b). There have been 39 sightings of harbour porpoise in the Study Area recorded in the DFO cetacean sightings database (see Table 4.9).

4.4.1.5 True Seals (Phocids)

Three species of seals including harp, hooded, and perhaps grey seals occur in the Study Area (see Table 4.8). None of these species are designated under *SARA* or by COSEWIC.

Harp Seal

Harp seals are widespread in the North Atlantic and Arctic Oceans, ranging from northern Hudson Bay and Baffin Island to the western North Atlantic and the Gulf of St. Lawrence; vagrants have been reported as far south as Virginia (Scheffer 1958; Rice 1998). They are considered the most abundant seal in the Northwest Atlantic. Based on survey data, the population size for eastern Canada was estimated at 8.3 million seals for 2008 (DFO 2012a). Reproductive rates declined after 2008, and the population size for 2012 was estimated at 7.1 million (Hammill et al. 2013a). COSEWIC is considering the harp seal as a *mid-priority candidate* species; it has no status under *SARA* (see Table 4.8)

Harp seals are common during late winter/early spring off northeast Newfoundland and southern Labrador, where they congregate to breed and pup on the pack ice during February and March (DFO 2012a). Large concentrations are found on the sea ice during the moult in April and May (DFO 2012a). The majority of the Northwest Atlantic population uses this region while the small remainder uses the Gulf of St. Lawrence (Lavigne and Kovacs 1988). During the summer, the majority of harp seals migrate to Arctic and Greenland waters, but some harp seals remain in southern waters (DFO 2012a). Offshore areas of southern Labrador and eastern Newfoundland appear to be major wintering areas (Stenson and Sjare 1997; Lacoste and Stenson 2000). Off Newfoundland and Labrador, harp seal diets are composed of capelin, Arctic cod, sand lance, herring, Atlantic cod, redfish, and Greenland halibut (Hammill and Stenson 2000).

Hooded Seal

Hooded seals are found in the North Atlantic, ranging from Nova Scotia to the high Arctic in Canada (Jefferson et al. 2008). Hooded seals have no status under *SARA* and are considered *not at risk* by COSEWIC; however, they are currently a *mid-priority candidate* species (see Table 4.8). There are an estimated 593,500 individuals in the Canadian Atlantic, the majority of which (~535,800 animals) whelp and breed in the pack ice off northeast Newfoundland and southern Labrador in late winter/early spring (Hammill and Stenson 2006). Four primary pupping and mating areas occur in the North Atlantic and include northeast Newfoundland/southern Labrador, the Gulf of St. Lawrence, Davis Strait, and northeast Greenland (Jefferson et al. 2008). Hooded seals fitted with transmitters in the Gulf of St. Lawrence in March started their migration to Greenland in May by traveling through Cabot Strait or the Strait of Belle Isle (Bajzak et al. 2009). Hooded seals aggregate in eastern Greenland to moult during early summer before dispersing to Davis Strait or the Greenland Sea for late summer and fall (see Hammill and Stenson 2006). Less is known about winter distribution, although there have been winter sightings on the Grand Banks and in the Study Area. Recent telemetry data suggest that hooded seals move along the continental shelf edge after leaving Greenland moulting grounds to Davis Strait and Baffin Bay, followed by southerly migrations into the Labrador Sea during winter (Andersen et al. 2009). Hooded seals consume benthic invertebrates, such as shrimp, as well as Greenland halibut, redfish, Arctic cod, and squid (Hammill and Stenson 2000).

Grey Seal

Grey seals inhabit cold temperate to sub-Arctic regions of the North Atlantic, ranging in Canada from Nova Scotia to Labrador (Jefferson et al. 2008). Grey seals have no status under *SARA* and are considered *not at risk* by COSEWIC (see Table 4.8). Over the last several decades, the Northwest Atlantic population has increased dramatically (Bowen 2011); population estimates in 2010 ranged from 348,900 (Thomas et al. 2011) to 402,700 seals (Hammill and Stenson 2011). The majority breed during the winter on Sable Island, south of Nova Scotia, but pups are also born in the Gulf of St. Lawrence, and along the coast of Nova Scotia (DFO 2010c). An unknown number range into eastern Newfoundland and Labrador. Although generally coastal, grey seals forage over the continental shelf (Lesage and Hammill 2001). Along the east coast of Newfoundland, their diet seems to be dominated by capelin and winter flounder, although other fish species including Atlantic cod, sculpins, and sand lance are also taken (Hammill et al. 2013b). Grey seals are considered rare in the Study Area.

4.4.2 Sea Turtles

Sea turtles regularly occur on the Grand Banks and adjacent waters, and three species could potentially occur within the Study Area. Table 4.10 provides a summary of habitat, occurrence and status in the Study Area for leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), and Kemp's Ridley sea turtles (*Lepidochelys kempii*). Of these species, the leatherback sea turtle is designated as *endangered* under COSEWIC and *SARA* (see Section 4.6 on Species at Risk for profile), and the loggerhead sea turtle is designated as *endangered* under COSEWIC and has no status under *SARA*. Kemp's Ridley sea turtle has no status under *SARA* and is considered a *low priority candidate* species by COSEWIC (Table 4.10).

Table 4.10 Sea Turtles Potentially Occurring in the Study Area.

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

Notes: E=Endangered, NC=Not Considered, NS=No Status, LPC=Low Priority Candidate.
[a]www.sararegistry.gc.ca/default_e.cfm, accessed January 2014.
[b]www.cosewic.gc.ca/eng/sct5/index_e.cfm, accessed January 2014.

4.4.2.1 Loggerhead Sea Turtle

The loggerhead sea turtle has no status under *SARA*, but is designated as *endangered* by COSEWIC (see Table 4.10). The adult female population in the western North Atlantic is estimated at 38,334 individuals (Richards et al. 2011), but there are no current population estimates for loggerhead sea turtles in Atlantic Canada (DFO 2010e). The loggerhead turtle is the most common sea turtle in North American waters (Spotila 2004). Its distribution is largely constrained by water temperature and it does not generally occur where the water temperature is below 15°C (O'Boyle 2001; Brazner and McMillan 2008), but rather prefers waters between 20–25°C (DFO 2010e). There appears to be a seasonal population of juvenile loggerheads in Atlantic Canada (COSEWIC 2010b). Loggerheads can migrate considerable distances between near-equatorial nesting areas and temperate foraging areas. (Hawkes et al. 2007). Loggerheads appear to move with the Gulf Stream into eastern Canadian waters during summer, especially the Scotian Shelf, Georges Bank, and Grand Banks from July through October (Smith 2001, 2002 *in* Brazner and McMillan 2008; Javitech 2002, 2003 *in* Brazner and McMillan 2008). Thousands of mostly immature loggerheads have been bycaught in the Canadian pelagic longline fishery off the east coast since 1999 (Brazner and McMillan 2008; Paul et al. 2010). Loggerheads may be seen in the open seas during migration and foraging (e.g., Mansfield et al. 2009). While foraging at sea, loggerheads likely consume gelatinous zooplankton and squid (Spotila 2004). Although they have not been reported in the Study Area, juvenile loggerhead turtles tagged in U.S. waters were recorded just south of the Study Area (Mansfield et al. 2009). Most loggerhead records offshore Newfoundland have occurred in deeper waters south of the Grand Banks, and sightings have extended as far east as the Flemish Cap (Figures 6 and 7 *in* COSEWIC 2010b).

4.4.2.2 Kemp's Ridley Sea Turtle

Kemp's Ridley sea turtle has no status under *SARA* and is considered a *low priority candidate* species by COSEWIC (see Table 4.10). The Kemp's Ridley sea turtle is more restricted in distribution than both the leatherback and loggerhead sea turtles, occurring primarily in the Gulf of Mexico. Some juveniles occasionally feed along the U.S. east coast and rarely range into eastern Canadian waters (Spotila 2004). Movements outside of the Gulf of Mexico likely occur during summer and in coastal areas. There are records of Kemp's Ridley sea turtle for Nova Scotia, but the presence of this sea turtle off Newfoundland has not been confirmed (McAlpine et al. 2007).

4.5 Seabirds

The offshore zone of the east coast of insular Newfoundland is rich in seabirds year-round. The southward flowing Labrador Current collides with the continental shelf edge causing mixing in the water column creating a productive environment for the growth of plankton. 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. The highly productive Grand Banks support large numbers of seabirds in all seasons (Lock et al. 1994; Fifield et al. 2009). The combination of shelf edges and the Labrador Current flowing through the Study Area create prime conditions for enhanced productivity of plankton, the basis of oceanic food chains.

4.5.1 Information Sources

Seabird surveys in the Study Area and surrounding areas have been conducted by the Canadian Wildlife Service (CWS) and through oil industry related seabird monitoring. Prior to 2000, seabird surveys were sparse 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 conducting seismic surveys or control source electromagnetic surveys within the Study Area from 2004-2008 as part of marine bird monitoring programs required by the C-NLOPB (Moulton et al. 2005a, 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) combined with CWS to fund a 3.5 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). A total of 76 surveys conducted in this time span include many from the Grand Banks and Orphan Basin. Monthly surveys were conducted to the northeast Grand Banks production area from 2006 to 2009.

The results from all of the above surveys have been used here to describe the abundance, diversity and spatial distribution of seabirds in the Study Area. The predicted monthly relative abundance for each species expected to occur regularly in the Study Area are provided in Table 4.11.

4.5.2 Summary of Seabirds in the Study Area

During the ECSAS surveys of Newfoundland and Nova Scotia waters the Sackville Spur, Orphan Basin and Flemish Pass all emerged as important to one or more species/groups in 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 found in summer along the southern edge of the Orphan Basin. ECSAS surveys in the Flemish Pass and Flemish Cap showed local hotspots during winter and spring for Northern Fulmar, Black-legged Kittiwake, Dovekie, gulls (spring only) and murres. Shearwaters were in high densities in summer.

Table 4.11 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
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				S	S	S	S	S	S	S		
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					VS	VS	VS	VS	VS	VS	VS	VS
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	S	S	S	S								
Black-legged Kittiwake	Rissa tridactyla	C	C	C	C	C	S	S	S	U	C	C	C
Arctic Tern	Sterna paradisaea					S	S	S	S	S			
Stercorariidae													
Great Skua	Stercorarius skua					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		
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	VS	VS	VS	S	C	C	C
Common Murre	Uria aalge	S-U	S-U	S-U	S-U	S	S	S	S	S	S-U	S-U	S-U
Thick-billed Murre	Uria lomvia	U-C	U-C	U-C	U-C	S-U	S-U	S-U	S-U	U-C	U-C	U-C	U-C
Razorbill	Alca torda				S	S	S	S	S	S	S	S	
Atlantic Puffin	Fratercula arctica				S	S	S	S	S	U	U	U	

Notes: C = Common, occurring in moderate to high numbers; U = Uncommon, occurring regularly in small numbers; S = Scarce, present, regular in very small numbers; VS = Very Scarce, very few individuals or absent. 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 and Jeanne d'Arc 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. (2005a, 2006); Lang et al. (2006); Lang (2007); Lang and Moulton (2008); Abgrall et al. (2008a,b, 2009.)

4.5.3 Breeding Seabirds in Eastern Newfoundland

Just over five million pairs of seabirds nest on the southeast and east coast of Newfoundland. This includes 4.2 million pairs of Leach's Storm-Petrels and 515,000 pairs of Common Murres (Table 4.12). 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 4.6 million pairs nest at these three locations alone (Table 4.12). This includes the largest Atlantic Canada colonies of Leach's Storm-petrel (3,336,000 pairs on Baccalieu Island), Common Murre (412,524 pairs on Funk Island), Black-legged Kittiwake (23,606 pairs on Witless Bay Islands), Thick-billed Murre (1,000 pairs at Cape St. Mary's), and Atlantic Puffin (216,000 pairs on Witless Bay Islands). These breeding birds may use the western edge of the Study Area during the breeding season. After the nesting season and breeding seabirds disperse over a large area of the Newfoundland and Labrador offshore area including the Study Area.

Table 4.12 Numbers of Pairs of Marine Birds Nesting at Marine Bird Colonies in Eastern Newfoundland.

Species	Wadham Islands	Funk Island	Cape Freels and Cabot Island	Baccalieu Island	Witless Bay Islands	Cape St. Mary's	Middle Lawn Island	Corbin Island	Green Island
Northern Fulmar	-	6[N]	-	12[A]	22[A,F]	Present[A]	-	-	-
Manx Shearwater	-	-	-	-	-	-	13[K, O]	-	-
Leach's Storm-Petrel	1,038[D]	-	250[J]	3,336,000[J]	667,086[H,I,J]	-	13,879[H]	100,000[J]	103,833[M]
Northern Gannet		9,203[N]		2,564[N]	-	14,789[L]	-	-	-
Herring Gull	-	500[J]	-	120[N]	4,638[E,J]	Present[J]	20[J]	5,000[J]	Present[M]
Great Black-backed Gull	Present[D]	100[J]	-	6[N]	166[E,J]	Present[J]	6[J]	25[J]	-
Black-legged Kittiwake	-	95[N]	-	5,100[N]	23,606[F,J]	10,000[J]	-	50[J]	-
Arctic and Common Terns	376[J]	-	250[J]	-	-	-	-	-	-
Common Murre	-	412,524[C]	2,600[J]	1,500[N]	83,001[F,J]	15,484[J]	-	-	-
Thick-billed Murre		250[J]	-	75[N]	600[J]	1,000[J]	-	-	-
Razorbill	273[D]	200[J]	25[J]	500[N]	676[F,J]	100[J]	-	-	-
Black Guillemot	25[J]	1[J]	-	150[N]	20+[J]	Present[J]	-	-	-
Atlantic Puffin	6,190[D]	2,000[J]	20[J]	30,000[J]	272,729[F,G,J]	-	-	-	-
TOTALS	7,902	424,879	3,145	3,376,027	1,052,546	41,373	13,918	105,075	103,833

Sources: A Stenhouse and Montevecchi (1999); B Chardine (2000); C Chardine et al. (2003); D Robertson and Elliot (2002); E Robertson et al. (2001); F Robertson et al. (2004); G Rodway et al. (2003); H Robertson et al. (2002); I Stenhouse et al. (2000); J Cairns et al. (1989); K Robertson (2002); L CWS (unpubl. data); M Russell (2008); N CWS 2012 (unpubl. data); O Fraser et al. 2013.

In addition to local breeding birds, there are many non-breeding seabirds within the Study Area at 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 completion of 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.

4.5.4 Seasonal Occurrence and Abundance

The world range and seasonal occurrence and abundance of seabirds occurring regularly in the Project Area are described below. Table 4.11 summarizes the predicted abundance status for each species monthly. The table uses four categories to define a relative abundance of seabirds species observed:

- Common = occurring in moderate to high numbers;
- Uncommon = occurring regularly in small numbers;
- Scarce = a few individuals occurring; and
- Very Scarce = very few individuals.

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. Information was derived from Abgrall et al. 2008a,b), Baillie et al. (2005), Brown (1986), Lang et al. (2006), Lang (2007), Lock et al. (1994), Moulton et al. (2005a, 2006) and Fifield et al. (2009).

4.5.4.1 Procellariidae (Fulmars and Shearwaters)

Northern Fulmar

Northern Fulmar is common in the Study Area year-round. The Northern Fulmar breeds in the North Atlantic, North Pacific, and Arctic oceans. In the Atlantic, it winters south to North Carolina and southern Europe (Brown 1986; Lock et al. 1994). Through band recoveries, it is known that most individuals in Newfoundland waters are from Arctic breeding colonies. Adults and sub-adult birds are present in the winter with sub-adults remaining through the summer. About 80 pairs breed in eastern Newfoundland (Stenhouse and Montevecchi 1999; Robertson et al. 2004). During the period 1999 to 2002 on the northeast Grand Banks, fulmars were found to be most numerous during spring and autumn (Baillie et al. 2005).

Results from monitoring programs on the Orphan Basin 2004–2007 show Northern Fulmar as being among the top four most numerous species from mid-May to September (Moulton et al. 2006; Abgrall et al. 2008b). Monthly average densities during June, July and August ranged from 1.7 birds/km^2 to 4.8 birds/km^2. Higher densities were recorded in May and September with 30.1 birds/km^2 in May 2005 and 16.1 birds/km^2 in September 2005, and 5.8 birds/km^2 in September 2006. Results from the Jeanne d'Arc Basin show an average of 5.1 birds/km^2 for July and August 2006, 1.2 birds/km^2 in late May to September 2008, and 14.7 birds/km in October and early November in 2005 (Abgrall et al. 2008a; Abgrall et al. 2009).

The ECSAS survey data from 2006–2009 in the Study Area show that Northern Fulmar was present during all seasons (spring, summer and winter) surveyed (Fifield et al. 2009). Densities within the Study Area (considering 1º survey blocks) ranged from 1.0 to 22.4 birds/km^2 in spring to 0 to 10.7 birds/km^2 in summer, and 0 to 33.7 birds/km^2 in winter. High densities were observed along the southern edge of Orphan Basin at the Sackville Spur in winter (Fifield et al. 2009).

Great Shearwater

Great Shearwater migrates north from breeding islands in the South Atlantic and arrives in the Northern Hemisphere during summer. A large percentage of the world population of Great Shearwaters is thought to moult their flight feathers during the summer months while in Newfoundland waters (Brown 1986; Lock et al 1994). Great Shearwater was among the top four most numerous species observed on the Orphan Basin during seismic monitoring 2004–2007 from June to September (Abgrall et al. 2008a; Abgrall et al. 2009). Monthly density averages ranged from 2.4 to 35.4 birds/km^2. Highest densities were in July and August 2005 with averages of 35.4 birds/km^2 and 21.2 birds/km^2 respectively. Great Shearwater can still be numerous in September on the Orphan Basin where an average density of 9.2 birds/km^2 was recorded during September 2005. Seismic monitoring on the Jeanne d'Arc Basin showed Great Shearwater was common in summer with a mean weekly density of 5.1 birds/km^2 from 9 July to 16 August 2006 (Abgrall et al. 2008a) and 11.9 birds/km^2 from 21 May to 29 September 2008 (Abgrall et al. 2009). The ECSAS survey data from 2006–2009 lumps all shearwater species within the Study Area and shows densities per 1º survey blocks ranging from 0 to 14.1 birds/ km^2 during the summer period May to August (Fifield et al. 2009).

Other Shearwaters

Sooty Shearwater follows movements similar to Great Shearwater but is scarce to uncommon during May to early November in the Study Area. Hedd et al. (2012) tracked Sooty Shearwaters from the nesting colony on the Falkland Is (south Atlantic) to waters offshore eastern Newfoundland, including the Study Area. Manx Shearwater breeds in the North Atlantic in relatively small worldwide numbers compared to Great Shearwater. It is expected to be scarce in the Study Area during May to October.

4.5.4.2 Hydrobatidae (Storm-petrels)

Leach's Storm-Petrel

Leach's Storm-Petrel is common and widespread in offshore waters of Newfoundland from April to early November. Very large numbers nest in eastern Newfoundland with more than 3,300,000 pairs breeding on Baccalieu Island (see Table 4.11). Adults range far from nesting sites on multi-day foraging trips during the breeding season. Non-breeding sub-adults stay at sea during the breeding season. It was among the top four most numerous species observed on the Orphan Basin during seismic monitoring 2004–2007 from May to September (Moulton et al. 2006; Abgrall et al. 2008b).

The average density for the period May to September 2005 was 7.43 birds/km^2 (Moulton et al. 2006). The average monthly densities during August and September 2006 were 6.1 birds/km^2 (Abgrall et al. 2008a). And the average density per survey in the period 23 July to 6 September 2007 was 4.3 birds/km^2 (Abgrall et al. 2008b). Densities of Leach's Storm-petrels were lower on seismic surveys on the Jeanne d'Arc Basin with an average of 0.6 birds/km^2 during the survey period 9 July to 16 August 2006 (Abgrall et al. 2008a) and 0.9 birds/km^2 during the period 21 May to 29 September 2008 (Abgrall et al. 2009). The ECSAS survey data from 2006–2009 for storm-petrels within the Study Area shows densities per 1º survey blocks ranging from 0 to 4.2 birds/km^2 during the summer period May to August (Fifield et al. 2009).

Wilson's Storm-Petrel

The Wilson's Storm-petrel migrates north from breeding islands in the South Atlantic to the North Atlantic in the summer months. Newfoundland is at the northern edge of its range. It is expected to be scarce in the Study Area from June to September.

4.5.4.3 Sulidae (Gannets)

Northern Gannet

More than 26,000 pairs of Northern Gannet nest on three colonies in eastern Newfoundland (see Table 4.12). Gannets are common near shore and scarce beyond 100 km from shore. The Study Area is beyond the range of most Northern Gannets. Very few were observed during seabird monitoring on the Orphan and Jeanne d'Arc basins in 2004–2007 (Abgrall et al. 2008a,b; Abgrall 2009; Moulton 2006). This species is expected to be a scarce visitor from April to October within the Study Area.

4.5.4.4 Phalaropodinae (Phalaropes)

Red and Red-necked Phalarope

The Red Phalarope and Red-necked Phalarope both breed in the Arctic to sub-Arctic regions of North America and Eurasia. They winter at sea mostly in the Southern Hemisphere. They migrate and feed offshore, including Newfoundland waters during their spring and autumn migrations. Phalaropes seek out areas of upwelling and convergence where rich sources of zooplankton are found. Very small numbers of migrant Red Phalaropes and Red-necked Phalaropes have been observed in the Orphan Basin and northern Grand Banks during monitoring surveys in 2005–2008 (Abgrall et al. 2008a, 2009). Phalaropes are expected to be scarce in the Study Area during May to October.

4.5.4.5 Laridae (Gulls and Terns)

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

Great Black-backed, Herring, Iceland, Glaucous, and Lesser Black-backed Gulls occur in the Study Area. Great Black-backed Gull and Herring Gull are widespread nesters on the North Atlantic including Newfoundland and Labrador. Glaucous and Iceland Gulls breed in Subarctic and Arctic latitudes. They are winter visitors to Newfoundland. Lesser black-backed Gull is a European gull increasing in numbers as a migrant and wintering species in eastern North America.

Great black-backed Gull is usually the most numerous of the large gulls found in the offshore regions of Newfoundland. The Sackville Spur has been identified as an area with a high concentration of large gulls, particularly in late winter and early spring (Fifield et al. 2009). On drilling platforms on the northeast Grand Banks during 1999 to 2002, Great Black-backed Gull was common from September to February and nearly absent from March to August (Baillie et al. 2005). A similar pattern was observed by environmental observers on offshore installations on the Terra Nova oil field from 1999 to 2009 (Suncor, unpubl. data). Herring Gulls were present in consistent numbers throughout the year but in lower numbers than Great Black-backed Gulls. Results from seismic monitoring programs in Jeanne d'Arc Basin indicate that large gulls were most numerous from mid-August to October ((Abgrall et al. 2008a; Abgrall et al. 2009). In the Orphan Basin, highest densities of Great Black-backed Gull occurred in September (Abgrall et al. 2008b; Moulton et al. 2006).

The ECSAS survey data from 2006–2009 in the Study Area shows 'large gulls' were present during all seasons (spring, summer, fall and winter) surveyed (Fifield et al. 2009). Densities within the Study Area (considering 1º survey blocks) were highest during the non-breeding season ranging from 0 to 7.1 birds/km^2 in spring and 0 to 3.8 birds/km^2 in winter. Herring Gulls were present in consistent numbers throughout the year but in lower numbers than Great Black-backed Gulls. Results from seismic monitoring programs in Jeanne d'Arc Basin between May and October showed that large gulls were most numerous from mid-August to October (Abgrall et al. 2008a; Abgrall et al. 2009).

Black-legged Kittiwake

Black-legged Kittiwake is an abundant species in the North Atlantic. It is a pelagic gull that goes to land only during the nesting season. Non-breeding sub-adults remain at sea for the first year of life. Black-legged Kittiwake is expected to be present within the Study Area year-round and most numerous during the non-breeding season (August to May). Black-legged Kittiwake is present in all months of the year on the Grand Banks. Observations from the drilling platforms on the northeast Grand Banks during 1999 to 2002 showed Black-legged Kittiwakes were present in October to May, but were most prevalent during November to December (Baillie et al. 2005). It was among the most numerous species observed by environmental observers on offshore installations on the Terra Nova oil field during the winter months (Suncor, unpubl. data).

Results from monitoring programs on the Orphan Basin 2004–2007 show Black-legged Kittiwake as being uncommon from mid-May to September (Abgrall et al. 2008a; Moulton et al. 2006). The monthly average density during surveys from 14 May to 24 September 2005 was 0.3 birds/km^2 (Moulton et al. 2006). Higher densities were recorded in August and September 2006 with an average of 3.9 birds/km^2 (Abgrall et al. 2008b). The average density during the survey period of 23 July to 6 September 2007 was 0.01 birds/km^2 (Abgrall et al. 2008b). Results from monitoring programs in the Jeanne d'Arc Basin show an average of 0.01 birds/km^2 for July and August 2006, 0.02 birds/km^2 for late May to September 2008, and 6.6 birds/km^2 in October and early November 2005 ((Abgrall et al. 2008a; Abgrall et al. 2009).

Based on ECSAS survey data collected within the Study Area from 2006–2009, densities of Black-legged Kittiwakes ranged from 0 to 10.2 birds/km2 during the winter period (November to February), 0 to 5.8 birds/km^2 during the spring period (March and April), and 0 to 2.1 birds/km^2 during the summer period May to August (Fifield et al. 2009).

Ivory Gull

The Ivory Gull was designated as an endangered species by COSEWIC in April 2006 and was still listed as endangered under *SARA* Schedule 1 (COSEWIC 2013). Ivory Gull is probably annual in small numbers north of 50°N within the Study Area during periods when sea ice is present in late winter and early spring. It probably occurs irregularly south of 50°N among the ice pack during heavier ice years.

Arctic Tern

Arctic Tern is the only species of tern expected in offshore waters of Newfoundland. It breeds in sub-Arctic to Arctic regions of North America and Eurasia. It winters at sea in the Southern Hemisphere. It migrates in small numbers through the Study Area from May to September. The species is present in such low densities that it is rarely recorded during systematic surveys.

4.5.4.6 Stercorariidae (Skuas and Jaegers)

Great Skua and South Polar Skua

These two skua species occur regularly but in very low densities in offshore waters of Newfoundland during the May to October period. The Great Skua breeds in the Northern Hemisphere, in Iceland and northwestern Europe. The South Polar Skua breeds in the Southern Hemisphere from November to March and migrates to the Northern Hemisphere where it is present from May to October. Identifying skuas to species is difficult at sea. They usually occur where other marine birds are numerous, particularly along shelf edges. Skuas occur in such low densities that they are infrequently recorded during systematic surveys during monitoring programs. Skuas are expected to be scarce in the Study Area from May to October, or early November.

Pomarine Jaeger, Parasitic Jaeger and Long-tailed Jaeger

All three species of jaeger nest in the Subarctic and Arctic in North America and Eurasia. They winter at sea in the Pacific and Atlantic oceans. Pomarine and Parasitic Jaegers winter mainly south of 35°N, and Long-tailed Jaegers winter mainly south of the equator. Adults migrate through Newfoundland waters in spring, late summer and fall, while sub-adults migrate only part-way to the breeding grounds and are present in Newfoundland waters all summer. Because of the low densities of jaegers, they are infrequently recorded during systematic surveys. All three jaeger species were observed in low densities during monitoring programs on the Orphan Basin and Jeanne d'Arc Basin. Jaegers are expected to be scarce in the Study Area from May to October or early November.

4.5.4.7 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 4.11). Dovekies nest mainly in Greenland. Dovekie, Common Murre, Thick-billed Murre, and Atlantic Puffin occur in the Study Area during a large part of the year. Black Guillemot and Razorbills are more coastal and are expected to be rare within the Study Area.

Dovekie

Dovekie breeds in the North Atlantic, primarily in Greenland and eastern Nova Zemlya, Jan Mayen and Franz Josef Land in northern Russia. This species winters at sea south to 35°N. The Dovekie is a very abundant bird, with a world population estimated at 30 million (Brown 1986). A large percentage of the Greenland-breeding Dovekies winter in the Northwest Atlantic, mainly off Newfoundland (Brown 1986). The predicted status in the Study Area is common from October to April, uncommon during the end of spring migration in May and at the beginning of fall migration in September, and very scarce during the summer months (June to August). The low numbers of Dovekies observed from the drill platforms on the northeast Grand Banks 1999 to 2002 was attributed to the difficulty in seeing the small birds from the observation posts (Baillie et al. 2005).

Fort et al. (2013) tracked Dovekies from large breeding colonies along northwestern and east Greenland to wintering areas offshore Newfoundland, where the birds spent the period from early December through April. Some of these birds likely passed through and/or over-wintered in the Study Area.

During seismic monitoring programs on the Orphan Basin in 2005 there was a density of 1.3 birds/km^2 during the last two weeks of May (Moulton et al. 2006). These were mostly birds flying north in late spring migration. Sightings were rare on the Orphan Basin monitoring programs between mid-June and mid-September (Abgrall et al. 2008b; Moulton et al. 2006).

During seismic monitoring programs on the Jeanne d'Arc Basin in 2005, 2006 and 2008, Dovekies were most numerous in October with an average density of 6.6 birds/km^2 during the period of 1 October to 8 November 2005 (Abgrall et al. 2008a). Incidental observations of Dovekies during these monitoring programs suggest larger numbers were present than the systematic surveys showed. For example, approximate daily totals from incidental observations were 500 on 3 October, 2,000 on 13 October, and 2,500 on 4 November (Abgrall et al. 2008a).

The ECSAS survey data from 2006–2009 for Dovekie within the Study Area shows densities per 1º survey blocks ranging from 0 to 22.59 birds/km^2 during the spring period (March and April), 0 to 5.17 birds/km^2 during the summer (May to August) and 0 to 11.41 birds/km^2 during winter (November to February; Fifield et al. 2009).

Murres

The two species of murre, Common and Thick-billed, are often difficult to tell apart with certainty at sea so are often lumped as "murres" during offshore seabird surveys. Common Murre is an abundant breeding species in eastern Newfoundland with just over a half million pairs nesting. Most of these occur at two colonies, Funk Island (412,524 pairs) (Chardine et al. 2003) and the Witless Bay Islands (83,001 pairs) (Robertson et al. 2004) (see Table 4.11). They spend the winter from eastern Newfoundland south to Massachusetts. Thick-billed Murre is an uncommon breeder in eastern Newfoundland with about 2,000 pairs (see Table 4.11); most nest much farther north. But Newfoundland waters are an important wintering area for many of the two million pairs breeding in Arctic Canada and Greenland.

The ECSAS survey data from 2006–2009 for murres within the Study Area shows densities per 1º survey blocks ranging from 0 to 6.65 birds/km^2 during the spring period (March and April), 0 to 6.39 birds/km^2 during summer (May to August) and 0 to 9.98 birds/km^2 during winter (November to February) (Fifield et al. 2009).

During monitoring surveys on the Orphan Basin in 2005, 2006 and 2007 murres were present in low densities May to September (Abgrall et al. 2008b; Moulton et al. 2006). For example during the 14 May to 24 September 2005 surveys, average monthly densities for Thick-billed Murre were 0.6 birds/km^2 in May and 0.7 birds/km^2 in June, but there were none in July to September (Moulton et al. 2006). During the same survey, Common Murre densities were recorded as 0.05 birds/km^2 in May, 0.06 birds/km^2 in June, 0.14 birds/km^2 in July, and none were recorded during surveys in August and September.

On the Jeanne d'Arc Basin, murres were present in moderate densities during seismic monitoring from 1 October to 8 November 2005 with average densities for the period of 4.11 birds/km^2 for Thick-billed Murre and 0.81 birds/km^2 for Common Murre (Abgrall et al. 2008a; Abgrall et al. 2009).

Recent tracking studies of Common and Thick-billed Murres have revealed connections between the Study Area and several murre nesting colonies along the northern and eastern coasts of Canada, from the high arctic to Newfoundland: Prince Leopold I (central high arctic), Coats I and East Digges I (northern Hudson Bay), the Minarets (Baffin I), Gannet Is (Labrador), and Funk I and the Witless Bay Is (Newfoundland) (McFarlane Tranquilla et al. 2013). In particular, Common Murres spent most of the non-breeding season in or near the Study Area (Hedd et al. 2011; Montevecchi et al. 2012), although both species used the Study Area. Some Funk Island parental male Common Murres with fledglings swam through the Orphan Basin during August and September en route to the Southeast Shoal of the Grand Bank (Montevecchi et al. 2012).

Other Alcids (Atlantic Puffin, Razorbill and Black Guillemot)

There are more than 310,000 pairs of Atlantic Puffin nesting in eastern Newfoundland (see Table 4.12). Atlantic Puffins winter off southern Newfoundland and Nova Scotia and they occur in low densities as far offshore as the Study Area. Non-breeding sub-adults occur throughout the summer whereas adults and juveniles can occur in late summer and fall. Seabird surveys during monitoring seismic operations in 2004-2008 conducted within the period mid-May to late September on the Orphan Basin and Jeanne d'Arc Basin recorded very low densities of Atlantic Puffins (Abgrall et al. 2008a,b; Abgrall 2009; Moulton 2006). During monitoring of the seismic survey of Jeanne d'Arc Basin 1 October to 8 November 2005 there was an average density of 1.46 birds/km^2 (Abgrall et al. 2008a). Within the Study Area, Atlantic Puffin is expected to be scarce during the breeding season (April to August) and scarce to uncommon during the post-breeding season (September to December).

About 38,000 pairs of Razorbills nest in eastern Canada (Chapdelaine et al. 2001). Fewer than 2,000 pairs nest in eastern Newfoundland (see Table 4.12). Razorbills tend to occur closer to shore than the murres. Very few were recorded during monitoring programs on the Orphan Basin and Jeanne d'Arc Basin 2004–2008 between mid-May and early November (Abgrall et al. 2008a,b; Abgrall 2009; Moulton 2006). Razorbill is expected to be very scarce in the Study Area from April to November and absent from December to March.

Black Guillemot is common nearshore in Newfoundland and Labrador but would not be expected as far offshore as the Study Area.

4.5.5 Prey and Foraging Habits

Seabirds in the Study Area consume a variety of prey ranging from small fish to zooplankton. Different foraging methods include plunge diving from a height of 30 m into the water, feeding on the surface, and sitting on the water then diving. Table 4.13 summarizes the feeding habits of birds expected to occur in the Study Area.

Table 4.13 Foraging Strategy and Prey of Seabirds in the Study Area.

Species	Prey	Foraging Strategy	Time with Head Under Water	Depth (m)
Procellariidae				
Northern Fulmar	Fish, cephalopods, crustaceans, zooplankton, offal	Surface feeding	Brief	1-2
Great Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	Usually <2, recorded maximum of 18.
Sooty Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	Usually <10, maximum recorded 60.
Manx Shearwater	Fish, cephalopods, crustaceans, zooplankton, offal	Shallow plunging, surface feeding	Brief	1-10
Hydrobatidae				
Wilson’s Storm-Petrel	Crustaceans, zooplankton	Surface feeding	Brief	<0.5
Leach's Storm-Petrel	Crustaceans, zooplankton	Surface feeding	Brief	<0.5
Phalaropodinae				
Red Phalarope	Zooplankton, crustaceans	Surface feeding	Brief	0
Red-necked Phalarope	Zooplankton, crustaceans	Surface feeding	Brief	0
Laridae				
Herring Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Iceland Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5
Glaucous Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Great Black-backed Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Ivory Gull	Fish, crustaceans, offal	Surface feeding, shallow plunging, scavenging	Brief	<0.5
Black-legged Kittiwake	Fish, crustaceans, offal	Surface feeding, shallow plunging	Brief	<0.5
Arctic Tern	Fish, crustaceans, zooplankton	Surface feeding, shallow plunging	Brief	<0.5
Stercorariidae				
Great Skua	Fish, cephalopods, offal	Kleptoparasitism	Brief	<0.5
Pomarine Jaeger	Fish	Kleptoparasitism	Brief	<0.5
Parasitic Jaeger	Fish	Kleptoparasitism	Brief	<0.5
Long-tailed Jaeger	Fish, crustaceans	Kleptoparasitism, surface feeding	Brief	<0.5
Alcidae				
Dovekie	Crustaceans, zooplankton, fish	Pursuit diving	Prolonged	Max 30, average is <30
Common Murre	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 100, average 20-50
Thick-billed Murre	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 100, average 20-60
Razorbill	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 120, average 25
Atlantic Puffin	Fish, crustaceans, zooplankton	Pursuit diving	Prolonged	Max 60, average <60

Sources: Cramp and Simmons (1983); Nettleship and Birkhead (1985); Lock et al. (1994); Gaston and Jones (1998); Ronconi (2010a,b).

4.5.5.1 Procellariidae (Fulmars and Shearwaters)

Northern Fulmar and the three species of shearwaters that are expected to occur in the Study Area feed on a variety of invertebrates, fish and zooplankton at or very near the surface. Capelin is an important food source for shearwaters. They secure their prey by swimming on the surface and picking at items on the surface, or dipping their head under the water. Shearwaters are also capable of diving a short distance under the surface, no deeper than a couple of metres on average.

4.5.5.2 Hydrobatidae (Storm-petrels)

Leach's and Wilson's Storm-petrels feed on small crustaceans, various small invertebrates and zooplankton. These storm-petrels usually feed while on the wing, picking small food items from the surface of the water.

4.5.5.3 Sulidae (Northern Gannet)

Northern Gannet feed on cephalopods and small fish such as capelin, mackerel, herring and Atlantic saury. They secure prey in a spectacular fashion by plunging from a height of up to 30 m into the water, reaching depths of 10 m. They pop back to the surface within a few seconds of entering the water.

4.5.5.4 Phalaropodinae (Phalaropes)

Red-necked and Red Phalaropes eat zooplankton at the surface of the water. They secure food by swimming and rapidly picking at the surface of the water. The head probably rarely goes beneath the surface.

4.5.5.5 Laridae (Gulls and Terns)

The large gulls, Herring, Great Black-backed, Glaucous, and Iceland Gull, are opportunists eating a variety of food items from small fish at the surface, to carrion, and refuse and offal from fishing and other ships at sea. They find this food at the surface and may plunge their head under water to grab food just below the surface but the entire body is rarely submerged.

Ivory Gull often feeds from the wing over water, dip feeding for small fish and invertebrates on the surface. It occasionally plunge dives so that the entire body may be submerged momentarily. It also swims and picks at the surface of the water and walks on ice to scavenge animal carcasses.

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

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

4.5.5.6 Stercorariidae (Skuas and Jaegers)

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

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

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

4.6 Species at Risk

The *Species at Risk Act* (*SARA*) was assented to in December 2002 with certain provisions coming into force in June 2003 (e.g., independent assessments of species by COSEWIC) and June 2004 (e.g., prohibitions against harming or harassing listed *endangered* and *threatened* species or damaging or destroying their critical habitat). Species are listed under *SARA* on Schedules 1 to 3, with only those designated as *endangered* or *threatened* on Schedule 1 having immediate legal implications. Schedule 1 is the official list of wildlife species at risk in Canada. Once a species/population is designated, the measures to protect and recover that species/population are implemented. Three cetacean species/populations, 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 4.14). In addition, Atlantic wolffish, the Atlantic population of fin whales, and Sowerby's beaked whale are designated as *special concern* on Schedule 1 (Table 4.14). Schedules 2 and 3 of *SARA* identify species that were designated "at risk" by COSEWIC prior to October 1999 and must be reassessed using revised criteria before they can be considered for addition to Schedule 1. Species that potentially occur in the Study Area and are considered at risk but which have not received specific legal protection (i.e., prescribed penalties and legal requirement for recovery strategies and plans) under *SARA* are also listed in Table 4.9, as are species designated as *endangered*, *threatened* or of *special concern* under COSEWIC.

Under *SARA*, a 'recovery strategy' and corresponding 'action plan' must be prepared for *endangered*, *threatened*, and *extirpated* species. A 'management plan' must be prepared for species considered as *special concern*. Final recovery strategies have been prepared for six species currently designated as either *endangered* or *threatened* under Schedule 1 and potentially occurring in the Study Area: (1) the leatherback sea turtle (ALTRT 2006); (2) the spotted wolffish (Kulka et al. 2008), (3) the northern wolffish (Kulka et al. 2008), (4) the blue whale (Beauchamp et al. 2009), (5) the North Atlantic right whale (Brown et al. 2009), and (6) the Scotian Shelf population of the northern bottlenose whale (DFO 2010d). A recovery strategy has also been proposed for the Ivory Gull (Environment Canada 2013). A management plan has been prepared for the Atlantic wolffish (Kulka et al. 2008), currently designated as *special concern* on Schedule 1.

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

Electromagnetic Geoservices Canada acknowledges the rarity of the Species at Risk and will continue to exercise due caution to minimize effects on them during all of its operations. Electromagnetic Geoservices Canada also acknowledges the possibility of other marine species being designated as *endangered* or *threatened* on 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.

Species profiles of fishes, birds, marine mammals, and sea turtles listed on Schedule 1 as *endangered* or *threatened* and any related special or sensitive habitat in the Study Area are described in the following subsections.

4.6.1 Profiles of *SARA*-Listed Species

Only those marine species that are listed under Schedule 1 of the *SARA* as either *endangered* or *threatened* are profiled in this subsection.

Table 4.14 *SARA*- listed and COSEWIC-assessed Marine Species that Potentially Occur in the Study Area.

Species		*SARA*[a]			COSEWIC[b]		
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Special Concern**	**Endangered**	**Threatened**	**Special Concern**
Marine Mammals							
Blue whale (Atlantic population)	*Balaenoptera musculus*	Schedule 1			X		
North Atlantic right whale	*Eubalaena glacialis*	Schedule 1			X		
Northern bottlenose whale (Scotian Shelf population)	*Hyperoodon ampullatus*	Schedule 1			X		
Fin whale (Atlantic population)	*Balaenoptera physalus*			Schedule 1			X
Sowerby's beaked whale	*Mesoplodon bidens*			Schedule 1			X
Harbour porpoise (Northwest Atlantic population)	*Phocoena phocoena*		Schedule 2				X
Humpback whale (Western North Atlantic population)	*Megaptera novaeangliae*			Schedule 3			
Killer whale (Northwest Atlantic/Eastern Arctic population)	*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			X		
Loggerhead sea turtle	*Caretta caretta*				X		
Fishes							
White shark (Atlantic population)	*Carcharodon carcharias*	Schedule 1			X		
Northern wolffish	*Anarhichas denticulatus*		Schedule 1			X	
Spotted wolffish	*Anarhichas minor*		Schedule 1			X	
Atlantic wolffish	*Anarhichas lupus*			Schedule 1			X
Atlantic cod	*Gadus morhua*			Schedule 3			
Atlantic cod (Newfoundland and Labrador population)	*Gadus morhua*				X		
Bluefin tuna	*Thunnus thynnus*				X		
Porbeagle shark	*Lamna nasus*				X		
Roundnose grenadier	*Coryphaenoides rupestris*				X		

Species		SARA[a]			COSEWIC[b]		
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Special Concern**	**Endangered**	**Threatened**	**Special Concern**
Cusk	*Brosme brosme*				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	
Blue shark (Atlantic population)	*Prionace glauca*						X
Basking shark (Atlantic population)	*Cetorhinus maximus*						X
Spiny dogfish (Atlantic population)	*Squalus acanthis*						X
Roughead grenadier	*Macrourus berglax*						X
Thorny skate	*Amblyraja radiata*						X
Birds							
Ivory Gull	*Pagophila eburnea*	Schedule 1			X		

Sources: [a]*SARA* website (http://www.sararegistry.gc.ca/default_e.cfm), accessed January 2014; [b]COSEWIC website (http://www.cosewic.gc.ca/index.htm); accessed January 2014; COSEWIC candidate species not included.

4.6.1.1 Fishes

Only three fish species are listed under Schedule 1 of the *SARA* as either *endangered* or *threatened*. Profiles of these three species are provided in this subsection. Other fish species/populations included in Table 4.14 that are routinely taken in commercial fisheries (i.e., Atlantic cod, American plaice, grenadier, and redfish) are profiled in Section 4.2.4.1.

White Shark

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

Off Atlantic Canada, the white shark has been recorded from the northeast Newfoundland Shelf, the Strait of Belle Isle, the St. Pierre Bank, the Sable Island Bank, the Forchu Misaine Bank, in St. Margaret's Bay, off Cape La Have, in Passamaquoddy Bay, in the Bay of Fundy, in the Northumberland Strait, and in the Laurentian Channel as far inland as the Portneuf River Estuary. In recent years, numerous white sharks have been tagged by OCEARCH, a non-profit organization devoted to global-scale research on white sharks and other large apex predators, providing open source, near-real time data (including satellite tracks) through the Global Shark Tracker (www.ocearch.org/tracker). An adult female, 'Lydia,' originally tagged in March 2013 off Jackson, Florida, was noted in Placentia Bay, NL, and on the Newfoundland Shelf west and southwest of the Study Area from October through early December 2013, and east of the Study Area through January 2014. The species is highly mobile, and individuals in Atlantic Canada are likely seasonal migrants belonging to a widespread Northwest Atlantic population. The white shark occurs in both inshore and offshore waters, ranging in depth from just below the surface to just above the bottom, down to depths of at least 1,280 m (*SARA* website, accessed January 2014).

In reproduction, the female produces eggs which remain in her body until they are ready to hatch. When the young emerge, they are born live. Gestation period is unknown, but may be about 14 months. Litter size varies, with an average of seven pups. Length at birth is assumed to be between 109 and 165 cm. Possible white shark pupping areas on the west and east coasts of North America include off southern California and the Mid-Atlantic Bight, respectively (*SARA* website, accessed January 2014).

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

Northern Wolffish

The northern wolffish is a deep water fish of cold northern seas that has been caught at depths ranging from 38 to 1,504 m, with densest observed concentrations between 500 and 1,000 m at water temperatures of 2 to 5°C. During 1980–1984, this species was most concentrated on the northeast Newfoundland and Labrador shelf and banks, the southwest and southeast slopes of the Grand Banks, and along the Laurentian Channel. From 1978 to 1994, abundance in the primary range off northeast Newfoundland declined by 98%. For the following decade there was little change, but since 2002 there have been small increases in both range size and abundance. Northern wolffish are known to inhabit a wide range of bottom substrate types, including mud, sand, pebbles, small rock, and hard bottom, with the highest concentrations observed over sand and shell hash in the fall, and coarse sand in the spring. Unlike other wolffish species, both juvenile and adult stages of this species have been found a considerable distance above the bottom, as indicated by diet (Kulka et al. 2008; COSEWIC 2012b).

Prey of northern wolffish are primarily bathypelagic (>200 m depth) biota, such as ctenophores and medusa, but also include mesopelagic biota (<200 m depth) and benthic invertebrates. Pelagic fish represent the largest percentage of stomach contents based on volume. Juvenile wolffish have been found in the stomachs of seals, Atlantic cod, Atlantic halibut, and haddock. Tagging studies have suggested limited migratory behaviour by these wolffish. Sexual maturation in northern wolffish is estimated to be between five to six years of age. Spawning occurs late in the year on rocky bottoms. Fertilization is internal and fecundity is low in comparison to other fish species of a similar size (COSEWIC 2012b). Cohesive masses of fertilized eggs are laid in crevices but are unattached to the substrate. Pelagic larvae hatch after an undetermined egg incubation time, and typically feed on crustaceans, fish larvae and fish eggs (Kulka et al. 2008; COSEWIC 2012b).

The northern wolfish was first assessed as *threatened* in 2001 by COSEWIC. That status has not changed in the latest assessment, which occurred in 2012. The species has been protected under *SARA* since 2003. While the species has no commercial value and there is no directed fishery for northern wolfish, it is still captured as bycatch in some fisheries. Some signs of recovery have been detected in the Newfoundland and Labrador region in the last decade, with wolffish starting to return to several historical areas and displaying similar distribution patterns to those observed during periods of high abundance (Simpson et al. 2011, 2012).

During DFO RV surveys conducted in the Study Area during 2007–2011, 515 northern wolffish were caught, during both spring and fall survey times. Northern wolffish catches were most concentrated in the central and southeastern portions of the Study Area (see Section 4.3.4).

Spotted Wolffish

The life history of the spotted wolffish is very similar to that of the northern wolffish except that it seldom inhabits the deepest areas occupied by the northern wolffish. Although spotted wolffish have been caught at depths ranging from 56 to 1,046 m, the densest observed concentrations occur between 200 and 750 m at water temperatures of 1.5 to 5.0°C. During 1980–1984, spotted wolffish were most concentrated on the northeast Newfoundland and Labrador shelf and banks, the southwest and southeast slopes of the Grand Banks, along the Laurentian Channel, and in the Gulf of St. Lawrence. Between 1995 and 2003, the area occupied and density within that area was considerably reduced. As with northern wolffish, spotted wolffish also inhabit a wide range of bottom substrate types, including mud, sand, pebbles, small rock, and hard bottom, with highest concentrations observed over sand and shell hash in the fall, and coarse sand in the spring (Kulka et al. 2008).

Prey of spotted wolffish are primarily benthic (>75%), typically including echinoderms, crustaceans, and molluscs associated with both sandy and hard bottom substrates. Fish also constitute part of the spotted wolffish diet (<25%) (Kulka et al. 2008). Juvenile spotted wolffish have been found in the stomachs of seals as well as fish, such as Atlantic cod and Atlantic halibut (COSEWIC 2012c). Tagging studies indicate spotted wolffish migrations are local and limited. Sexual maturation occurs between approximately five to six years of age (COSEWIC 2012c). Spotted wolfish reproduction includes internal fertilization, which in Newfoundland and Labrador waters typically occurs in July and August on stony bottom. Cohesive masses of eggs are deposited in crevices, remaining unattached to the substrate. After an undetermined incubation time, pelagic larvae hatch and start to feed on crustaceans, fish larvae and fish eggs within a few days of hatching (Kulka et al. 2008; COSEWIC 2012c).

The spotted wolfish was first assessed as *threatened* in 2001 by COSEWIC. That status has not changed in the latest assessment, which occurred in 2012. The species has been protected under *SARA* since 2003. While the species has no commercial value and there is no directed fishery for spotted wolfish, it is still captured as bycatch in some fisheries. Some signs of recovery have been detected in the Newfoundland and Labrador region in the last decade, with wolffish starting to return to several historical areas and displaying similar distribution patterns to those observed during periods of high abundance (Simpson et al. 2011, 2012).

During DFO RV surveys conducted in the Study Area during 2007–2011, 430 spotted wolffish were caught, during both spring and fall survey times. Spotted wolffish catches were most concentrated in the northwestern and southeastern portions of the Study Area where water depths were less than at the primary catch locations of northern wolffish (see Section 4.3.4).

4.6.1.2 Seabirds

Ivory Gull

The Ivory Gull nests in the central and eastern Canadian arctic, northern Greenland, Svalbard, and some archipelagos in the northwestern Russian Federation (Mallory et al. 2008). During the winter, however, its range is nearly circumpolar and often associated with drifting pack ice. Off eastern Canada, the Ivory Gull regularly winters along the ice edge from Davis Strait, south off the Labrador coast, to north-eastern Newfoundland (Mallory et al. 2008). The Ivory Gull is designated as *endangered* by COSEWIC (COSEWIC 2013), and listed as *endangered* on Schedule 1 of *SARA*. It is also considered near threatened on the Red List of Threatened Species, with a declining population (IUCN 2013).

In comparison to most gulls, Ivory Gulls have reduced reproductive output, in that they usually only lay one to two eggs (Mallory et al. 2008). They depart from colonies immediately following breeding for offshore foraging areas associated with the ice edge of permanent, multi-year pack ice. At sea, the Ivory Gull is a surface-feeder and its main prey includes ice-associated small fish and macro-zooplankton. It is also an opportunistic scavenger of carrion (e.g., seals killed by hunters or polar bears; Mallory et al. 2008).

Currently, the Canadian breeding population is estimated at 400 pairs (Mallory et al. 2008). Surveys conducted during 2002 to 2005 indicate a total decline of 80% and an annual decline of 8.4% over the last 18 years. If this decline continues at a steady rate, the breeding population will decrease by a further 62% over the next decade, to approximately 190 individuals. A March 2004 survey conducted within the pack ice off the coast of Newfoundland and Labrador recorded a decrease in Ivory Gull observations as compared to 1978 results. Numbers of Ivory Gulls observed per 10-minute watch period were 0.69 and 0.02 individuals for 1978 and 2004, respectively (COSEWIC 2006c). Considering that changes to the breeding environment have been insignificant, causes for the observed decline are likely related to factors occurring during migration or on the wintering grounds (Stenhouse 2004).

During heavy ice winters, the Ivory Gull may occasionally reach the northern Grand Banks in the Study Area, late in the winter or early spring when sea ice reaches the maximum southern extremity. The 30-year median of ice concentration shows ice extending into the northern edge of the Grand Banks east to 48°W during late February to late March. A total of 21 Ivory Gulls reported from drill platforms on the northeast Grand Banks during 1999 to 2002 seems improbable, especially considering that most sightings were reported during ice-free periods (Baillie et al. 2005). The Ivory Gull is reported regularly along the coast of Labrador and the tip of the Great Northern Peninsula of Newfoundland in winter (Stenhouse 2004). There are occasional sightings of Ivory Gulls south along the east coast of Newfoundland. It is expected to be very rare in the Study Area.

4.6.1.3 Marine Mammals

North Atlantic Right Whale

The North Atlantic right whale is currently listed as *endangered* on Schedule 1 of *SARA* and by COSEWIC (see Table 4.11; COSEWIC 2003b). Research suggests the existence of six major habitats or congregation areas for North Atlantic right whales: the coastal waters of the southeastern United States; the Great South Channel; Georges Bank/Gulf of Maine; Cape Cod and Massachusetts Bays; the Bay of Fundy; and the Scotian Shelf (COSEWIC 2003b; Waring et al. 2013). Roseway Basin, on the Scotian Shelf, and Grand Manan Basin, in the Bay of Fundy, have been designated as critical habitat for North Atlantic right whales pursuant to *SARA* (Brown et al. 2009). Based on a census of individual whales identified using photo-identification, the western North Atlantic population size is estimated to be comprised of at least 510 individuals (NARWC 2013). This species is considered extremely rare in the Study Area. However, there have been some relatively recent sightings of small numbers of North Atlantic right whales off Iceland and Greenland (Mellinger et al. 2011), and it is possible (although highly unlikely) that this species may occur in the Study Area. North Atlantic right whales were recorded once in the Study Area on 27 June 2003 during a Provincial Airlines (PAL) reconnaissance survey (see Table 4.9; J. Lawson, DFO, pers. comm.).

Blue Whale

The blue whale has a cosmopolitan distribution, but tends to be more frequently observed in deep water than in coastal environments (Jefferson et al. 2008). Blue whales became severely depleted during industrial whaling and still occur at relatively low densities in the North Atlantic. The Atlantic population of blue whales is considered *endangered* on *SARA* Schedule 1 and by COSEWIC. The recovery strategy for blue whales in the Northwest Atlantic notes a long-term recovery goal of reaching a total of 1,000 mature individuals through the achievement of three 5-year objectives (Beauchamp et al. 2009). No critical habitat was identified. Numbers of blue whales in the Northwest Atlantic are likely in the low hundreds and blue whales have been sighted only sporadically off the northeast coast of Newfoundland (COSEWIC 2002b). There were two sightings of blue whales in the Study Area recorded in the DFO cetacean sightings database, occurring in April 1992 and June 1993 (see Table 4.9). During a monitoring program in 2007 for a CSEM survey in Orphan Basin, there were two sightings of blues whales in the Study Area, occurring in August-September in water depths of 2,366 m and 2,551 m (Abgrall et al. 2008b). Blue whales feed primarily on krill, and their distribution is often associated with areas of upwelling or shelf edges where their prey may concentrate. Blue whales are considered rare in the Study Area.

Northern Bottlenose Whale

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

Although the Scotian Shelf population is designated *endangered* under Schedule 1 of *SARA* and by COSEWIC, the Davis Strait population has no status under *SARA* and is considered of *special concern* by COSEWIC. The proposed recovery target for the Scotian Shelf population of northern bottlenose whales is to increase population size and maintain the current distribution (DFO 2010d; DFO 2011e). The Gully Marine Protected Area and areas deeper than 500 m in Haldimand and Shortland Canyons have been designated as critical habitat for the Scotian Shelf population (DFO 2010d). Although the stock origin of northern bottlenose whales off Newfoundland and Labrador is unknown (DFO 2011e; Harris et al. 2013), it seems likely that whales in the Study Area belong to the Davis Strait population. This population is considered to occur in the area year-round, with mating and births occurring between April and June, with a peak in April (Benjaminsen 1972 *in* COSEWIC 2011; DFO 2011e). The calving season of the Scotian Shelf population peaks in August (Whitehead et al. 1997). No matches of photo-identified individuals have been made between the Scotian Shelf and the Davis Strait-Labrador populations (COSEWIC 2011), and nuclear and mitochondrial markers revealed very little interchange between these two populations (Dalebout et al. 2006). The encounter rate during boat surveys was 0.03

encounters per hour for the Labrador-Davis Strait population, and 0.50 for the Gully population (COSEWIC 2011b *as cited in* Whitehead and Hooker 2012).

Occurring primarily in deep waters over canyons and the shelf edge, northern bottlenose whales routinely dive to depths over 800 m and remain submerged for over an hour (Hooker and Baird 1999). Foraging apparently occurs at depth, primarily on deep-water squid and fish (COSEWIC 2011; DFO 2011h). Northern bottlenose whales may occur at low densities, but year-round, throughout the deep, offshore waters of the Orphan Basin and the Flemish Pass area. Based on the DFO cetacean sightings database, there have been 28 sightings of northern bottlenose whales in the deeper waters of the Study Area in March and from May to October (see Table 4.9). This species is not expected to occur in the shelf waters of the Study Area.

4.6.1.4 Sea Turtles

Leatherback Turtle

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

There are an estimated 34,000 to 94,000 leatherback adults in the North Atlantic (TEWG 2007), but there is no current estimate of the number of leatherbacks using eastern Canadian waters (COSEWIC 2012d). Nonetheless, James et al. (2006) suggested that Canadian waters support high densities of leatherbacks during the summer and fall, and that Canadian waters should be considered critical foraging habitat for this species. Even though the species appears to be virtually absent during the winter months (James 2000), leatherback turtles have been sighted off the east coast of Canada, and off Newfoundland, during the winter (McAlpine et al. 2007). The leatherback turtle is designated as *endangered* (Schedule 1) on *SARA* and by COSEWIC, but no critical habitat has been designated by ALTRT (2006). In the recovery strategy for leatherback turtle in the Canadian Atlantic Ocean, the recovery goal is to "achieve the long-term viability of the leatherback turtle populations frequenting Atlantic Canadian waters" via six supporting objectives (ALTRT 2006).

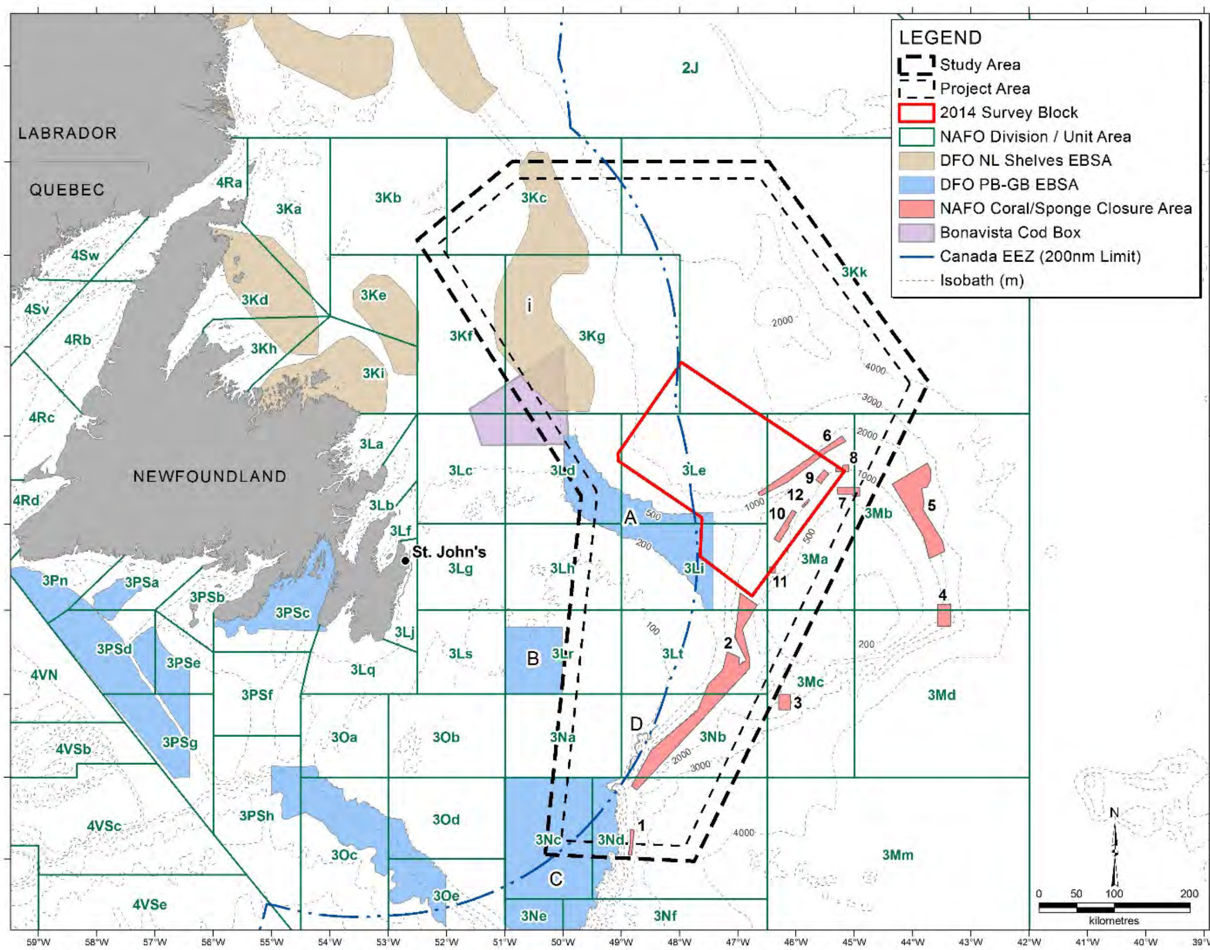
Adult leatherbacks are considered regular summer visitors to eastern Newfoundland, with the northernmost records occurring off Labrador at nearly 54ºN. Observations around Newfoundland and Labrador occur from June to November, but are most common in August and September (Goff and Lien

1988). Most sea turtles migrate southward by mid-October (Sherrill-Mix et al. 2008). James et al. (2006) noted that increasing sea surface temperatures in Canadian waters result in a significant increase in turtle sightings. Most leatherbacks that occur in Atlantic Canadian waters are large sub-adults and adults, with a female-biased sex ratio among mature turtles (James et al. 2007). DFO Newfoundland Region has maintained a database of leatherback turtle sightings and entanglements in Newfoundland and Labrador (J. Lawson, DFO, pers. comm.). One leatherback turtle was recorded in the southern portion of the Study Area in August 2007. 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 have also been tracked near or within the Study Area (TEWG 2007).

4.7 Sensitive Areas

There are a variety of regulatory frameworks that deal directly or indirectly with sensitive areas in Newfoundland and Labrador. Marine fisheries are administered by DFO through the federal *Fisheries Act*. Management of marine mammals, including species at risk, is controlled by DFO under the *Marine Mammals Regulations* of the *Fisheries Act*. All species at risk are administered under the *Species at Risk Act* (2002) which lists the species and provides measures to protect those species. The *Oceans Act* Marine Protected Areas are established by DFO to protect and conserve important fish and marine mammal habitats, *endangered* marine species, unique features and areas of high biological productivity or biodiversity. Migratory birds, including species at risk, are solely or jointly managed (depending on the species) between Canada and the U.S. through the Canadian Wildlife Service (CWS) branch of Environment Canada. Current legislation and agreements regarding migratory birds include the Convention for the Protection of Migratory Birds (1916), *Migratory Birds Convention Act*, and the North American Waterfowl Management Plan (CWS and United States Fish and Wildlife Services (USFWS) 1986; CWS, USFWS, and SEMARNAP 1998). Waterfowl are managed according to "flyways" denoting wintering and summering habitat connected by international migration corridors.

Previously defined (by regulators and stakeholders) Ecologically and Biologically Significant Areas (EBSAs), coral/sponge closure areas and the Bonavista Cod Box are considered to be the relevant sensitive areas (Figure 4.36) in this EA.



NL Shelves EBSA: Orphan Spur (i)
PBGB LOMA EBSA: Northeast Shelf and Slope (A), Virgin Rocks (B), Southeast Shoal and Tail of the Banks (C), Lilly Canyon-Carson Canyon (D).

Figure 4.36 Locations of the NL Shelves EBSA, PBGB LOMA EBSAs, Bonavista Cod Box, and NAFO Coral/Sponge Closure Areas Relative to the Study Area.

4.7.1 Integrated Management Areas

The Study Area includes portions of the Placentia Bay Grand Banks (PBGB) Large Ocean Management Area (LOMA), and the Newfoundland and Labrador Shelves Bioregion, marine regions established to form the planning basis for implementation of integrated-management plans by DFO. The LOMAs are typically thousands of square kilometres in size. Their boundaries are determined using a combination of ecological and administrative considerations. For each LOMA, all levels of government, aboriginal groups, industry organizations, environmental and community groups, and academia work together to develop a strategic, long-term plan for sustainable management of resources within its boundaries. This plan is intended to be adaptive in that strategies and plans may change as new information is obtained through ongoing monitoring and reporting (DFO 2012b). The LOMAs are delineated so that ecosystem health and economic development issues within their boundaries can be addressed and suitably managed.

This can best be accomplished using an integrated ocean management approach, an approach based on addressing the socio-economic and cultural needs of humankind while preserving the health of the marine ecosystem (DFO 2012b).

Dimensions of the EBSAs that were considered during the identification process include the following (DFO 2007):

- Uniqueness (rarity);
- Aggregation (density/concentration);
- Fitness Consequences (importance to reproduction/survival); and
- Sensitivity (resilience to disturbance).

The PBGB LOMA has been recognized by DFO as one of five priority LOMAs in Canada. The PBGB LOMA Committee comprises a group of stakeholders partnering for the sustainable use and development of coastal and ocean resources within the LOMA. The designation of EBSAs is a tool to allow appropriate management of “geographically or oceanographically discrete areas that provide important services to one or more species/populations of an ecosystem or to the ecosystem as a whole, compared to other surrounding areas or areas of similar ecological characteristics” (DFO 2013a). DFO Newfoundland and Labrador Region has identified 11 EBSAs within the PBGB LOMA as potential Areas of Interest (AOIs) for Marine Protected Area (MPA) designation, three of which overlap the Study Area (i.e., Northeast Shelf and Slope EBSA, Southeast Shoal and Tail of the Banks EBSA, and the Lilly Canyon-Carson Canyon EBSA), and another, the Virgin Rocks EBSA, which abuts the Study Area on its western boundary (see Figure 4.36). DFO (2012b) ranked the PB-GB EBSAs in terms of significance; the Southeast Shoal and Tail of the Banks EBSA ranks first, the Lilly Canyon-Carson Canyon EBSA ranks eighth, the Northeast Shelf and Slope EBSA ranks ninth, and the Virgin Rocks EBSA ranks eleventh. Note that the representation of Lilly Canyon-Carson Canyon in Figure 4.36 (letter designation is ‘D’) is difficult to see given its narrow shape.

DFO has also recently identified fifteen EBSAs within the Newfoundland and Labrador Shelves Bioregion (exclusive of the PBGB LOMA), of which 14 are spatially defined; of these, most of the Orphan Spur EBSA overlaps the Study Area (see Figure 4.36) (DFO 2013g).

Key physical and biological aspects of the four dimensions listed above that relate specifically to the PB-GB LOMA EBSAs are presented in Table 1 *in* DFO (2007). The key physical and biological aspects of the Orphan Spur EBSA are presented in Appendix A of DFO (2013g).

The *Oceans Act* provides the Minister of Fisheries and Oceans with a leadership role for coordinating the development and implementation of a federal network of MPAs, which can include areas within and outside of the Integrated Management (IM) area that have yet to be developed within the Region. Therefore, there remains potential for further identification of EBSAs, AOI, MPAs and other sensitive areas within the Study Area.

4.7.2 Coral and Sponge Areas

In 2008 and 2009, the NAFO Scientific Council identified areas of significant coral and sponge concentrations within the NAFO Regulatory Area. Based on these identifications, areas for closure to fishing with bottom contact gear were delineated. Figure 4.36 shows the locations of these 12 areas, eight of which occur entirely partially within the proposed Study Area, and six that occur either entirely or partially within the proposed 2014 Survey Block. Implementation date of the closures started on 1 January 2010 (NAFO website).

4.7.3 Bonavista Cod Box

In March 2003, as protection for the Northern cod, the *Fisheries Resource Conservation Council (*FRCC) recommended the establishment of an experimental ‘cod box’ in the Bonavista Corridor (see Figure 4.36). The Corridor has been identified as an area important for cod spawning and juvenile cod. The FRCC recommended that this area be protected from all forms of commercial fishery (excluding snow crab trapping) and other invasive activity such as seismic exploration (see www.frcc.ccrh.ca).

4.7.4 Important Bird Areas

There are nine seabird breeding colonies on the east coast of Newfoundland from Cape Freels to the Burin Peninsula that meet the criteria for an Important Bird Area (IBA) (see Table 4.12). An IBA is defined as a site that provides essential habitat for one or more species of breeding or non-breeding birds. These sites may contain threatened species, endemic species, species representative of a biome, or highly exceptional concentrations of birds (www.ibacanada.com).

Designated important bird areas (IBAs) are shown in Figure 4.37. There are no IBAs within or immediately adjacent to the Study Area although birds from the eastern colonies may forage in the western portion of the Study Area.

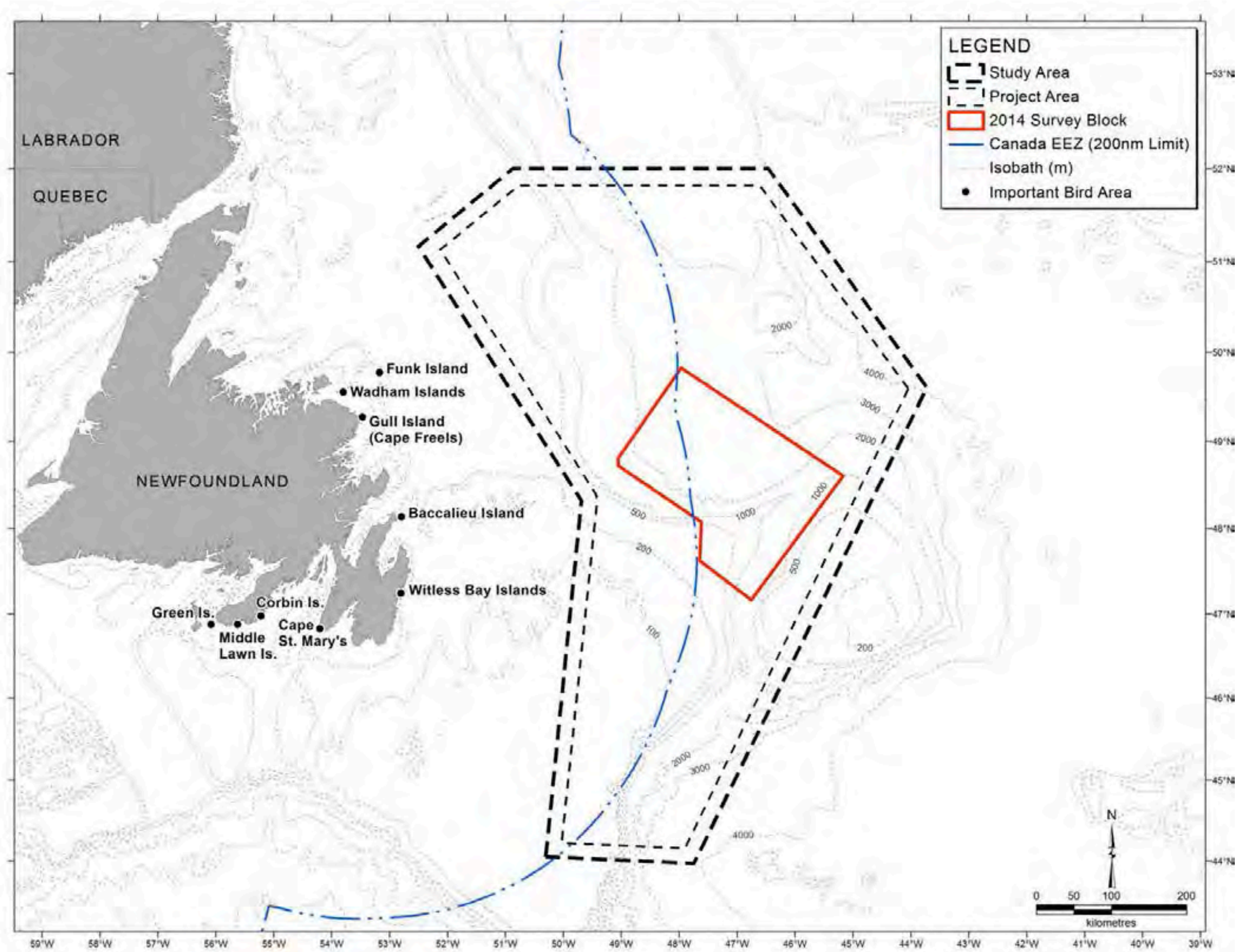


Figure 4.37 Eastern Newfoundland Important Bird Areas.

5.0 Effects Assessment

Two general types of effects are considered in this EA:

- Effects of the environment on the Project; and
- Effects of the Project on the environment, particularly the biological environment represented by "Valued Ecosystem Components" (VECs) as described below in Section 5.2.

Methods of effects assessment used here are comparable to those used in recent east coast offshore drilling (e.g., LGL 2008b, 2012b), seismic (e.g., LGL 2011b; 2012a,c; 2013a,b; Suncor 2013), geophysical (LGL 2011a), and CSEM (LGL 2007e; 2009a) EAs. These documents, approved by the C-NLOPB, conform to the *Canadian Environmental Assessment Act* (*CEAA*) and associated Responsible Authority's Guide and the CEA Agency Operational Policy Statement (OPS-EPO/5-2000) (CEA Agency 2000). Cumulative effects are incorporated within the procedures in accordance with *CEAA* (CEA Agency 1994) as adapted from Barnes and Davey (1999) and used in the White Rose EA (Husky 2000) and most subsequent offshore EAs in Newfoundland and Labrador waters.

5.1 Scoping

The C-NLOPB provided a Scoping Document (dated January 28, 2014) for the Project which outlined the factors to be considered in the assessment. In addition, various stakeholders were contacted for input (see below). Scoping for the effects assessment also involved reviewing recent regional EAs including (but not limited to) those for Orphan Basin, Northern Grand Banks and Flemish Pass, the Jeanne d'Arc Basin, exploration and drilling EAs, as referenced above in the preceding section. A review of current knowledge of the effects of underwater sound on marine organisms was also conducted (see LGL 2007c, 2009a,b; Buchanan et al. 2011; Tsoflias et al. 2012; and the present EA).

The purpose of consultations was to describe EMGS's proposed CSEM program, to identify any issues and concerns, and to gather any additional information relevant to the EA. A summary of the results of these consultations is provided in the following section and in the appended consultation report prepared by Canning & Pitt and LGL (Appendix A).

5.1.1 Consultations

A short description of the proposed program, including program location map and species harvesting location maps, were sent to the relevant agencies and industry stakeholder groups in early January 2014. 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 EMGS's proposed Project were undertaken with the following agencies, stakeholders and interest groups:

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

In addition, on 6 February 2014, EMGS inquired of Transport Canada (TC) whether or not their vessel would require a Coastal Trading Letter of Compliance. The TC response was that a Coastal Trading Letter of Compliance was not required for the EMGS vessel.

5.1.1.1 Issues and Concerns

No specific significant issues/concerns were raised during the consultations. However, the following main points were raised:

- EA should address potential effects on marine fish (especially sharks), marine mammals, sea turtles, and seabirds;
- EA should refer to previous MMO/SBO reports;
- Potential deleterious substances in the degradable receiver anchors;
- Potential conflict with fisheries and DFO R/V surveys should be addressed;
- Cumulative effects with other potential surveys (e.g., potentially three or more seismic programs for 2014);
- The FFAW expects a FLO to be onboard to alleviate any conflicts with the commercial fisheries; and
- The FFAW requests shape files for final surveys lines.

EMGS will continue to communicate with the FFAW, One Ocean and others once the 2014 survey lines are finalized.

5.2 Valued Ecosystem Components

The Valued Ecosystem Component (VEC) approach was used to focus the assessment on those biological resources of most potential concern and value to society and include the following groups:

- Rare or threatened species or habitats (as defined by the *SARA* and COSEWIC);
- Species or habitats that are unique to an area or valued for their aesthetic properties;
- Marine species harvested by people (e.g., commercial fishery target species); and
- Marine species with some potential to be affected by the Project.

The VEC approach is standard for East Coast offshore EAs. This approach was further refined for this EA by selecting focal or representative species for detailed analyses—for example, those species with documented abilities to detect electromagnetic emissions.

The VECs were identified based on the scoping exercise as described in Section 5.2 above. The VECs and their associated rationale include:

- **Fish and Fish Habitat** with emphasis on those species potentially most sensitive to electromagnetic emissions (e.g., elasmobranchs) and *SARA* species. Fish and their associated habitat are important ecologically, economically, and socio-culturally.

- **Commercial fisheries** are directly linked to the fish and fish habitat VEC above but all fisheries (trawling, gillnetting, longlines, pots, etc.) are considered where relevant. The commercial fishery is a universally acknowledged important element in the society, culture, economic and aesthetic environments of Newfoundland and Labrador. This VEC is of prime concern from both a public and scientific perspective, at local, national and international scales.

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

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

- **Sea Turtles**, uncommon in the Study Area, are mostly *threatened* and *endangered* on a global scale. The leatherback sea turtle that forages in eastern Canadian waters is considered *endangered* under *SARA*. While they are of little or no economic, social or cultural importance to Newfoundland and Labrador, their *endangered* status warrants their inclusion as a VEC. Also, this VEC is of prime concern from both a public and scientific perspective, at national and international scales.

- **Species at Risk** are those listed as *endangered* or *threatened* on Schedule 1 of *SARA*. All species at risk in Newfoundland and Labrador offshore waters are captured in the VECs listed above. However, due to their special status, they are also discussed separately.

- **Sensitive Areas** are those areas officially designated for various levels of sensitivity and/or protection measures.

5.3 Boundaries

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

5.3.1 Temporal

The temporal boundaries for the first CSEM survey are 1 May to 31 November in 2014. In subsequent years (2015 to 2018), surveys may also occur from 1 May to 31 November.

5.3.2 Spatial

The ***Project Area*** is defined as the area within which electromagnetic data could be acquired (see Figure 1.1). It encompasses all gear deployment and vessel turns while towing.

The ***Study Area***, slightly larger than the Project Area with an additional 20 km buffer, is defined as the area within which any potential effects on the VECs could occur (e.g., accidental events). The Study Area is the same as the "Affected Area" as originally defined by *CEAA*.

The ***Regional Area*** is loosely defined as the northern Grand Banks and Orphan Basin (e.g., to include the major Grand Banks developments such as Hibernia, Terra Nova, White Rose, and Hebron). This area is referred to when considering 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.

5.4.1 Identification and Evaluation of Effects

Interaction matrices identifying all possible Project activities that could interact with any of the VECs were prepared. The interaction matrices are used to identify potential interactions only and they do not make any assumptions about the potential effects of the interactions.

Interactions were then evaluated for their potential to cause effects. In instances where the potential for an effect of an interaction was deemed impossible or extremely remote, these interactions were not considered further. This approach allows the assessment to focus on key issues and the more substantive environmental effects.

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

- Location and timing of the interaction;
- Literature on similar interactions and associated effects (CSEM EAs for offshore Newfoundland and Labrador and internationally);
- Consultation with other experts, when necessary; and
- Results of similar effects assessments, especially monitoring studies done in other areas.

If data were insufficient to allow precise effects evaluations, predictions were made based on professional judgement. In such cases, the uncertainty is documented in the EA. Effects were evaluated for the proposed geophysical survey program, and included the consideration of mitigation measures that are either mandatory or have become standard operating procedure in the industry.

5.4.2 Classifying Anticipated Environmental Effects

Classification of environmental effects means determining whether they are negative, positive or neutral. The following are key factors that are considered for determining negative environmental effects, as per the CEA Agency guidelines (CEA Agency 1994):

- Negative effects on the health of biota;
- Loss of rare or *endangered* species;
- Reductions in biological diversity;
- Loss or avoidance of productive habitat;
- Fragmentation of habitat or interruption of movement corridors and migration routes;

- Transformation of natural landscapes;
- discharge of persistent and/or toxic chemicals;
- Toxicity effects on human health;
- either loss of or detrimental change in the current use of lands and resources for traditional purposes;
- Foreclosure of future resource use or production; and
- Negative effects on human health or well-being.

5.4.3 Mitigation

Mitigation measures appropriate for effects predicted in the matrix were identified and the effects of various Project activities were then evaluated assuming the application of appropriate mitigation measures. These effects after application of the mitigation measures are known as 'residual effects'. Residual effects predictions were made taking into consideration both standard and Project-specific mitigations.

5.4.4 Evaluation Criteria for Assessing Environmental Effects

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

- Magnitude;
- Geographic extent;
- Duration;
- Frequency;
- Reversibility; and
- Ecological, socio-cultural and economic context.

5.4.4.1 Magnitude

Magnitude describes the nature and extent of the residual effect for each activity.

Ratings for this criterion are defined as:

0 *Negligible* - Measureable effect on individuals but less than the 'low' rating. Once an effect is determined to be *negligible*, no further analysis or prediction is conducted.

1 *Low* - Affecting >0 to 10 percent of individuals in the affected area (i.e. Study Area) (e.g., geographic extent). Effects may include acute mortality, sublethal effects or exclusion due to disturbance.

2 *Medium* - Affecting >10 to 25 percent of individuals in the affected area (i.e. Study Area). Effects may include acute mortality, sublethal effects or exclusion due to disturbance.

3 *High* - Affecting >25 percent of individuals in the affected area (i.e. Study Area). Effects may include acute mortality, sublethal effects or exclusion due to disturbance.

Definitions of magnitude used in this EA have been used previously in numerous offshore oil-related environmental assessments under *CEAA*. Some example assessments include the Petro-Canada seismic EA (LGL 2007a), the White Rose Oilfield Comprehensive Study (Husky 2000), the StatoilHydro Jeanne d'Arc Basin area seismic and geohazard program EA (LGL 2008a), the ConocoPhillips Laurentian Sub-Basin exploration drilling EA (Buchanan et al. 2006a), the Chevron Labrador and northern Grand Banks seismic EAs (LGL 2010, 2011b), the Hebron Project Comprehensive Study (ExxonMobil 2011), and Husky seismic EA (LGL 2012a).

5.4.4.2 Geographic Extent

Geographic extent refers to the specific area (km^2) of the residual effect caused by the Project activity. Geographic extent will likely vary depending on the activity and the relevant VEC.

Ratings for this criterion are defined as:

1 = <1 km^2
2 = 1-10 km^2
3 = >10-100 km^2
4 = >100-1,000 km^2
5 = >1,000-10,000 km^2
6 = >10,000 km^2

5.4.4.3 Duration and Frequency

Duration describes how long a residual effect will occur.

Ratings for this criterion are defined as:

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

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

5.4.4.4 Frequency

Frequency describes how often a residual effect will occur.

Ratings for this criterion are defined as:

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

5.4.4.5 Reversibility

Reversibility refers to the capability of a VEC population to return to either its pre-Project or an improved condition, after the Project has ended.

Ratings for this criterion are defined as:

R = reversible
I = Irreversible

5.4.4.6 Ecological, Socio-cultural and Economic Context

The ecological, socio-cultural and economic context refers to the pre-Project status of the Study Area (i.e., potential affected area) in terms of existing environmental effects. The Study Area is not considered to be strongly affected by human activities.

Ratings for this criterion are defined as:

1 = Environment not negatively affected by human activity (i.e., relatively pristine area)
2 = Evidence of existing negative effects on the environment

5.4.5 Cumulative Effects

Projects and activities considered in the cumulative effects assessment include other human activities in Newfoundland and Labrador offshore waters, with emphasis on the Grand Banks Regional Area.

- Within-Project cumulative impacts. For the most part, and unless otherwise indicated, within-Project cumulative effects are fully integrated within this assessment;
- Existing and *in progress* offshore oil developments in Newfoundland and Labrador: Hibernia (GBS platform), Terra Nova FPSO, White Rose FPSO and associated extension, and the Hebron GBS;

- Other offshore oil exploration activity (particularly seismic surveys and exploratory drilling as outlined on the C-NLOPB website). In 2014, other possible oil exploration activity in the Regional Area include 2D/3D seismic surveying by Hebron and the possibility that Chevron will drill an exploratory well in the Orphan Basin (just north of the Grand Banks) in 2014. There is also some potential for several 2D/3D/4D, geohazard and VSP surveys in any given year.
- Fisheries (domestic and foreign commercial, recreational, aboriginal/subsistence);
- Marine transportation (tankers, cargo ships, supply vessels, naval vessels, fishing vessel transits, etc.); and
- Hunting activities (marine birds and seals).

5.4.6 Integrated Residual Environmental Effects

Upon completion of the evaluation, the residual environmental effects are assigned a rating of significance for:

- Each project activity;
- Cumulative effects of activities within the Project; and
- Cumulative effects of combined projects in the Regional Area.

As such, this represents an integrated residual environmental effects evaluation.

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

- Determination of the significance of residual environmental effects;
- Establishment of the level of confidence for prediction; and
- Evaluation of the scientific certainty and probability of occurrence of the residual impact prediction.

Ratings for level of confidence associated with each prediction are presented in the table of residual environmental effects. In the case of a significant predictive rating, ratings for probability of occurrence and determination of scientific certainty are also included in the table of residual environmental effects. The guidelines used to determine these ratings are discussed in the following sections.

5.4.6.1 Significance Rating

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

Having either a high magnitude regardless of duration and geographic extent ratings, or a medium magnitude for more than one year over a geographic extent greater than 100 km^2

A residual effect can be considered *significant* (S), *not significant* (NS), or *positive* (P).

5.4.6.2 Level of Confidence

The significance of the residual environmental effects is based on a review of relevant literature, consultation with experts, and professional judgment. In some instances, making predictions of potential residual environmental effects are difficult due to the limitations of available data (i.e., technical boundaries). Ratings are therefore provided to qualitatively indicate the level of confidence for each prediction. The level of confidence is considered low (1), medium (2) or high (3).

5.4.6.3 Probability of Occurrence

The probability of occurrence of a *significant* residual effect, based on professional judgement, is considered low (1), medium (2) or high (3).

5.4.6.4 Scientific Certainty

The scientific certainty of a *significant* residual effect, based on scientific information, statistical analysis and/or professional judgement, is considered low (1), medium (2) or high (3).

5.5 Mitigation Measures

As discussed in previous sections, any resultant potential effects after mitigations are applied are termed "residual effects". All effects predictions in this EA are related to residual effects. The Project will utilize a number of mitigations to minimize or eliminate any negative effects, in summary by VEC to include:

- **Fish and Fish Habitat.** Electromagnetic source will be turned off during vessel turns; environmentally benign anchors will be used.
- **Commercial Fisheries.** Use of a FLO, SPOC, and OneOcean protocols and a communication program to reduce potential for conflicts with fishing gear.
- **Seabirds.** Lighting will be minimized without compromising safety. Use of CWS stranded seabird handling and release procedures.
- **Marine Mammals and Sea Turtles**. Electromagnetic source will be turned off during vessel turns; environmentally benign anchors will be used. Marine mammal observers will be utilized to oversee ramp up procedures if required.
- ***SARA* Species and Sensitive Areas**. All of the above mitigations will be utilized. The *SARA* website will be monitored for any changes.
- **All VECs.** Accidental spills will be mitigated using EMGS' Spill Response Plan.

5.6 Effects of Environment on Project

The physical environment is summarized in Section 3.0 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 as the regulatory authority in this matter. 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.

Most environmental constraints on surveys offshore Newfoundland and Labrador are those imposed by wind and wave. If the Beaufort wind scale is six or greater, seismic survey vessels typically cease operations. 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. If the sea state exceeds 3.0 m or winds exceed 40 kt (20.6 m/s), then continuation/termination of surveying will be evaluated. The absolute operating limits for seismic streamer vessels are 3.5 m combined sea significant wave height and 45 kt (23.2 m/s) winds. Based on multi-year data at grid point 11423 in the Flemish Pass, these wave limits may be approached about 8% of the time in May, 4% in June, 2% in July, 4% in August, 12% in September, 27% in October, and 38% in November (see Section 3.2; Figure 2.23 *in* Oceans 2012). Similar percentages for exceedance of significant wave height were observed at grid points 14845 (Figure 2.15 *in* Oceans 2012), 13912 (Figure 2.19 *in* Oceans 2012), and 08026 (Figure 2.26 *in* Oceans 2014).

Based on the above comparison with seismic operations in the region, sea conditions may constrain operations late in the year; however, it is important to note that the CSEM technology can be used in somewhat rougher conditions than seismic because of the robustness of the towed gear, smaller tow packages, and less concern with ocean background noise (Buchanan et al. 2006). In addition, the Project scheduling avoids most of the continuous extreme weather conditions and contractors will be thoroughly familiar with East Coast operating conditions.

Poor visibility can constrain helicopter operations, and it may hinder sightings of other vessels and fishing gear. During the 2004 seismic monitoring program in Orphan Basin, EOs collected environmental data, including systematic records of visibility (i.e., estimated distance an observer could see). During 1,198 h of observations from the seismic ship in 2004, 22.4% were limited by visibility <500 m. Poor visibility due to fog was most evident in July when 33.0% of sighting conditions were <500 m (Buchanan et al. 2006b). 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 can also contribute to the reduction in visibility (see Section 3.2.4). Helicopter operations are not anticipated for 2014.

Given the Project time window of May to November for CSEM survey operations, sea ice should have little or no effect on the Project (see Section 3.4.1). Icebergs in the spring and early summer may cause some survey delays if tracks have to be altered to avoid them. Icebergs may cause some detours in May and June when icebergs are most likely to occur in the Study Area (see Section 3.4.2).

The biological environment is summarized in Section 4.0 and the reader is referred to this section to assist in determining the effects of the environment on the Project. Effects of the biological environment on the Project are unlikely, although there is the potential of CSEM equipment being attacked by elasmobranchs, such as sharks, skates, and rays. Swimming sharks and rays exhibited avoidance responses when subjected to voltage gradients of 1-10 μV/cm (Kalmijn 1966); however, elasmobranchs have also been observed attacking submarine cables (Marra 1989). Given the low frequency of the CSEM source, it is most reasonable to infer that elasmobranchs will be repelled as they get closer to the source and the field gets stronger (see Section 5.7.2.2).

The Department of National Defense (DND) will be contacted in regard to potential unexploded ordnance (UXO) in the area and defense exercises prior to the deployment of any CSEM equipment. The DND has thus far noted one disposal area and two WWII submarines sunk in the Study Area. The DND will likely be operating in the area during 2014 but does not anticipate any conflicts with the Project.

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

5.7 Effects of the Project on the Environment

The effects assessments section is organized by first identifying those aspects of the Project that may have potential to cause negative effects to marine animals, especially those aspects that are unique to marine CSEM surveys. This is then followed by a review of existing information concerning these potential effects on various types of animals. Once this information was assembled, an interaction matrix was constructed with Project activities/components on the vertical axis and the VECs on the horizontal axis. The interaction matrix and associated discussion then resulted in a list of Project Components (with detailed reference to the Scoping Document) whose effects could range beyond *negligible* and thus require more detailed effects analyses and predictions. In most cases, this also entailed the selection and use of representative species.

5.7.1 CSEM Survey Components

A CSEM survey operation is not a seismic survey and does not use strong sound sources. Most of the general CSEM survey vessel characteristics and operations are similar to other marine operations using similar-size diesel-electric vessels and towing gear. The only unique aspects of the Project are a towed electromagnetic source on a single streamer, towed 30-50 m above the seabed, and the placement and retrieval of receiver antennae anchored by expendable anchors. Attributes of these components are provided in Table 5.1.

The anchors are composed of environmentally benign components and designed to degrade quickly into sand. Components include those shown in the text table below. The offshore drilling and production *Offshore Chemical Selection Guidelines* (C-NLOPB 2009) do not apply to the proposed Project.

Anchor Ingredients:

Rapid Portland Cement
Free Water
Limestone Filler
Anhydrite
Sand 0-8mm
Sand 0-4mm
Crushed Stone 8-16mm

Table 5.1 Project Components Unique to CSEM Surveys.

Component	No.	Description	Purpose	Interactions
EM Source	1	AC current, 1,250 A, extremely low frequency (variable, <20 Hz) (ELF); towed at 2-3 kts 30-50 m above the seabed	Measure resistivity of underlying seabed in order to assist in discriminating oil from water.	Electromagnetic emissions can be detected by a variety of marine animals and some may react to them.
Streamer	1	Cable (0.7 m x 300 m); streamer of 5 50-m sections and 1 14-m section containing flotation fluid (670 L per 50-m section; 187 L per 14-m section), conductors, source anode and cathode.	Connect the source to vessel generators and to serve as conductor of source outputs.	Presence of towed cable. Potential for flotation fluid leakage.
Receivers	200	Small packages with 4 antennae, equipped with pingers and acoustic releases.	Set on seabed in grid pattern to collect electromagnetic signals.	Small, temporary disturbance of the seabed from anchors (see below).
Anchors	200	102 x 810 x 920 mm in dimension; compressed sand and other natural components. Degrades to sand within one year.	Temporarily anchor the receivers to the seabed.	Small, temporary disturbance (<1 y) of the seabed.

5.7.2 Review of Effects of EM Emissions

The following sections review the available scientific information on the effects of EM emissions on marine VECs of relevance to the proposed Project. We are not aware of any relevant information on the effects of streamers or receivers on marine fauna but any potential effects are most likely some negligible physical disturbance simply from presence of this equipment. A brief description and discussion of the composition of the degradable anchors is also included here.

The potential effects of CSEM emissions on marine animals have been reviewed in detail in previous offshore Newfoundland and Labrador CSEM (Buchanan et al. 2006b; LGL 2007c, 2009a) and international EAs (Buchanan et al. 2011; Tsoflias et al. 2012). Much of the recent literature on the effects of EM concerns high voltage submarine power cables (both DC and AC lines) originating from offshore wind farms, especially in Europe (e.g., Tricas and Gill 2011; Woodruff et al. 2012; Bergstrom et al. 2013; Gill et al. 2013; Hooper and Austen 2014). These latter references are only partially applicable to a CSEM EA because power cables (mostly DC) are more or less permanent features whereas CSEM emissions are AC and relatively ephemeral in exposure times. None of these recent reviews increase the level of knowledge contained in the original CSEM EA for international waters (Buchanan et al. 2011).

5.7.2.1 EM Background Information

In order to understand the potential effects of EM, it is first necessary to understand some basics of electromagnetic physics such as Faraday's Law. The major basic points include:

- The electric source generates both an electric and magnetic fields. These can be considered separately for the purposes of the present EA.
- A conductor (e.g., an animal) moving through an electric field will induce a magnetic field and vice versa (Faraday).
- A conductor (e.g., an animal) can induce an electric field by moving through a magnetic field and vice versa (Faraday).
- Movement one way generates DC current and movement back and forth generates AC current.
- The units of measurement most often used in the biological literature are the nano tesla (nT) (for magnetic fields) and the micro volt (uV) (for electric fields).
- The Earth generates natural geomagnetic field intensity on the order of 51,000 nT at the latitude of the Grand Banks. Worldwide, large natural anomalies exist in this field. Daily solar fluctuations cause anomalies on the order of 100 nT. Further, solar storms can cause fluctuations as high as 800 nT. [Earth EM fields are DC whereas CSEM is AC.]
- To our knowledge there are no recorded health effects from short duration exposure to extremely low frequency electromagnetic radiation.

5.7.2.2 Effects on Fish and Fish Habitat VEC

Scientists have been interested in geomagnetic orientation and navigation, especially related to long distance bird migration, for many years. Research into geomagnetic orientation in fish has focused primarily on two groups that undergo long migrations: (1) salmon, and (2) eels of the genus *Anguilla*. Salmon hatch from freshwater spawning grounds then migrate out to sea where they can undergo extensive oceanic or coastal feeding migrations for hundreds or even thousands of kilometers. After spending their adult lives foraging and growing at sea, salmon migrate back to their natal rivers to spawn. *Anguilla* species have an opposite life cycle. They inhabit coastal rivers throughout the world but migrate back to oceanic breeding grounds to mate and spawn. In the Atlantic, the European eel (*A. anguilla*) migrates to spawning grounds in the Sargasso Sea off the southeastern coast of the U.S. where they spawn and presumably die (Facey and Van Den Avyle 1987). The American eel (*A. rostrata*) migrates from rivers on the U.S. east coast to the same general locale in the Sargasso Sea. Newly spawned eels are carried in the North Atlantic Gyre where they disperse back to rivers in the U.S or Europe. The fact that salmon and eels undergo long ocean migrations makes them likely candidates for a geomagnetic guidance system. Few studies have focused on the role of geomagnetic orientation in fish since the late 1980s. However, Nishi et al. (2004) and Nishi and Kawamura (2005) demonstrated that both the glass eel and adult phases of Pacific eel (*A. japonica*), in contrast to the American and European species, are highly magnetosensitive. These authors further hypothesized that Pacific eels may use this sensitivity to migrate the long distances to and from the spawning grounds.

Elasmobranchs

It is reasonable to assume based upon existing information that elasmobranchs are the group of fishes most likely to be affected by electromagnetic emissions. Elasmobranchs are the principal group of electroreceptive fishes in the marine environment (sharks, skates, and rays, and chimeras or deep sea ratfish). Very little research has been conducted on chimerids. It is well documented that ampullae of Lorenzini in marine species are capable of detecting weak electric currents in seawater. Kalmijn (1966) showed that swimming sharks and rays exhibited avoidance responses when subjected to voltage gradients of 1-10 μV cm^{-1}. Sedate sharks and rays visibly responded to a square wave field of 5 Hz with a voltage gradient of 0.1 μV cm^{-1}. Changes in the heart rate of a ray were detected down to a voltage gradient of 0.01 μV cm^{-1}. The dogfish displayed behavioral responses to gradients as low as 5 nV/ cm^{-1} (Kalmijn 1982). The blacktip reef shark and whitetail stingray both showed threshold responses at about 4 nV cm^{-1} (Haine et al. 2001).

Navigation

Despite evidence that elasmobranchs can detect DC electric fields, ampullae of Lorenzini are not DC receptors. Rather, they detect changes in the surrounding electric field, making them AC receptors with an adaptation time constant of about 3-5 seconds (Kalmijn 2003). When a shark, skate, or ray moves in a straight line for more than 3-5 seconds at a constant velocity in a uniform DC field, its sense organs do not register the field. Ampullae can only detect AC changes in the field. The fish must actually explore and probe its surroundings by purposely varying its direction of travel. It is the unequal clustering of ampullae over the surface of the body that enables elasmobranchs to determine, by constant intra-ampullae comparison of microchanges in the surrounding field, the intensity, spatial configuration and direction of the electrical source.

Prey Detection

Despite the extraordinary electrosensory capabilities of elasmobranchs, the effective range for detection of prey in nature is rather short. This is not because ampullae are short-range sensors. But rather the electric fields produced by aquatic organisms are very weak and the elasmobranch must pass close to the source to detect them. Haine et al. (2001) conducted electrosensory studies on the blacktip reef shark and whitetail stingray and found that both exhibited threshold responses at about 4 nV cm^{-1}.

The electric fields generated by invertebrates were size dependant with large specimens giving off stronger fields. For both invertebrates and fish, fields were strongest at their anterior ends presumably because of the closer proximity to physical and neural activity associated with feeding and respiratory processes. Based upon the interaction of multiple electric fields, Haine et al. (2001) calculated that the distance at which the source potential dropped below the detection level of the shark and ray was 250 cm.

Electroreceptive Navigation

In the "active mode" model of electroreceptive navigation, the elasmobranch senses voltage gradients in its own body that it inductively generates as it swims through the Earth's geomagnetic field. The horizontal velocity of the animal interacts with the horizontal component of the geomagnetic field producing a vertical electromotive field. Theoretically, the elasmobranch electrosensory system could provide it with 360° navigational ability.

Geomagnetic Navigation

Behavioral responses to shifts in geomagnetic fields have been documented in laboratory studies for leopard sharks, round stingrays, sandbar sharks, and scalloped hammerhead sharks (Kalmijn 1978; Meyer et al. 2004). In field studies, there is evidence that hammerhead sharks in the Gulf of California did exhibit movement patterns consistent with tropotaxis. Telemetry studies indicated that some individuals followed consistent forging routes from their daytime resting area in the vicinity of a seamount to their nocturnal feeding grounds. While the pattern was unrelated to current patterns or bottom topography, more than a random number of routes were associated with sharp gradients in the local geomagnetic landscape.

Marine Invertebrates

Historically, there has been relatively little research on the effects of EM on marine invertebrates. However, this is beginning to change with the increasing use of submarine power cables and their associated environmental effects monitoring studies.

The western Atlantic spiny lobster (*Panulirus argus*) has been the subject of several magnetic orientation studies. The spiny lobster undertakes mass migrations in which thousands of lobsters walk across the seafloor in head-to-tail procession. Laboratory and field behavioral studies have demonstrated that individuals can detect Earth-strength shifts in surrounding magnetic fields (Lohmann 1985; Lohmann et al. 1995) They have also shown that they can orient in the field along specific geomagnetic compass bearings (Boles and Lohmann 2003). Based upon the testing criteria of the studies, the authors concluded that lobsters orient to the polarity of the Earth's field (polarity compass) and not its inclination (inclination compass).

Lohmann and Willows (1987) observed the body angle alignment of the marine mollusc *Tritonia diomedea* (nudibranch) under two geomagnetic fields: the Earth's normal field, and a field in which the horizontal component of the Earth's field was neutralized. In the Earth's field, the orientation of the animals was significant along a mean angle of 87.6° (approximately east). Animals tested in the canceled field oriented randomly. Results suggested that eastward orientation was mediated by magnetic field detection. Preferred magnetic direction also shifted with the day of the lunar month. Lohmann et al.

(1991) later found that there was altered electrical activity in the brain neurons of *Tritonia* in response to changes in ambient Earth-strength magnetic fields.

5.7.2.3 Commercial Fisheries VEC

Electromagnetic emissions should have no effect on commercial fisheries unless they happen to affect the behaviour of target species (see above discussion).

5.7.2.4 Seabird VEC

The CSEM source emissions should have little or no effect on seabirds due to rapid attenuation of the fields and the distribution of the birds near surface (discussed further in the specific effects assessment sections). Although geomagnetic navigation has been demonstrated in several species of terrestrial birds, few seabirds have been studied. In experiments with juvenile herring gull and ring-billed gull, orientation to a migratory heading toward the species' usual wintering grounds is disrupted in experiments in which the earth's magnetic field is disturbed by magnetic storms or by the placement of magnets on the birds or in their cages (Moore 1975). In contrast, placing magnets on the heads of procellariiforme seabirds (black-browed albatross, wandering albatross, and white-chinned petrel) did not prevent them from homing to nesting colonies when returning from their typically long foraging trips (Bonadonna et al. 2005).

5.7.2.5 Marine Mammal VEC

Some species of cetaceans migrate long distances and appear able to use geomagnetic cues for navigation. Several studies have correlated mass strandings with geomagnetic contours perpendicular to the coast and anomalies originating from solar storms. Total intensity variations of as little as 50 nT (0.1% of the total field) were sufficient to influence stranding location in the data (Kirschvink et al. 1986). Other studies in areas of no consistent pattern in geomagnetic anomalies have found no such correlations (Brabyn and Frew 1994; Hui 1994). In addition to potential effects from electromagnetic fields, cetaceans are known to be able to detect and react to sound from vessel propulsion systems such as thrusters.

5.7.2.6 Sea Turtle VEC

Sea turtles undergo extensive migrations during the course of their lifetime. Newly hatched turtles of most species migrate offshore from their natal beaches into open-ocean convergence zones where they occupy driftline assemblages of seaweed and flotsam. These convergence zones are areas of high productivity. This oceanic period of surface foraging may last from 2-20 years depending upon species and long-term oceanic conditions. Little is known about this stage of sea turtle life and it is often referred to as "the lost years". During this pelagic phase, juvenile turtles can be dispersed for thousands of kilometers by major oceanic gyres and currents. Hatchlings appear to use visual cues and wave directions during their initial entry into the water. Studies have shown that juvenile loggerheads and leatherbacks can detect changes in their surrounding geomagnetic field. However, in contrast to the case for young sea turtles, there is little scientific evidence that adult sea turtles use geomagnetic navigation to any large extent (Buchanan et al. 2011).

5.7.2.7 Species at Risk VEC

As described previously, there are eight endangered or threatened Schedule 1 *SARA* species that may occur in the Study Area: three whale species, one turtle, three fish (including the elasmobranch, white shark), and one seabird. These species all belong to the groups discussed above in regard to their potential sensitivities to EM. Effects predictions on these and other important groups are provided in detail in subsequent sections (Section 5.7.10).

5.7.2.8 Sensitive Areas VEC

There are no potential effects on these areas that are not covered in the above summaries on the effects of EM on the various VECs. Effects predictions on these and other important VECs are detailed in subsequent sections.

5.7.3 Environment-Project Interactions

Potential interactions of Project Activities that may have some type of effect on VEC components are shown in Table 5.2. These interactions are discussed in the following effects prediction sections.

Table 5.2 Potential Interactions between the Project and Environmental Components. The x's denote potential interactions but do not imply any particular level of effect, which could range from negligible to significant. Adapted from Buchanan et al. (2006b).

Environmental Component	Receiver Deployment	Receiver Retrieval[1]	CSEM Source	Towing Operation[1]	Lights	Small Accidental Spills (e.g., flotation and hydraulic)
Fish Habitat	x	-	x	-	-	-
Invertebrates	x	-	x	-	-	x (plankton)
Bony fish migration (e.g., Atlantic salmon)	-	-	x	-	-	-
Elasmobranch migration	-	-	x	-	-	-
Elasmobranch prey detection	-	-	x	-	-	-
Sea turtle migration	-	-	x	-	x	-
Sea bird stranding	-	-	-	-	x	x (oiling)
Cetaceans	-	x	x	x	-	-
Fisheries (fixed) gear)	-	-	-	x	-	x (oiling)
SARA species	x	x	x	x	-	-
Sensitive Areas	x	-	-	-	-	-

5.7.4 Geographic Extent, Duration and Frequency of Effects

The geographic extents, durations and frequencies estimated below are considered applicable to all VECs. Again, this is a conservative application of the relevant parameters and includes both direct and indirect potential effects.

5.7.4.1 Geographic Extent or Zone of Influence - EM Source

The geographic extent of effects varies with project activity and VEC. The geographic extent of effects (i.e., zone of influence) of electromagnetic fields generated by the CSEM source was determined by the EM modeling conducted by EM survey industry. Results of modeling were then combined with a theoretical biological threshold based on the scientific literature across a wide range of organisms (Buchanan et al. 2011).

It is useful to define thresholds of effects in order to be able to describe potential zones of influence and to subsequently predict effects. Based on presently available scientific information and the professional judgment of the authors it is reasonable to select 200 nT and 386 nV cm^{-1} as generic thresholds of effects for magnetic and electric fields generated by EM surveys (see Buchanan et al. 2011). Effects in this case simply mean an elicited response of some kind with no negative or positive implications. Many animals will have no reactions to these levels while others may be able to detect fields below these values. These values are used in the following sections.

For a deep-towed source, combining the EM field modeling results with a 200 nT threshold results in a maximum 400 m radius of zone of influence for the magnetic field. Modeling with a 386 nV cm-1 threshold results in a maximum zone of influence of 800 m (Buchanan et al. 2011). These results are in general agreement with earlier modeling conducted by the ExxonMobil Upstream Group (Buchanan et al. 2006b). Again, these zones of influence are based on reported abilities of some of the more sensitive groups of animals (e.g., elasmobranchs) to detect fields and do not imply any effects *per se*.

Another potential source for effects on marine organisms is the chlorine produced by electrolysis. Chlorine gas will be produced by the source electrodes but in the marine environment it is very quickly hydrolyzed into various natural compounds. In addition, the source's position underwater, natural water currents, plus the towing at 2-4 knots will rapidly disperse any residual chlorine or any other harmful compounds derived from the electrolytic process to negligible levels. Any effects of electrolysis products from the CSEM electrodes are predicted to be negligible in geographic extent and effect.

Thus, the instantaneous geographic extent (area) used in predictions is conservatively on the order of 0.5 km^2 – 2.0 km^2. However, duration of exposure of a fixed point along the axis of the tow (i.e., "worst case") would be short, on the order of 14-21 minutes with the vessel moving at 2 kts.

5.7.4.2 Geographic Extent – Underwater Noise

Underwater noise is a typical concern related to seismic surveys that tow a strong sound source. This applies particularly to cetaceans that likely can perceive low frequency underwater noise from strong sound sources at great distances. However, CSEM surveys do not use a strong sound source and hence the concerns associated with seismic surveys are not relevant to the proposed Project. Nonetheless, the CSEM vessel will generate underwater noise from its main propulsion and thruster systems; the former is used during towing and the latter during station holding (e.g., while retrieving receivers). The underwater noise generated by thrusters may be a source of disturbance to marine mammals, perhaps more so than the steady noise of ship propulsion noise when moving at a constant slow speed. There is no mitigation for this type of disturbance except to select quieter models of thruster if available and to minimize the use of thrusters where feasible. The underwater noise generated by the ship's thrusters has some potential to create some minor behavioral effects on cetaceans (Buchanan et al. 2011).

In order to determine a precise zone of influence for CSEM vessel noise, underwater noise modeling using the particular specifications of the specific vessel used, combined with the environmental characteristics of the Project Area would be required. This very specific modeling exercise was deemed beyond the scope of an EA concerning a CSEM survey that does not generate any more noise than other vessels in the region such as fishing or transport vessels.

In order to gain some perspective of the potential zone of influence of noise generated by thrusters on the CSEM vessel, this EA used a "worst case" scenario approach by reviewing a recent EA that modeled underwater noise for on a drill ship continuously using dynamic positioning thrusters (Matthews 2012; LGL and Grontmiji 2012). The *JOIDES Resolution* has seven diesel-electric engines that produce an average total power output of 7 megawatts. Four of these engines are used during transit and three are used to power the 12 DP thrusters that may be used to maintain position over the borehole. JASCO modelled sound levels of the *JOIDES Resolution* DP thrusters at three coring sites. Sound levels in close proximity (i.e., ~0.4–5 km) to the coring vessel ranged from 130–140 dB re 1 μPa_{rms}. The CSEM vessel has fewer thrusters and much less power than a drill ship's DP thrusters system.

Thus, for the present EA, a geographic extent of <1 km^2 to 10 km^2 was used for underwater noise as determined by reference to the above and other recent seismic EAs that consider all sources of underwater noise in detail (e.g., see Table 5.13 *in* LGL and GXT 2013; Table 5.11 *in* LGL 2013b).

5.7.4.3 Geographic Extent – Receivers/Anchors

A receiver will have a small footprint on the seabed of about a square meter each. The receivers will be retrieved and only a degradable anchor will be left on the seafloor. Based on EMGS' experience with returns of receivers washed up on the beach, the anchors will all degrade within 9-12 months. In total, the area covered by the anchors could be on the order of 0.01 km^2 for no more than about one year.

5.7.4.4 Duration and Frequency

For the purposes of EA predictions, the overall duration of the survey of 7 months was used with a frequency of once per year. The anchors will all degrade within 9-12 months. For some components of the Project (i.e., the source—see preceding discussion), this definition of duration/frequency is a very conservative simplification.

5.7.4.5 Reversibility and Pristine/Not Pristine

All effects discussed in this EA are reversible at the population level but not necessarily at the individual level. The Study Area is likely not completely pristine given past and present human activities in the area.

5.7.5 Effects on Fish and Fish Habitat

5.7.5.1 Waste Management

There will be interactions between sanitary and domestic waste and the 'fish habitat' component of the Fish and Fish Habitat VEC (i.e., water and sediment quality, phytoplankton, zooplankton, and benthos) (see Table 5.2), However, the relatively small volumes, adherence to current waste discharge regulations (e.g. MARPOL), treatment, and rapid dispersal will likely reduce effects of any interactions to a level small relative to the overall environments or populations. Solid waste will be compacted and/or incinerated in an approved burner. Any hazardous waste will be safely contained and brought ashore to be handled by a licensed waste handler. Thus, any effects from Project waste are considered *negligible* residual effects (Table 5.3) and hence *not significant*.

Table 5.3 Assessment of Effects on VECs.

Valued Ecosystem Components (All)								
Project Activity	Potential Positive (P) or Negative (N) Environmental Effect	Mitigation	Evaluation Criteria for Assessing Environmental Effects					
			Magnitude	Geographic Extent	Frequency	Duration	Reversibility	Ecological/ Socio-Cultural and Economic Context
Sanitary/Domestic Waste	Increased Food (N/P)	Treatment; containment; adherence to MARPOL	0-1	1	1	2	R	2
CSEM Source	Disturbance to migration and prey detection (elasmobranchs); electrolysis with chlorine derivatives (N)	Ramp up source. Turn off source when not in use.	0-1	1	6	2	R	2
Sound								
Receiver Deployment and Retrieval	Disturbance (N)	Minimize use of thrusters	0-1	1-2	6	2	R	2
Towing	Disturbance (N)	None	1	1-2	6	2	R	2
Seabed Disturbance								
Receiver	Disturbance (N)	Slow descent	1	1	5	2	R	2

Valued Ecosystem Components (All)								
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**
Deployment (instrument drops)		due to buoyancy						
Receiver Retrieval (anchors in place)	Smothering (N)	Compacted sand; designed to degrade to natural substance within 1 year	1	1	5	2	R	2
Light Attraction	Bird collision and stranding (e.g. petrels) (N)	CWS handling and release protocols	1	2	3	2	R	2
Vessel/gear	Disturbance (fisheries) (N)	Communication plan; FLO; short streamer towed near bottom; compensation	0-1	1	6	2	R	2
Accidental Spills (e.g., streamer fluid, lubricants)	Injury/Mortality (seabirds) (N); taint and gear fouling (fisheries) (N)	Spill Response Plan; communication; compensation	1	1-2	1	1	R	2

Key:

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

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

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

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

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

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

5.7.5.2 CSEM Source

Benthic animals, including invertebrates and fish along a survey line will receive EM emissions for a short duration. Potentially these may be detected by some animals, especially elasmobranchs. The instantaneous geographic extent (area) used in predictions is conservatively on the order of

0.5 km^2 -2.0 km^2 (see above). However, duration of exposure of a fixed point along the axis of the tow (i.e., "worst case") would be short, on the order of 14-21 minutes with the vessel moving at 2 kts. This duration of exposure to ELF EM emissions is too short to interfere with any known processes such as orientation, movements or prey detection. Thus, any effects are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.5.3 Underwater Sound

Underwater sound generated by the Project vessel is considered no greater than by some other routine vessels in the region (e.g., trawlers). This EA used a "worst case" approach by using results from a recent EA that modeled underwater noise for on a drill ship continuously using dynamic positioning thrusters (Matthews 2012; LGL and Grontmiji 2012). Sound levels in close proximity (i.e., ~0.4–5 km) to the drill ship ranged from 130–140 dB re 1 μPa_{rms}. This is well below the sound levels believed to cause hearing damage to marine animals. The CSEM vessel has fewer thrusters and much less power than a drill ship's DP thrusters system.

Thus, effects from underwater sound on fish (including invertebrates) are deemed to be *negligible* to low, with a geographic extent of <10 km^2, continuous and of no more than 7 months' duration (see Table 5.3). Any effects are predicted to be *not significant*.

5.7.5.4 Receiver Deployment and Retrieval

Placement and retrieval of on bottom receivers may cause some small disturbance to fish habitat as they slowly descend through the water column and settle on the bottom. Receivers will only be on the bottom for a matter of days until the grid of several hundred receivers is surveyed. Receivers are then retrieved and moved to another survey area. The compacted sand anchors remain on the bottom but degrade within 9-12 months to natural substances. The area involved is small and should rapidly return to normal suggesting a prediction of *negligible* residual effects (see Table 5.3) on fish habitat of the Study Area from this Project component and hence *not significant*.

5.7.5.5 Light Attraction

Some fish are attracted to lights on the water at night. This can be considered a neutral and much localized effect—negative for prey but positive for predators. This effect is considered *negligible* in the case of fish (see Table 5.3).

5.7.5.6 Vessel/Gear

The physical presence of the vessel and towed gear as it passes through the water will cause some *negligible* disturbance to fish and invertebrate populations (see Table 5.3). However, there is potential for conflict with fisheries (see below).

5.7.5.7 Accidental Events

The probability is very low of any accidental event (i.e., hydrocarbon release) being of large enough magnitude to cause a significant effect on offshore fish habitat. Potential spill scenarios include loss of Isopar M-filled streamer integrity, small on-deck spills of petroleum products such as lubricants, and small spills during refuelling, if it occurs offshore. If a streamer is punctured the maximum oil leakage would be 670 L (i.e., the volume of a 50-m compartment). Isopar is a kerosene-like hydrocarbon that evaporates and disperses relatively rapidly. Communication and inspection procedures and oil spill response will minimize the number and severity of events. Adult fish have the ability to avoid spills. Such spill events are predicted to be very unlikely, low magnitude, <10 km^2 in extent, and <1 month duration, and hence *not significant* to the Fish and Fish Habitat VEC (see Table 5.3).

5.7.6 Effects on Fisheries

There are no recreational, subsistence or aboriginal fisheries in the Study Area. Commercial fisheries are described in detail in Section 4.3.

As discussed above, effects on Fish and Fish Habitat by the Project from waste management, the EM source, underwater sound, receiver deployment and retrieval, light attraction, and vessel/gear presence were all predicted to be *negligible* and thus *not significant*. As a result, any indirect effects on the fisheries caused by these components will be *negligible* as well, with the possible exception of vessel/gear presence (see Table 5.3).

5.7.6.1 Vessel/Gear

The physical presence of the vessel and towed gear may conflict with fish activities or gear, especially fixed gear such as gillnets and crab pots. Potential conflicts will be minimized or eliminated through the use of the onboard FLO to liaise with fishing vessels and a communications program including Notice to Mariners and a single point of contact (SPOC). In the event of identifiable fishing gear damage attributable to EMGS activities, compensation will be instituted. In addition, it should be noted that a CSEM vessel tows a short (compared to a seismic streamer) single streamer 50 m above the bottom; it typically tows much closer to the tow vessel than seismic gear. Other vessels can safely pass within 1,000 m of the CSEM vessel's stern.

These Project attributes and mitigations will result in *no significant effect* on the commercial fisheries from vessel/gear conflicts.

5.7.6.2 Accidental Events

The probability is very low of any accidental event (i.e., hydrocarbon release) being of large enough magnitude to cause a significant effect on offshore commercial fisheries. Potential spill scenarios include loss of Isopar M-filled streamer integrity, small on-deck spills of petroleum products such as lubricants, and small spills during refuelling, if it occurs offshore. If a streamer is punctured the maximum oil leakage would be 670 L (i.e., the volume of a 50-m compartment). Isopar is a kerosene-like hydrocarbon that evaporates and disperses relatively rapidly. Concerns relate to the fouling of fishing gear and a market perception of product tainting by petroleum hydrocarbons. Communication and inspection procedures and oil spill response will minimize the number and severity of events. Adult fish have the ability to avoid spills. Compensation may be used in the event of a spill large enough to affect fishing gear. Such spill events are predicted to be very unlikely, low magnitude, <10 km^2 in extent, and <1 month duration, and hence *not significant* to the Fisheries VEC (see Table 5.3).

5.7.7 Effects on Seabirds

5.7.7.1 Waste Management

There may be interactions between sanitary and domestic waste and seabirds VEC (see Table 5.2), However, the relatively small volumes, adherence to current waste discharge regulations (e.g. MARPOL), treatment, and rapid dispersal will likely reduce effects of any interactions to a level small relative to the overall environments or populations. Solid waste will be compacted and/or incinerated in an approved burner. Any hazardous waste will be safely contained and brought ashore to be handled by a licensed waste handler. Thus, any effects from Project waste on seabirds are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.7.2 CSEM Source

It is unlikely that seabirds that spend most of their time near-surface will be exposed to EM emissions from a source towed just above the bottom. Deep divers such as murres might encounter emissions if they dive near the source tow line. As discussed previously, there are no reported health effects from low frequency EM and any potential exposure would be on the order of a few minutes at most. Thus, any effects on seabirds are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.7.3 Underwater Sound

Underwater sound generated by the Project vessel is no greater than by most other routine vessels operating in the region. As discussed previously, seabirds spend most of their time in surface waters where underwater sound generated by vessel propulsion systems is more attenuated than at deeper depths. Although data are few, seabirds are not believed to be particularly sensitive to underwater sound. Effects from underwater sound on seabirds are deemed to be *negligible* (see Table 5.3).

5.7.7.4 Receiver Deployment and Retrieval

Placement and retrieval of on bottom receivers may cause some small disturbance or even attraction to seabirds as the receivers slowly descend through the water column and settle on the bottom. Receivers will only be on the bottom for a matter of days until the grid of several hundred receivers is surveyed. Receivers are then retrieved and moved to another survey area. The compacted sand anchors remain on the bottom but degrade within 9-12 months to natural substances. The area involved is small and should rapidly return to normal. It is unlikely that seabirds in the Study Area feed on the bottom to any large extent although Dovekies and murres can dive deep enough to do so. Any residual effects on seabirds of the Study Area from this Project component are predicted to be *negligible* (see Table 5.3) and hence *not significant*.

5.7.7.5 Light Attraction

Aside from accidental petroleum hydrocarbon spills, the main effect of the Project on seabirds involves attraction to the lighted vessel at night, especially during very low visibility. This attraction can result in strandings and occasional mortalities due to collision with the vessel's superstructure. Light attraction has been reviewed in detail in previous EAs (see LGL 2013b). The species involved in strandings in the region is almost always the most common species in the Study Area, Leaches Storm Petrel (LGL Ltd., unpubl. data; LGL 2013b).

Monitoring of pelagic seabird stranding on board seismic vessels due to light attraction has been conducted by LGL biologists during 16 seismic programs between 2004 and 2011 off both Newfoundland and Labrador. While seismic programs off Newfoundland and Labrador have been initiated as early as 7 May and terminated as late as 8 November, most have been conducted during the June to September period. Bird stranding during these seismic programs has been monitored for a total of 888 nights. The number of nights per week with strandings and the number of individuals stranded per night have been highest from late-August to mid-October. This period coincides with the fledging of Leach's Storm-Petrels from Newfoundland colonies. Young of this species fledge from Great Island (Witless Bay), Newfoundland, as early as 10 September but the majority fledges from mid-September to late-October (Huntington et al. 1996). The mean fledging date is 25 September. Juveniles constituted a large majority of stranded Leach's Storm-Petrels near a colony off Scotland (Miles et al. 2010). However, in wintering areas, adult Leach's Storm-Petrels may also strand due to attraction to light (Rodríguez and Rodríguez 2009). Visibility during nights when storm-petrels stranded on seismic vessels off Newfoundland and Labrador was typically reduced due to fog, rain or overcast conditions. This has also been documented for other seabird species (Telfer et al. 1987; Black 2005). It has also been noted that seabird strandings seem to peak around the time of the new moon (i.e., when moonlight levels are lowest) (Telfer et al. 1987; Rodríguez and Rodríguez 2009; Miles et al. 2010).

Mitigation measures to rescue stranded storm-petrels on board the seismic vessel will be the responsibility of a designated environmental observer (EO). This individual will conduct daily searches of the ship and the ship's crew will also be notified to contact the EO if a bird is found. Procedures developed by the CWS and Petro-Canada (now Suncor) will be used to handle the birds and eventually release them (Williams and Chardine, n.d.). The vessel will have a copy of the manual developed by CWS and Suncor on proper procedure and handling of stranded storm-petrels (Williams and Chardine, n.d.). EMGS acknowledges that a CWS *Bird Handling Permit* will be required. Project personnel will also be made aware of bird attraction to the lights on offshore structures. Deck lighting will be minimized (if it is safe and practical to do so) to reduce the likelihood of stranding. A report documenting each stranded bird will be completed and delivered to the CWS by the end of the calendar year. The report includes the date of stranding, global position of the stranding, general condition of the feathers, and if the bird is releasable, its condition upon release.

Mitigation and monitoring for stranded birds will result in residual effects of attraction to lights of *low* to *medium* magnitude for a duration of *<1 month* to *1* to *12 months* over a geographic extent of <1 to *1-10 km^2* (see Table 5.3). Therefore, the reversible residual effects of vessel lights on the Seabird VEC are predicted to be *not significant*.

5.7.7.6 Vessel/Gear

The physical presence of the vessel and towed gear as it passes through the water will cause some *negligible* disturbance to seabirds (see Table 5.3).

5.7.7.7 Accidental Events

The probability is very low of any accidental event (i.e., hydrocarbon release) being of large enough magnitude to cause a significant effect on offshore habitat. Potential spill scenarios include loss of Isopar-filled streamer integrity, small on-deck spills of petroleum products such as lubricants, and small spills during refuelling, if it occurs offshore. Isopar is a kerosene-like hydrocarbon that evaporates and disperses relatively rapidly. The EMGS streamer used for the EM source contains a paraffinic hydrocarbon called Isopar M to provide buoyancy. The specific effects of Isopar M on seabirds are not known. However, petroleum products typically have detrimental effects on the insulating attributes of seabird feathers. Isopar M is a kerosene-like product that leaves a relatively thin layered slick on the surface of water and evaporates readily. CSEM fluid-filled streamers are constructed of self-contained 50-m and 14-m length sealed compartments. Therefore, a single leak or puncture in a streamer could result in a maximum loss 670 L of Isopar M (i.e., the amount contained in one 50-m section, see Table 5.1). Any on-deck spills will be immediately contained since all EMGS vessels have fully enclosed decks. All refueling will occur in port by a certified refueling company.

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 Isopar M. 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 Isopar M.

Communication and inspection procedures and oil spill response will minimize the number and severity of events. An exposure to a surface release of petroleum hydrocarbons under calm conditions may harm or kill individual birds, especially those species (e.g. murres that spend a relatively large amount of time on the water). 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. Mitigations will focus on prevention and the oil spill response plan. Potential accidental releases would likely be small and evaporation/dispersion rapid, the effects on seabirds are predicted to have *low* to *medium* magnitude for a duration of *<1 month* over a geographic extent of *<1 km^2* to *1-10 km^2* (see Table 5.3). Therefore, the residual effects of an accidental release (e.g., Isopar M) on the seabird VEC are predicted to be *not significant*.

5.7.8 Effects on Marine Mammals

5.7.8.1 Waste Management

There may be interactions between sanitary and domestic waste and marine mammals (see Table 5.2). However, the relatively small volumes, adherence to current waste discharge regulations (e.g. MARPOL), treatment, and rapid dispersal will likely reduce effects of any interactions to a level small relative to their overall environment or populations. Solid waste will be compacted and/or incinerated in an approved burner. Any hazardous waste will be safely contained and brought ashore to be handled by a licensed waste handler. Thus, any effects from Project waste are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.8.2 CSEM Source

Depending upon water depths marine mammals could receive EM emissions for a short duration. Potentially these may be detected by some marine mammals, especially cetaceans. Magnetized material has been found in the Pacific dolphin (Zoeger et al. 1981 *in* Wiltschko and Wiltschko 1995) and humpback whale (Fuller et al. 1985). It has been theorized based on a major study of strandings data in the UK that cetaceans use geomagnetic information for orientation. Many whale and dolphin species are sensitive to stranding when the Earth's B-field has a total intensity variation of less than 0.5 mG (5×10^{4} G) and where geomagnetic contour lines run perpendicular to the shore (Klinowska 1985). Species found to be significantly statistically sensitive include: short-beaked common dolphin, Risso's dolphin, Atlantic white-sided dolphin, fin whale, and long-finned pilot whale (Kirschvink et al. 1986). Live strandings of toothed and baleen whales have also been correlated with local geomagnetic anomalies (Kirschvink et al. 1986).

In contrast, some studies show no evidence of the use of cetacean use of geomagnetics to orient or navigate. Brabyn and Frew (1994) examined whale strandings in New Zealand dating back to 1940 following the analytical methods used by Klinowska (1985) and Kirschvink et al. (1986). The New Zealand cetacean strandings showed no relationship to regions where geomagnetic contours were perpendicular to the coastline nor to geomagnetic maxima or minima. The authors note that one explanation for the difference in their results and those of Klinowska (1985) and Kirschvink et al. (1986) is that much of New Zealand is surrounded by a shallow marine platform characterized by no consistent pattern in geomagnetic anomalies. In addition, it has been suggested that some cetacean species use geomagnetic cues to navigate accurately over long-distances of open ocean where geological features are not present to aid in orientation (Valburg 2005 *in* OWET 2010).

The difficulty in studying the possible role of geomagnetic navigation in cetaceans is that the large size of the animals makes them almost impossible to control for behavioural studies. A study by Bauer et al. (1985 *in* Wiltschko and Wiltschko 1995) was unsuccessful in an attempt to condition bottlenose dolphins, a common species used in experiments, to respond to magnetic fields.

In the absence of specific data on potential zones of influence of EM on marine mammals, this EA has used a conservative approach based on criteria from a range of organisms known to use electromagnetic clues (see Buchanan et al. 2011).

The instantaneous geographic extent (area) used in predictions is conservatively on the order of 0.5 km^2 – 2.0 km^2 (see Fish and Fish Habitat above). However, duration of exposure of a fixed point along the axis of the tow (i.e., "worst case") would be short, on the order of 14-21 minutes with the vessel moving at 2 kts. This is likely an over-estimation since the animal will be moving, at least part of the time near-surface where any EM signals will be weak, and probably away from the vessel and any towed gear. This duration of exposure to EM emissions is much too short to interfere with any processes such as orientation or movements. There are no reported health effects on mammals from ELF electromagnetic emissions. It is also likely that any EM signal from an alternating (AC) source would cancel out any false clues to an animal's navigation system, which if it exists would have to be based on the Earth's direct current (DC) field. In addition, any marine animal using a geomagnetic-based navigation system must be able to respond to a variety of other clues due to "noise" in the Earth's field caused by anomalies and solar storms. Thus, any effects are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.8.3 Underwater Sound

Underwater sound generated by the Project vessel is considered no greater than by some other routine vessels in the region (e.g., trawlers). This EA used a "worst case" approach by using results from a recent EA that modeled underwater noise for on a drill ship continuously using dynamic positioning thrusters (Matthews 2012; LGL and Grontmiji 2012). Sound levels in close proximity (i.e., ~0.4–5 km) to the drill ship ranged from 130–140 dB re 1 μPa_{rms}. This is well below the sound levels believed to cause hearing damage to marine mammals. The CSEM vessel has fewer thrusters and much less power than a drill ship's DP thrusters system.

Thus, effects from underwater sound on marine mammals, while probably detectable are deemed to be *negligible* (see Table 5.3) and hence *not significant*.

5.7.8.4 Receiver Deployment and Retrieval

Placement and retrieval of on bottom receivers may cause some small disturbance to marine mammals as they slowly descend through the water column and settle on the bottom. Receivers will only be on the bottom for a matter of days until the grid of several hundred receivers is surveyed. Receivers are then retrieved and moved to another survey area. The compacted sand anchors remain on the bottom but degrade within 9-12 months to natural substances. Very few if any marine mammals feed at the seabed in the Study Area. The area involved is small and should rapidly return to normal suggesting a prediction of *negligible* residual effects (see Table 5.3) on marine mammals of the Study Area from this Project component and hence *not significant*.

5.7.8.5 Light Attraction

Some prey may be attracted to lights on the water at night. This can be considered a neutral and very localized effect—negative for prey but positive for predators. This effect is considered *negligible* in the case of marine mammals (see Table 5.3).

5.7.8.6 Vessel/Gear

The physical presence of the vessel and towed gear as it passes through the water will cause some *negligible* disturbance to marine mammals (see Table 5.3).

5.7.8.7 Accidental Events

The probability is very low of any accidental event (i.e., hydrocarbon release) being of large enough magnitude to cause a significant effect on offshore marine mammals. Potential spill scenarios include loss of Isopar M-filled streamer integrity, small on-deck spills of petroleum products such as lubricants, and small spills during refuelling, if it occurs offshore. If a streamer is punctured the maximum oil leakage would be 670 L (i.e., the volume of a 50-m compartment). Isopar is a kerosene-like hydrocarbon that evaporates and disperses relatively rapidly. Communication and inspection procedures and oil spill response will minimize the number and severity of events. Marine mammals have the ability to avoid spills. Such spill events are predicted to be very unlikely, low magnitude, <10 km^2 in extent, and <1 month duration (see Table 5.3), and hence *not significant* to the Marine Mammal VEC.

5.7.9 Effects on Sea Turtles

5.7.9.1 Waste Management

There may be interactions between sanitary and domestic waste and sea turtles (see Table 5.2). However, the relatively small volumes, adherence to current waste discharge regulations (e.g. MARPOL), treatment, and rapid dispersal will likely reduce effects of any interactions to a level small relative to the overall environments or populations. Solid waste will be compacted and/or incinerated in an approved burner. Any hazardous waste will be safely contained and brought ashore to be handled by a licensed waste handler. Thus, any effects from Project waste are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.9.2 CSEM Source

Several species of sea turtles are known to travel large transoceanic distances and there is a large body of research concerning sea turtles and geomagnetic orientation and migration. Most of this research deals with hatchlings and there is little evidence to support the hypothesis that adult sea turtles use geomagnetic navigation. Some research suggests that several species, Kemps Ridley's, green, and loggerhead sea turtles, use the earth's B-fields for migration, although the use of these fields is not necessary for these species (Lohmann and Lohmann 1996a).

There is strong evidence that leatherback and loggerhead sea turtle hatchlings, (Lohmann and Lohmann 1994a,b; 1996a,b) and loggerhead juveniles (Avins and Lohmann 2003) use geomagnetic clues to assist navigation. Experiments support the hypothesis that young turtles can respond to three parameters of the earth's magnetic field: angle, polarity, and intensity, thus enabling them to use a bi-coordinate system. Such a system might act alone or with other cues such as light, temperature, current, or chemical gradients (Lohmann and Lohmann 1994b; Avins and Lohmann 2003, 2004). Leatherback is the sea turtle most likely to be encountered in the Study Area, although loggerhead juveniles have been recorded just south of the Study Area.

Depending upon water depths sea turtles could receive EM emissions for a short duration. Potentially these may be detected by some sea turtles, especially juveniles. In the absence of specific data on potential zones of influence of EM on sea turtles, this EA has used a conservative approach based on criteria from a range of organisms known to use electromagnetic clues (see Buchanan et al. 2011).

The instantaneous geographic extent (area) used in predictions is conservatively on the order of 0.5 km^2 – 2.0 km^2 (see Fish and Fish Habitat above). However, duration of exposure of a fixed point along the axis of the tow (i.e., "worst case") would be short, on the order of 14-21 minutes with the vessel moving at 2 kts. This is likely an over-estimation since the animal will be moving, at least part of the time near-surface where any EM signals will be weak, and probably away from the vessel and any towed gear. This duration of exposure to EM emissions is much too short to interfere with any processes such as orientation or movements. There are no reported health effects on sea turtles from ELF electromagnetic emissions. It is also likely that any EM signal from an alternating (AC) source would cancel out any false clues to an animal's navigation system, which if it exists would have to be based on the Earth's direct current (DC) field. In addition, any marine animal using a geomagnetic-based navigation system must be able to respond to a variety of other clues due to "noise" in the Earth's field caused by anomalies and solar storms. Thus, any effects are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

Underwater Sound

Underwater sound generated by the Project vessel is considered no greater than by any other routine vessel in the region. Thus, effects from underwater sound on sea turtles are deemed to be *negligible* (see Table 5.3).

5.7.9.3 Receiver Deployment and Retrieval

Placement and retrieval of on bottom receivers may cause some small disturbance to sea turtles as the instruments slowly descend through the water column and settle on the bottom. Receivers will only be on the bottom for a matter of days until the grid of several hundred receivers is surveyed. Receivers are then retrieved and moved to another survey area. The compacted sand anchors remain on the bottom but degrade within 9-12 months to natural substances. Very few if any sea turtles feed at the seabed in the Study Area. The area involved is small and should rapidly return to normal suggesting a prediction of *negligible* residual effects (see Table 5.3) on sea turtles of the Study Area from this Project component and hence *not significant*.

5.7.9.4 Light Attraction

Some prey may be attracted to lights on the water at night. This can be considered a neutral and very localized effect—negative for prey but positive for predators. This effect is considered *negligible* in the case of sea turtles (see Table 5.3).

5.7.9.5 Vessel/Gear

The physical presence of the vessel and towed gear as it passes through the water will cause some *negligible* disturbance to sea turtles (see Table 5.3).

5.7.9.6 Accidental Events

The probability is very low of any accidental event (i.e., hydrocarbon release) being of large enough magnitude to cause a significant effect on offshore sea turtles. Potential spill scenarios include loss of Isopar M-filled streamer integrity, small on-deck spills of petroleum products such as lubricants, and small spills during refuelling, if it occurs offshore. If a streamer is punctured the maximum oil leakage would be 670 L (i.e., the volume of a 50-m compartment). Isopar is a kerosene-like hydrocarbon that evaporates and disperses relatively rapidly. Communication and inspection procedures and oil spill response will minimize the number and severity of events. Marine mammals have the ability to avoid spills. Such spill events are predicted to be very unlikely, low magnitude, <10 km^2 in extent, and <1 month duration (see Table 5.3), and hence *not significant* to the Marine Mammal VEC.

5.7.10 Effects on Species at Risk

As profiled in Section 4.0, the following Schedule I (threatened or endangered) species may occur in the Study Area:

- White shark
- Northern wolffish
- Spotted wolffish
- Leatherback sea turtle
- Ivory Gull
- North Atlantic right whale
- Blue whale
- Northern bottlenose whale

The probability of encountering these species in the Study Area is low because they are rare, and in some cases would be at the limits of their present range (e.g., North Atlantic right whale). The Ivory Gull tends to be associated with ice, something which the Project will attempt to avoid. Northern bottle nose whale have been observed in and near the Study Area but it is not known if they belong to the Schedule 1 population resident in the Gully off Nova Scotia, or the Davis Strait population.

5.7.10.1 Waste Management

There may be interactions between sanitary and domestic waste and *SARA* species (see Table 5.1). However, the relatively small volumes, adherence to current waste discharge regulations (e.g. MARPOL), treatment, and rapid dispersal will likely reduce effects of any interactions to a level small relative to the overall environments or populations. Solid waste will be compacted and/or incinerated in an approved burner. Any hazardous waste will be safely contained and brought ashore to be handled by a licensed waste handler. Thus, any effects from Project waste are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.10.2 CSEM Source

Several *SARA* species (e.g., white shark and leatherback) are known to migrate large oceanic distances. Both species may use the Earth's EM field for navigational clues and both may be sensitive to EM emissions, the sharks more so than adult leatherbacks. White shark may use EM clues to detect prey at very close range under low visibility conditions.

Depending upon water depths *SARA* species could receive EM emissions for a short duration. Potentially these may be detected by some sea turtles (especially juveniles) and elasmobranchs (i.e., sharks). It is not known how white shark might respond to EM emissions but reactions could range from avoidance (some shark repellent measures use electric fields) to attraction (anecdotal accounts exist of sharks biting seismic cables). In the absence of specific data on potential zones of influence of EM on *SARA* species, this EA has used a conservative approach based on criteria from a range of organisms known to use electromagnetic clues (see Buchanan et al. 2011).

The instantaneous geographic extent (area) used in predictions is conservatively on the order of 0.5 km^2 – 2.0 km^2 (see Fish and Fish Habitat, Section 4.2). However, duration of exposure of a fixed point along the axis of the tow (i.e., "worst case") would be short, on the order of 14-21 minutes with the vessel moving at 2 kts. This is likely an over-estimation since some animals will be moving, at least part of the time near-surface where any EM signals will be weak, and probably away from the vessel and any towed gear. This duration of exposure to EM emissions is much too short to interfere with any processes such as orientation or movements. There are no reported health effects on *SARA* species from ELF electromagnetic emissions. It is also likely that any EM signal from an alternating (AC) source would cancel out any false clues to an animal's navigation system, which if it exists would have to be based on the Earth's direct current (DC) field. In addition, any marine animal using a geomagnetic-based navigation system must be able to respond to a variety of other clues due to "noise" in the Earth's field caused by anomalies and solar storms. Thus, any effects are considered *negligible* residual effects (see Table 5.3) and hence *not significant*.

5.7.10.3 Underwater Sound

Underwater sound levels generated by the Project vessel are considered no greater than by any other routine vessel in the region. Thus, effects from underwater sound on *SARA* species are deemed to be *negligible* (see Table 5.3).

Receiver Deployment and Retrieval

Placement and retrieval of on bottom receivers may cause some small disturbance to marine animals as the instruments slowly descend through the water column and settle on the bottom. Receivers will only be on the bottom for a matter of days until the grid of several hundred receivers is surveyed. Receivers are then retrieved and moved to another survey area. The compacted sand anchors remain on the bottom but degrade within 9-12 months to natural substances. Very few if any sea turtles, seabirds or marine mammals feed at the seabed in the Study Area. The anchors are unlikely to interfere with wolffish since the fish are mobile and their dens are located in rocky areas, unlikely to be smothered by a flat anchor. The area involved is small and should rapidly return to normal suggesting a prediction of *negligible* residual effects (see Table 5.3) on *SARA* species of the Study Area from this Project component and hence *not significant*.

5.7.10.4 Light Attraction

Some prey may be attracted to lights on the water at night. This can be considered a neutral and very localized effect—negative for prey but positive for predators. In addition, the Ivory Gull is not known to be sensitive to light attraction and the associated stranding as the Leaches Storm Petrel is by far the species most affected (LGL 2013b). This effect is considered *negligible* in the case of *SARA* species (see Table 5.3).

5.7.10.5 Vessel/Gear

The physical presence of the vessel and towed gear as it passes through the water will cause some *negligible* disturbance to *SARA* species (see Table 5.3).

5.7.10.6 Accidental Events

The probability is very low of any accidental event (i.e., hydrocarbon release) being of large enough magnitude to cause a significant effect on offshore *SARA* species. Potential spill scenarios include loss of Isopar M-filled streamer integrity, small on-deck spills of petroleum products such as lubricants, and small spills during refuelling, if it occurs offshore. If a streamer is punctured the maximum oil leakage would be 670 L (i.e., the volume of a 50-m compartment). Isopar is a kerosene-like hydrocarbon that evaporates and disperses relatively rapidly. Communication and inspection procedures and oil spill response will minimize the number and severity of events. Sea turtles, marine mammals and adult fish have the ability to avoid oil spills. Seabirds are generally most vulnerable to surface slicks. Such spill events are predicted to be very unlikely, low magnitude, <10 km^2 in extent, and <1 month duration (see Table 5.3), and hence *not significant* to the Marine Mammal VEC.

5.7.11 Sensitive Areas

Sensitive areas are described in detail in Section 4.7 and Figures 4.36 and 4.37. The Study Area includes portions of two DFO EBSAs: (1) part of the Placentia Bay-Grand Banks, and (2) Newfoundland and Labrador Shelf. It also includes the northeast half of the Bonavista Cod Box and several narrow NAFO coral/sponge closure areas (see Figure 4.36).

The CSEM project will have little or no effect on the attributes that contribute to the sensitive habitat or the physical habitat itself of these defined sensitive areas. The anchors have some potential to interact with the seabed but receivers are widely spaced and the anchors degrade to natural substances within one year. It is predicted that the Project will have *negligible* effect (see Table 5.3) and thus *no significant effect* on the Sensitive Areas VEC.

5.8 Unexploded Explosive Ordnance

The Department of National Defense (DND) indicates that there are two wrecks present within the immediate survey area; the U-520 Submarine (47.78N, 49.83W) and U-658 Submarine (50.00N, 46.53W) (DND 2014). The submarine shipwrecks may contain Unexploded Explosive Ordnance (UXO). Other UXOs from WWII actions may be present on the eastern Grand Banks in general and there is one disposal site in the Study Area (Sydney Shallow Disposal Site).

EMGS will avoid all ship wrecks to avoid receiver loss. Project activities have little potential to interact with UXOs; if any are located EMGS will immediately provide locations to DND. DND will review the EA and EMGS will communicate with DND prior to operations to avoid any potential conflicts.

In 2014, DND does not anticipate any conducting any naval exercises in the Study Area although they may be operating near the area in a non-interferring manner. In future years, EMGS will communicate with DND to avoid conflicting with any potential operations.

5.9 Uncertainty and Data Gaps

The C-NLOPB Scoping Document (C-NLOPB 2014) requires that important data gaps be identified. For the present CSEM EA, there are three main areas of data gaps:

1. Relatively few marine animals, especially invertebrates and large marine mammals, have undergone testing for electromagnetic sensitivities;
2. It is known that a wide variety of animals can detect EM field and may react or use these in various ways, in most cases the specific mechanisms remain unknown; and
3. Common to all offshore EAs, there are data gaps on distribution in time and space of important species, including *SARA* species.

The present EA has addressed these uncertainties and gaps in the following manner:

1. EM sensitivities: conservative thresholds were selected from the wide variety of animals that have been tested, with focus on elasmobranchs, which scientific research thus far has shown to be the most sensitive group;
2. Mechanisms: the use of geomagnetism for animal navigation has been studied for many years, especially with birds that migrate long distances. While considerable knowledge has been obtained, the specific mechanisms involved remain theoretical. A conservative intuitive approach was used in this EA. For example, as with any navigation system, migratory animals must use a variety clues in order to successfully navigate from Point A to B in a "EM-noisy" marine environment; and
3. Distributional data gaps are common to all offshore EAs. It is especially difficult to account for rare, highly mobile species (e.g., most of the *SARA* species such as whales and sea turtles). These data gaps are gradually being at least partially addressed by observer programs on seismic vessels. Again, the conservative approach used in this EA should account for any data gaps.

5.10 Cumulative Effects

This EA has assessed cumulative effects within the Project and thus, the residual effects described in preceding sections include any potential cumulative effects from the EMGS CSEM program activities in the Project Area.

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

- Commercial and research survey fishing;
- Vessel traffic (e.g., transportation, defense, yachts);
- Hunting (e.g., seabirds, seals), and
- Offshore oil and gas industry.

Fishing has been discussed and assessed in detail in Section 4.3. Fishing activities, by their nature, cause mortality and disturbance to fish populations and may cause incidental mortalities or disturbance to non-target fish species, seabirds, marine mammals, and sea turtles. It is predicted that the CSEM surveys will not cause any mortality to these VECs (with the potential exception of small numbers of petrels) and thus, there will be either *no* or *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. The CSEM 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 predicted to be *not significant*.

In the summer, the main North Atlantic shipping lanes between Europe and North America lie to the north of the Grand Banks into the Strait of Belle Isle. In the winter, that traffic shifts to the main shipping lanes along the southern Grand Banks into the Gulf of St. Lawrence. Thus, potential for cumulative effects with other shipping is predicted to be *low*.

The vast majority of hunting of seabirds (mostly murres) in Newfoundland and Labrador waters occurs near shore from small boats. Also, it is predicted that no murres will suffer mortality from the Project's routine activities. Thus, there is little or no potential for cumulative effects on this VEC. Similarly, most, if not all, seal hunting would occur inshore of the Project Area and the Project will cause no mortality to seals even in the event of an accidental spill of petroleum hydrocarbons.

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

- Hebron activities;
- HMDC 2D/3D/4D seismic program, 2013-life of field;
- Husky White Rose Extension Project (WREP);
- Multi Klient Invest ASA (MKI) 2D seismic program on Northeast Newfoundland Shelf (i.e., Labrador Basin, Orphan Basin, Flemish Pass, Jeanne d'Arc Basin), 2012-2017
- Statoil 3D/2D geophysical program including geohazard and electromagnetic surveys in Jeanne d'Arc and Central Ridge/Flemish Pass Basins, 2011-2019;
- WesternGeco 3D/2D seismic program in the Jeanne d'Arc Basin, 2012-2015;
- 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 exploratory drilling program Orphan Basin;
- 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 White Rose new drill centre construction and operations program, 2008-2015; and
- Husky exploration and delineation drilling program in Jeanne d'Arc Basin, 2008-2017.

In addition, the following Grand Banks projects are presently undergoing EA (C-NLOPB website 13 Feb 2014):

TGS NOPEC	TGS NOPEC Geophysical Company ASA and Multi Klient Invest AS Offshore Labrador Seafloor and Seabed Sampling Program, Newfoundland and Labrador Offshore Area, 2014-2019
ARKeX Ltd.	ARKeX Ltd. TGS-NOPEC Labrador Sea Gravity Gradient Survey, 2014-2018
GXT	GXT GrandSPAN Marine 2d Seismic Gravity and Magnetic Survey, 2014-2018
MKI	Multi Klient Invest Southern Grand Banks Seismic, 2014-2018
MKI	Multi Klient Invest AS Labrador Sea Seismic Program, 2014 to 2018
Suncor Energy Inc.	Suncor Energy's Eastern Newfoundland Offshore Area 2D/3D/4D Seismic Program, 2014-2024
Black Spruce Exploration Corp. and Shoal Point Energy Ltd.	Black Spruce Exploration Corp. and Shoal Point Energy Ltd. Western Newfoundland Drilling Program, 2013 to 2019
Hibernia Management and Development Company Ltd	Hibernia Management and Development Company Ltd. 2D/3D/4D Seismic Projects for the Hibernia Oil and Gas Production Field, 2013 to Remaining Life of Field
Western Geco Canada	Western Geco Canada Jeanne d'Arc Basin Seismic Program, 2012-2015

While the above lists suggest potential for many programs to run concurrently, it should be noted that the East Coast operators tend to coordinate their logistics. As a result, based on historical levels of activities, there typically would be no more than two or three drill rigs and two or three geophysical programs operating off Newfoundland and Labrador during any one season.

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

There are no other CSEM surveys planned for the Study Area so there will be no cumulative effects from other similar programs. There is potential for cumulative effects with other geophysical programs (e.g., seismic and geohazard) that will be active for 2014 (e.g., see above lists). Several programs tend to use the same survey vessel so that any cumulative effects will be minimal. In future years, different geophysical programs could potentially be operating in relatively close proximity. During these periods, VECs may be exposed to disturbance from more than one of the survey programs. It will be in the interests of the different parties for good coordination between programs in order to provide sufficient buffers and to minimize acoustic interference, and to allow safe turning areas. EMGS will participate in a coordinated effort to provide sufficient spatial buffers between geophysical vessels operating concurrently in the Grand Banks area.

Assuming maintenance of sufficient separation of other vessels operating concurrently in the Project Area, cumulative effects on fish and fish habitat, fisheries, seabirds, marine mammals, sea turtles and species at risk are predicted to be *not significant*. However, there are uncertainties regarding this prediction. The potential for temporal and spatial overlap of future activity of geophysical programs (2014-EF) in the area will be assessed in the EA update process.

As discussed in this EA, negative effects on key sensitive VECs such as elasmobranchs appear unlikely beyond a localized area from the EM source. In addition, all programs will use mitigation measures detailed in the VEC effects sections and the following mitigation summary section (Section 6.0). Thus, it seems likely that while some animals may undergo disturbance from one or more geophysical programs, the current scientific prediction is that *no significant residual effects* will result.

6.0 Mitigations and Follow-up

Project mitigations have been detailed in the various individual sections of the preceding EA and are summarized in the text provided below and in Table 6.1.

While this EA covers 2014 to 2018, details on any post-2014 surveys will be provided in EA validation documents to be submitted to the C-NLOPB.

Table 6.1 Summary of Mitigation Measures.

Potential Effects	Primary Mitigations
Interference with fishing vessels	• Conduct upfront planning to avoid high concentrations of fishing vessels • Request input from fishing captains through FFAW PIL regarding streamer deployment and testing plan • Utilize Single Point of Contact (SPOC) • Release advisories and communications • Employ FLO • Plan transit route to and between Survey Areas (if required)
Fishing gear damage	• Conduct upfront planning to avoid high concentrations of fishing gear • Utilize SPOC • Release advisories and communications • Employ FLO and picket vessel • Compensation • Plan transit route to and between Survey Areas (if required)
Interference with shipping	• Utilize SPOC • Release advisories and communications • Employ FLO
Interference with DFO/FFAW research vessels	• Maintain communications and scheduling
Temporary disturbance to Species at Risk	• Delay start-up if any *SARA* species are within 500 m • Ramp-up EM source • Shutdown EM source for endangered or threatened elasmobranchs, marine mammals and sea turtles • If required, use qualified observers to monitor for Ivory Gull, white shark, marine mammals and sea turtles during daylight EM operations.
Injury (mortality) to stranded seabirds	• Monitor vessel daily • Comply with conditions in CWS permit • Provide strandings report to CWS within one year (see CWS protocols Appendix B) • Minimize lighting if safe to do so
Exposure to hydrocarbons	• Adhere to International Convention for the Prevention of Pollution from Ships (MARPOL) • Utilize Spill Response Plan • Report oiled birds to CWS (see CWS protocols Appendix B)

6.1 *SARA* Species, Including Marine Mammals and Sea Turtles

If required, mitigation measures designed to reduce any potential effects on sharks, marine mammals and sea turtles will include ramp-ups, no initiation of the EM source if a shark, 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 a Schedule 1 *endangered* (or *threatened*) animal is observed within the 500 m safety zone. Prior to the onset of the CSEM survey, the source will be gradually ramped up. An on-board observer will watch for shark, marine mammals and sea turtles 30 min prior to ramp-up. If a shark, marine mammal or sea turtle is sighted within 500 m of the source, then ramp-up will not commence until the animal has moved beyond the 500 m zone or 20 min have elapsed since the last sighting. The observers will watch for shark, marine mammals and sea turtles when the source is active (during daylight periods) and note the location and behaviour of these animals. The source will be shut down if an *endangered* (or *threatened*) species is sighted within the safety zone. The planned monitoring and mitigation measures, including ramp-ups, visual monitoring, and shut-down of the EM source when *endangered* or *threatened* marine animals are seen within the "safety radii", will minimize the already-low probability of exposure of marine animals to EMFs strong enough to be detected. Any dead or distressed marine mammals or sea turtles, and *SARA* species will be recorded and reported to the C-NLOPB.

6.2 Seabirds

Any seabirds (most likely Leach's Storm-Petrel) that become stranded on the vessel will be released using the mitigation methods consistent with *The Leach's Storm-Petrel: General Information and Handling Instructions* by U. Williams (Petro-Canada) and J. Chardine (CWS) (n.d.). It is understood by EMGS that a CWS *Migratory Bird Handling Permit* will be required and this will be secured by EMGS. In the unlikely event that marine mammals, turtles or birds are injured or killed by Project equipment or accidental spills of fuel or streamer flotation fluid, a report will immediately be filed with C-NLOPB and the need for follow-up monitoring assessed. Handling of stranded oiled and non-oiled birds will be according to the CWS Bird Handling Permit (see also Appendix B). As per CWS protocols (appended), any dead *SARA* species will be collected and sent to CWS. Any dead birds (non-*SARA*) in a stranding event exceeding 10 birds will also be sent to CWS.

Seabird data collection protocols will be consistent with those provided by CWS in Gjerdrum et al. (2012). If required, data will be collected by a qualified MMO or MMO/SBO assisted by the FLO. A monitoring report will be submitted to the C-NLOPB within one year after completion of the surveys.

6.3 Fisheries

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. In addition, 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 immediately. Fishing gear may only be retrieved from the water by the gear owner (i.e. fishing license owner). This includes buoys, radar reflectors, rope, 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 the CSEM streamer; 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). EMGS will advise the C-NLOPB prior to compensating and settling all valid lost gear/income claims promptly and satisfactorily.

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

- Survey lines will be submitted to the C-NLOPB and the FFAW at least 6 weeks prior to start-up ;
- Timely and clear communications (VHF, HF, Satellite, etc.);
- Utilization of fisheries liaison officers (FLOs) for advice and coordination in regard to avoiding fishing vessels and fishing gear;
- FLO onboard;
- Posting of advisories with the Canadian Coast Guard and the CBC Fisheries Broadcast;
- Compensation in the event any project activities damage fishing gear [Compensation will be according to established procedures—e.g., C-NLOPB and C-NSOPB (2002) and One Ocean (2013).]; and
- Single Point of Contact (SPOC).

EMGS will also coordinate with DFO, St. John's, and the FFAW to avoid any potential conflicts with survey vessels that may be operating in the area. EMGS commits to ongoing communications with other operators with active geophysical programs within the general vicinity of its CSEM program to minimize the potential for cumulative effects on the VECs.

While this EA covers the Project from 2014 to 2018, details on any post-2014 surveys will be provided in EA validation documents to be submitted to the C-NLOPB.

7.0 Residual Effects of the Project

A summary of the Project's residual effects on the environment, those effects that remain after all mitigations have been instituted, are shown in Table 7.1. In conclusion, EMGS' 2014-2018 CSEM Project is predicted to have *no significant effects* on the VECs.

Table 7.1 Significance of Potential Residual Environmental Effects of HMDC's Proposed Seismic Program on VECs in the Study Area.

All Valued Ecosystem Components (VECs)				
Project Activity	**Significance Rating**	**Level of Confidence**	**Likelihood [a]**	
	Significance of Predicted Residual Effects		**Probability Occurrence**	**Scientific Certainty**
Sanitary/Domestic Wastes	NS	2-3	-	-
CSEM Source	NS	3	-	-
Underwater Sound				
• Deploy Receiver	NS	3	-	-
• Retrieve Receiver	NS	3	-	-
• Streamer Towing	NS	3	-	-
Seabed Disturbance				
• Deploy Receiver	NS	2-3	-	-
• Retrieve Receiver	NS	2-3	-	-
Light Attraction	NS	3	-	-
Physical Presence				
• Vessel/Gear	NS	3	-	-
• Supply Vessel	NS	3	-	-
Accidental Spills	NS	2-3	-	-

Key:

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

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

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

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

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

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

8.0 Literature Cited

Abgrall, P., A.L. Lang, and V.D. Moulton. 2008a. Marine mammal and seabird monitoring of Husky Energy's 3-D seismic program in the Jeanne d'Arc Basin, 2006 and 2005-2006 combined. LGL Rep. SA920. Rep. by LGL Limited, St. John's, NL, for Husky Energy Inc., Calgary, AB. 98 p. + appendices.

Abgrall, P., B.D. Mactavish, and V.D. Moulton. 2008b. Marine mammal and seabird monitoring of Orphan Basin controlled source electromagnetic survey program, 2006 – 2007. LGL Rep. SA904/939. Rep. by LGL Limited, St. John's, NL, for ExxonMobil Canada Ltd., St. John's, NL. 96 p. + appendices.

Abgrall, P., A.L. Lang, B.D. Mactavish, and V.D. Moulton. 2009. Marine mammal and seabird monitoring of StatoilHydro Canada and Husky Energy's 2008 seismic program in the Jeanne d'Arc Basin. Draft LGL Rep. SA984. Rep. by LGL Limited, St. John's, NL, for StatoilHydro Canada Exploration & Production Inc., St. John's, NL and Husky Energy Inc., Calgary, AB. 98 p. + appendices.

ALTRT (Atlantic Leatherback Turtle Recovery Team). 2006. Recovery Strategy for Leatherback Turtle (*Dermochelys coriacea*) in Atlantic Canada. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. vi + 45 p.

Andersen, J.M., Y.F. Wiersma, G.B. Stenson, M.O. Hammill, and A. Rosing-Asvid. 2009. Movement patterns of hooded seals (*Cystophora cristata*) in the Northwest Atlantic Ocean during the post-moult and pre-breed seasons. J. Northw. Atl. Fish. Sci. 42: 1-11.

Anderwald, P., A.K. Daníelsdóttir, T. Haug, F. Larsen, V. Lesage, R.J. Reid, G.A. Víkingsson, and A.R. Hoezel. 2011. Possible cryptic stock structure for minke whales in the North Atlantic: Implications for conservation and management. Biol. Conserv. 144: 2479-2489.

Auster, P.J., J. Moore, K.B. Heinonen, and L. Watling. 2005. A habitat classification for seamount landscapes: Assessing the functional role of deep-water corals as fish habitat. pp. 761-769 *In* A Freiwald and J.M. Roberts (eds.). Cold-water corals and ecosystems. Springer-Verlag, Heidelberg.

Avins, L., and K.J. Lohmann. 2003. Use of multiple orientation cues by juvenile loggerhead sea turtles, *Caretta.* J. Exp. Biol. 206: 4317-4325.

Avins, L., and K.J. Lohmann. 2004. Navigation and seasonal migratory orientation in juvenile sea turtles. J. Exp. Biol. 207:1771-1778.

Baillie, S.M., G.J. Robertson, F.K. Wiese, and U.P. Williams. 2005. Seabird data collected by the Grand Banks offshore hydrocarbon industry 1999-2002: results, limitations and suggestions for improvement. Canadian Wildlife Service Technical Report Series No. 434. Atlantic Region.

Baillon, S., J.-F. Hamel, V.E. Wareham, and A. Mercier. 2012. Deep cold-water corals as nurseries for fish larvae. Front. Ecol. Environ. 10(7): 351-356.

Baird, R.W., P J. Stacey, and H. Whitehead. 1993. Status of the Striped Dolphin, *Stenella coeruleoalba*, in Canada. Canadian Field-Naturalist 107: 455-465.

Baker, K.D., R.L. Haedrich, D.A. Fifield, and K.D. Gilkinson. 2012. Grenadier abundance examined at varying spatial scales in deep waters off Newfoundland, Canada, with special focus on the influence of corals. J. Ichthyol. 52(10): 678-689.

Bajzak, C.E., S.D. Côté, M.O. Hammill, and G. Stenson. 2009. Intersexual differences in the postbreeding foraging behaviour of the Northwest Atlantic hooded seal. Mar. Ecol. Prog. Ser. 385: 285-294.

Barlow, J. and R. Gisiner. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales. J. Cetac. Res. Manage. 7(3): 239-249.

Barnes, J.L. and L.H. Davey. 1999. A practical approach to integrated cumulative environmental effects assessment to meet the requirements of the *Canadian Environmental Assessment Act*. Paper presented at the 1999 Annual Meeting of the International Association for Impact Assessment.

Barrie, J.D., B.A. Bennett, S.M. Browne, and A.J. Moir. 1980. Offshore Labrador biological studies, 1979: Benthos. Nearshore studies of marine benthos in the Makkovik Bay and Cartwright regions. Rep. by Atlantic Biological Services Ltd. (LGL-Northland), for Total Eastcan Exploration Ltd. 158 p.

Beauchamp, J., H. Bouchard, P. de Margerie, N. Otis, and J.-Y. Savaria. 2009. Recovery Strategy for the blue whale (*Balaenoptera musculus*), Northwest Atlantic population, in Canada [FINAL]. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. 62 p.

Benjamins, S., W. Ledwell, J. Huntington, and A.R. Davidson. 2012. Assessing changes in numbers and distribution of large whale entanglements in Newfoundland and Labrador. Mar. Mamm. Sci. 28(3): 579-601.

Bergström, L., F. Sundqvist, and U. Bergström. 2013. Effects of an offshore wind farm on temporal and spatial patterns in the demersal fish community. Mar. Ecol. Prog. Ser. 485:199-210.

BIO (Bedford Institute of Oceanography) and NAFC (Northwest Atlantic Fisheries Center). 2007. Skates and rays of Atlantic Canada. Available at http: //www.marinebiodiversity.ca/ skatesandrays/Skates%20and%20Rays%20Overall.htm.

Black, A. 2005. Light induced mortality on vessels operating in the Southern Ocean: Incidents and mitigation measures. Ant. Sci. 17: 67-68.

Bochert, R., and M.L. Zettler. 2004. Long-term exposure of several marine benthic animals to static magnetic fields. Bioelectromagnetics 25: 498-502.

Boje, J. 2002. Intermingling and seasonal migrations of Greenland halibut (*Reinhardtius hippoglossoides*) populations determined from tagging studies. Fish. Bull. 100: 414–422.

Boles, L.C., and K.J. Lohmann. 2003. True navigation and magnetic maps in spiny lobsters. Nature 421: 60-63.

Bonadonna, F., C. Bajzak, S. Benhamou, K. Igloi, P. Jouventin, H. P. Lipp, and G. Dell'Omo. 2005. Orientation in the wandering albatross: interfering with magnetic perception does not affect orientation performance. Proc. R. Soc. Lond. [Biol]. 272:489-495.

Bowen, W.D. 2011. Historical grey seal abundance and changes in the abundance of grey seal predators in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/026. vi + 4 p.

Bowering, W.R. 1983. Age, growth, and sexual maturity of Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum) in the Canadian Northwest Atlantic. Fish. Bull. 81: 599-611.

Bowering, W.R. and W.B. Brodie. 1995. Greenland halibut (*Reinhardtius hippoglossoides*): A review of the dynamics of its distribution and fisheries off eastern Canada and Greenland. pp. 113-160 *In* A.G. Hopper (ed.). Deep-Water Fisheries of the North Atlantic Oceanic Slope. Kluwer Academic Publishers, Boston. 420 p.

Bowering, W.R. and K.H. Nedreaas 2000. A comparison of Greenland halibut (*Reinhardtius hippoglossoides* (Walbaum)) fisheries and distribution in the Northwest and Northeast Atlantic. Sarsia, 85: 61–76.

Brabyn, M., and R. Frew. 1994. New Zealand herd stranding sites do not relate to geomagnetic topography. Mar. Mam. Sci. 10: 195-207.

Bradbury, I.R., P.V.R. Snelgrove, and S. Fraser. 2000. Transport and development of eggs and larvae of Atlantic Cod, *Gadus morhua*, in relation to spawning time and location in coastal Newfoundland. Can. J. Fish. Aquat. Sci. 57: 1761-1772.

Bradbury, I.R., P.V.R. Snelgrove, and S. Fraser. 2002. The Influence of temperature on the loss of Atlantic Cod (*Gadus morhua*) eggs and larvae from the inshore environment: a combined modeling and observational approach. Fish. Oceanogr. 10: 342-352.

Bradbury, I.R., B. Laurel, D.Robichaud, G.A. Rose, P.V.R. Snelgrove, G.B and D. Cote. 2008. Discrete spatial dynamics and essential habitat of coastal cod populations: conservation and management implications. Fish. Res. 91: 299-309.

Brazner, J.C., and J. McMillan. 2008. Loggerhead turtle (*Caretta caretta*) bycatch in Canadian pelagic longline fisheries: relative importance in the western north Atlantic and opportunities for mitigation. Fish. Res. 91: 310-324.

Breeze, H., D.S. Davis, M. Butler, and V. Kostylev. 1997. Distribution and status of deep sea corals off Nova Scotia. Ecology Action Centre, Marine Issues Committee Special Publication 1. 58 p.

Brown, R.G.B. 1986. Revised atlas of Eastern Canadian seabirds. 1. Shipboard surveys. Bedford Institute of Oceanography and Canadian Wildlife Service, Dartmouth, NS, and Ottawa, ON.

Brown, M.W., D. Fenton, K. Smedbol, C. Merriman, K. Robichaud-Leblanc, and J.D. Conway. 2009. Recovery strategy for the North Atlantic right whale (*Eubalaena glacialis*) in Atlantic Canadian waters [Final]. *Species at Risk Act* Recovery Strategy Series. Fisheries and Oceans Canada. vi + 66 p.

Buchanan, R.A., J. Christian, V. Moulton, and B. Mactavish. 2004. Orphan 3-D Seismic Program, 2004-2006 environmental assessment. LGL Rep. SA799. Rep. by LGL Limited, St. John's, NL, for Chevron Canada Resources and ExxonMobil. 209 p. + appendices.

Buchanan, R.A., J.R. Christian, V.D. Moulton, B. Mactavish, R. Pitt, J. Bobbitt, S. Canning, R. Belore, P. Rudkin, D. Dunbar, and M. Wawrzkow. 2006a. Laurentian sub-basin exploration drilling program environmental assessment. LGL Rep. SA832. Rep. by LGL Limited with Oceans Limited, Canning & Pitt Associates, Inc., Provincial Airlines Limited, SL Ross Environmental Research Ltd., Calixte Environmental Management and PAL Environmental Services, St. John's, NL, for ConocoPhillips Canada Resources Corporation, Calgary, Alberta. 408 p. + appendices.

Buchanan, R.A., R. Fechhelm, J. Christian, V.D. Moulton, B. Mactavish, R. Pitt, and S. Canning. 2006b. Orphan Basin controlled source electromagnetic survey program environmental assessment. LGL Rep. SA899. Rep. by LGL Limited and Canning & Pitt Associates Inc., St. John's, NL, for ExxonMobil Canada Ltd., St. John's, NL. 128 p. + appendix.

Buchanan, R.A., R. Fechhelm, P. Abgrall, and A.L. Lang. 2011. Environmental Impact Assessment of Electromagnetic Techniques Used for Oil & Gas Exploration & Production. LGL Rep. SA1084. Rep. by LGL Limited, St. John's, NL, for International Association of Geophysical Contractors, Houston, Texas. 132 p. + appendices. Available at http://www.iagc.org/files/2645/.

Burke, C.M., G.K. Davoren, W.A. Montevecchi, and F.K. Wiese. 2005. Surveys of seabirds along support vessel transects and at oil platforms on the Grand Banks. pp. 587-614 *In* P.J. Cransford and K. Lee (eds.). Offshore Oil and Gas Environmental Effects Monitoring. Battelle Press, Columbus, Ohio.

Busby, C.D, M.J. Morgan, K.S. Dwyer, G.M. Fowler, R. Morin, M. Treble, D. Maddock Parsons, and D. Archambault. 2007. Review of the structure, the abundance and distribution of American plaice (*Hippoglossoides platessoides*) in Atlantic Canada in a species-at-risk context. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/069.

Cairns, D.K., W.A. Montevecchi, and W. Threlfall. 1989. Researcher's guide to Newfoundland seabird colonies. Second edition. Memorial University of Newfoundland Occasional Papers in Biology, No. 14. 43 p.

Campbell, D.C., D.J.W. Piper, E.V. Dougla, and S. Migeon. 2002. Surficial geology of Flemish Pass: Assessment of hazards and constraints to development. Geological Survey of Canada, Open File 1454. 61 p.

Canadian Ice Service. 2014. 30-year Ice Atlas. Available at http://iceweb1.cis.ec.gc.ca/30Atlas10/.

Carey, A.G., Jr. 1991. Ecology of North American Arctic continental shelf benthos: A review. Cont. Shelf Res. 11: 865-883.

CEAA (Canadian Environmental Assessment Agency). 1994. Environmental Assessment Guidelines. Canadian Environmental Assessment Agency, Ottawa.

CEAA. 2000. Preparing project descriptions under the Canadian Environmental Assessment Act. Canadian Environmental Assessment Agency Operational Policy Statement OPS –EPO/5-2000. 6 p.

CEAA. 2012. Canadian Environmental Assessment Act, 2012. Available at http://laws-lois.justice.gc.ca/eng/acts/C-15.21/index.html.

Chapdelaine, G., A.W. Diamond, R.D. Elliot, and G.J. Robertson. 2001. Status and population trends of the Razorbill in eastern North America. Canadian Wildlife Service, Occ. Paper, No. 105.

Chardine, J.W. 2000. Census of Northern Gannet colonies in the Atlantic Region in 1999. Canadian Wildlife Service, Atlantic Region, Technical Report Series No. 361.

Chardine, J.W., G.J. Robertson, P.C. Ryan, and B. Turner. 2003. Abundance and distribution of Common Murres breeding at Funk Island, Newfoundland 1972 and 2000. Canadian Wildlife Service, Atlantic Region, Technical Report Series No. 404.

Christian, J.R. 2008. Environmental assessment of Petro-Canada Jeanne d'Arc Basin exploration drilling program, 2009-2017. LGL Rep. SA993. Rep. by LGL, St. John's, NL, for Petro-Canada, St. John's, NL. 258 p. + appendix.

Christian, J.R., C.G.J. Grant, J.D. Meade, and L.D. Noble. 2010. Habitat requirements and life history characteristics of selected marine invertebrate species occurring in the Newfoundland and Labrador region. Can. Manuscr. Rep. Fish. Aquat. Sci. 2925. vi + 207 p.

Chumakov, A.K. 1975. Localities of the Greenland halibut stocks in the Northwest Atlantic. Tr. Polyarn. Naucho-Issled. Proektn. Inst. Morsk. Rybn. Khoz. Okeanogr. 35: 203-209.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy, and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Can. J. Zool. 71: 440-443.

C-NLOPB (Canada-Newfoundland and Labrador Offshore Petroleum Board). 2012. Canada-Newfoundland and Labrador Offshore Petroleum Board: Geophysical, Geological, Environmental and Geotechnical Program Guidelines, January 2012.

C-NLOPB. 2014. Electromagnetic Geoservices Canada, Inc. Controlled Source Electromagnetic Survey, 2014 to 2018, Scoping Document. Prepared by C-NLOPB, Environmental Affairs Department, St. John's, NL. 11 p.

C-NLOPB and C-NSOPB. 2002. Compensation guidelines respecting damages relating to offshore petroleum activity. Canada-Newfoundland and Labrador Offshore Petroleum Board, St. John's, NL and Canada-Nova Scotia Offshore Petroleum Board, Halifax, NS. 15 p.

Colbourne, E.B. and K.D. Foote. 2000. Variability of the stratification and circulation on the Flemish Cap during the decades of the 1950s-1990s. J. Northw. Atl. Fish. Sci. 26: 103–122.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2002. COSEWIC assessment and update status report on the blue whale *Balaenoptera musculus* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. vi + 32 p.

COSEWIC. 2003a. COSEWIC assessment and status report on the sei whale *Balaenoptera borealis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 27 p.

COSEWIC. 2003b. COSEWIC assessment and update status report on the North Atlantic right whale *Eubalaena glacialis* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 28 p.

COSEWIC. 2005. COSEWIC assessment and update status report on the fin whale *Balaenoptera physalus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 37 p.

COSEWIC. 2006a. COSEWIC assessment and update status report on the Sowerby's beaked whale *Mesoplodon bidens* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 20 p.

COSEWIC. 2006b. COSEWIC assessment and update status report on the harbour porpoise *Phoecena phoecena* (Northwest Atlantic population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 32 p.

COSEWIC. 2006c. COSEWIC assessment and update status report on the Ivory Gull *Pagophila eburnea* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 42 p.

COSEWIC. 2007. COSEWIC assessment and status report on the roughhead grenadier *Macrourus berglax* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 40 p.

COSEWIC. 2008. COSEWIC assessment and update status report on the killer whale *Orcinus orca*, southern northern population, northern resident population, west coast transient population, offshore population and Northwest Atlantic / Eastern Arctic population, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. vii + 65 p.

COSEWIC. 2009. COSEWIC assessment and status report on the American Plaice *Hippoglossoides platessoides*, Maritime population, Newfoundland and Labrador population and Arctic population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 74 p.

COSEWIC. 2010a. COSEWIC assessment and update status report on the Atlantic cod *Gadus morhua* in Canada. Committee on the Status of Endangered Wildlife in Canada. COSEWIC assessment and update status report on the Atlantic cod Gadus morhua in Canada. Ottawa. xiii + 105 pp.

COSEWIC. 2010b. COSEWIC assessment and status report on the Loggerhead Sea Turtle *Caretta caretta* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 75 p.

COSEWIC. 2011. COSEWIC assessment and status report on the northern bottlenose whale *Hyperoodon ampullatus*. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. xii + 31 p.

COSEWIC. 2012a. COSEWIC assessment and status report on the Atlantic Wolffish *Anarhichas lupus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 56 p.

COSEWIC. 2012b. COSEWIC assessment and status report on the Northern Wolffish *Anarhichas denticulatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 41 p.

COSEWIC. 2012c. COSEWIC assessment and status report on the Spotted Wolffish *Anarhichas minor* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 44 p.

COSEWIC. 2012d. COSEWIC assessment and status report on the leatherback sea turtle *Dermochelys coriacea* in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa, ON. xv + 58 p.

COSEWIC. 2013. Canadian Wildlife Species at Risk. May 2013. 105 p. Available at http://www.cosewic.gc.ca/eng/sct0/rpt/csar_e_2013.pdf.

COSEWIC website. 2014. Committee on the Status of Endangered Wildlife in Canada. Available at http://www.cosepac.gc.ca/eng/sct5/index_e.cfm.

Cramp, S. and K.E.L. Simmons (eds.). 1983. The birds of the western Palearctic, Volume 1: Ostrich to ducks. Oxford Univ. Press, Oxford. 722 p.

Dalebout, M.L., D.E. Ruzzante, H. Whitehead, and N.I. Øien. 2006. Nuclear and mitochondrial markers reveal distinctiveness of a small population of bottlenose whales (*Hyperoodon ampullatus*) in the western North Atlantic. Mol. Ecol. 15:3115-3129.

Davoren, G.K. 2013. Distribution of marine predator hotspots explained by persistent areas of prey. Mar. Biol. doi 10.1007/x00227-013-2294-5.

Desrosiers, G., C. Savenkoff, M. Olivier, G. Stora, K. Juniper, A. Caron, J.-P. Gagné, L. Legendre, S. Mulsow, J. Grant, S. Roy, A. Grehan, P. Scaps, N. Silverberg, B. Klein, J.-É. Tremblay, and J.-C. Therriault. 2000. Trophic structure of macrobenthos in the Gulf of St. Lawrence and on the Scotian Shelf. Deep-Sea Research II. 47: 663-697.

DFO. 1998. Newfoundland Region: Skate in divisions 3L, 3N, 3O and subdivision 3Ps. DFO Stock Status Rep. 98/A2-18.

DFO. 2006. Assessment of Division 0B – 3K Northern Shrimp. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2006/007.

DFO. 2007. Placentia Bay-Grand Banks Large Ocean Management Area Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/052.

DFO. 2008a. Fishery Management Plan, Greenland halibut, NAFO Subarea 0, 2006-2008. Produced by Fisheries and Oceans Canada, Central and Arctic Region, Winnpeg, MB. 59 p.

DFO. 2008b. Advice on the stock definition of redfish (*Sebastes fasciatus* and *S. mentella*) in Units 1 and 2. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/026.

DFO. 2008c. Proceedings of the review of DFO science information for American plaice (*Hippoglossoides platessoides*) relevant to status assessment by COSEWIC. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2007/042.

DFO. 2009a. International Fisheries – Thorny skate (*Amblyraja radiata*). Available at http: //www.dfo-mpo.gc.ca/international/facts-faits/thskate-raieep-eng.htm.

DFO. 2009b. Atlantic mackerel – Effective 2007. Integrated Fisheries Management Plan. Available at http: //www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/ifmp-gmp/mackerel-atl-maquereau/mac-atl-maq-2007-eng.htm.

DFO. 2010a. Occurrence, susceptibility to fishing, and ecological function of corals, sponges, and hydrothermal vents in Canadian waters. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/041.

DFO. 2010b. Assessment of redfish stock (*Sebastes fasciatus* and *S. mentella*) in Units 1 and 2. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/037.

DFO. 2010c. Stock assessment of Northwest Atlantic grey seals (*Halichoerus grypus*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/091.

DFO. 2010d. Recovery strategy for the Northern Bottlenose Whale, Scotian Shelf population, in Atlantic Canadian waters. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada. vi + 61p.

DFO. 2010e. Recovery potential assessment for loggerhead sea turtles (*Caretta caretta*) in Atlantic Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/042.

DFO. 2011a. Assessment of the Arctic surf clam (*Mactromeris polynuma*) stock on Grand Bank. DFO Can. Sci. Advis. Sec. Sci. Advis. Res. Doc. 2011/052. v + 55 p.

DFO. 2011b. Recovery potential assessment of American plaice (*Hippoglossoides platessoides*) in Newfoundland and Labrador. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/030.

DFO. 2011c. Blue hake. Available at http: //www.dfo-mpo.gc.ca/species-especes/aquatic-aquatique/blue-hake-eng.htm.

DFO. 2011d. Using satellite tracking data to define important habitat for leatherback turtles in Atlantic Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/036.

DFO. 2011e. Recovery potential assessment for northern bottlenose whales (*Hyperoodon ampullatus*) in Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/031.

DFO. 2012a. Current status of Northwest Atlantic harp seals, (*Pagophilus groenlandicus*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/070.

DFO 2012b. State of the Ocean: Placentia Bay-Grand Banks Large Ocean Management Area. DFO Can. Man. Rep. Fish. Aquat. Sci. 2983

DFO. 2013a. Assessment of Divisions 2G-3K northern shrimp. DFO Can. Sci. Advis. Sci. Stock Advis. Rep. 2013/012.

DFO. 2013b. Assessment of Newfoundland and Labrador snow crab. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/013.

DFO. 2013c. Assessment of capelin in SA2 + DIV. 3KL in 2013. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/011.

DFO. 2013d. Mackerel: A tough fish to monitor. Fisheries and Oceans Canada website, last updated 2013-04-22. Available at http://www.dfo-mpo.gc.ca/science/publications/article/2009/09-08-09-eng.html.

DFO. 2013e. Underwater World - Yellowtail Flounder (Western North Atlantic Ocean). Available at http://www.dfo-mpo.gc.ca/Science/publications/uww-msm/articles/yellowtailflounder-limandeaqueuejaune-eng.html.

DFO. 2013f. Stock assessment of Northern (2J3KL) cod in 2013. DFO Can. Sci. Advis. Rep. 2013/014.

DFO. 2013g. Identification of Additional Ecologically and Biologically Significant Areas (EBSAs) within the Newfoundland and Labrador Shelves Bioregion. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/048.

DFO. 2013h. Underwater World – The Witch Flounder. Available at http://www.dfo-mpo.gc.ca/science/publications/uww-msm/articles/witchflounder-pliegrise-eng.htm.

DND (Department of National Defence). 2014. DND (Maritime Forces Atlantic, P.O. Box 99000, Stn. Forces, Halifax, NS). Letter to: C-NLOPB (140 Water St., 4th Floor, St. John's, NL). January 2014. MARL: 1262-7 (N48). TD: 2014-000045. 2 p.

Donovan, G.P. 1991. A review of IWC stock boundaries. Rep. Int. Whal. Comm. (Special Issue) 13: 39-68.

Edinger, E, K. Baker, R. Devillers, and V. Wareham. 2007. Coldwater corals off Newfoundland and Labrador: Distributions and fisheries impacts. World Wildlife Foundation, Toronto, Canada.

Edinger, E., V. Wareham, K. Baker, and R. Haedrich. 2009. Relationships between deep-sea corals and groundfish. pp. 39-55 *In* K. Gilkinson and E. Edinger (eds.). The ecology of deep-sea corals of Newfoundland and Labrador waters: biogeography, life history, biogeochemistry, and relation to fishes. Can. Tech. Rep. Fish. Aquat. Sci. 2830. vi + 136 p.

Environment Canada. 2013. Recovery strategy for the Ivory Gull (*Pagophila eburnean*) in Canada [Proposed]. Species at Risk Act Recovery Strategy Series. Environment Canada, Ottawa. iv + 22 p.

ExxonMobil. 2011. Hebron project comprehensive study report. Prepared by Stantec Consulting Limited, St. John's, NL, in association with AMEC Earth & Environmental, Applied Science Associates Incorporated, Canning & Pitt Associates

Incorporated, Cormorant Limited, Fugro Jacques Geosurveys Incorporated, JASCO Applied Sciences, LGL Limited, Oceans Limited, Provincial Aerospace Limited (PAL), and SL Ross Environmental Research Limited. 25 p.

Facey, D.E., and M.J. Van Den Avyle. 1987. American eel. *In* Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (North Atlantic). USFWS-SEFSC Biological Report 82, TR EL-82-4.

Fahay, M.P. 1983. Guide to early stages of marine fishes occurring in the western North Atlantic Ocean, Cape Hatteras to the southern Scotian Shelf. J. Northw. Atl. Fish. Sci. 4. 424 p.

Fifield, D.A., K.P. Lewis, C. Gjerdrum, G.J. Robertson, and R. Wells. 2009. Offshore seabird monitoring program. Environment Studies Research Funds Report No. 183. St. John's, NL. 68 p.

Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. Killer Whales. Second Edition ed. UBC Press, Vancouver. 104 p.

Fort. J., B. Moe, H. Strøm, D. Grémillet, J. Welcker, J. Schultner, K. Jerstad, K.L. Johansen, R.A. Phillips and A. Mosbech. 2013. Multicolony tracking reveals potential to little auks wintering in the North Atlantic from marine pollution and shrinking sea ice cover. Diversity and Distributions (2013): 1-11.

Frank, K.T., J.E. Carscadden, and W.C. Leggett. 1993. Causes of spatio-temporal variation in the patchiness of larval fish distributions: differential mortality or behaviour? Fish. Oceanogr. 2: 114-123.

Franklin, A. 1972. The cockle and its fisheries. Ministry of Agriculture, Fisheries and Food. Laboratory Leaflet (New Series) No.26. Essex. 37 p.

Fraser. G.S., J. Russell, G.J. Robertson, R. Bryant and D.A. Fifield. 2013. Prospects for the Manx Shearwater colony on Middle Island, Newfoundland, Canada. Marine Ornithology 41: 137-140.

Fuller, M., W.S. Gorse, and W.L. Goodman. 1985. An introduction to the use of SQUID magnetometers in biomagnetism. pp. 103-151. *In* J.L. Kirschvink, D.S. Jones, and B.J. MacFadden (eds.). Magnetite Biomineralization and Magnetoreception in Organisms. Plenum Press, New York.

Gaskin, D.E. 1992. Status of the common dolphin, *Delphinus delphis*, in Canada. Can. Field Nat. 106(1): 55-63.

Gass, S. 2003. Conservation of deep-sea corals in Atlantic Canada. World Wildlife Fund Canada, Toronto, ON.

Gaston, A.J. and I.L. Jones. 1998. Bird families of the world: The Auks (Alcidae). Oxford University Press, Oxford. 349 pp.

Gilkinson, K. and E. Edinger (eds.). 2009. The ecology of deep-sea corals of Newfoundland and Labrador waters: Biogeography, life history, biogeochemistry, and relation to fishes. Can. Tech. Rep. Fish. Aquat. Sci. 2830. vi + 136 p.

Gill, A. B., and H. Taylor. 2002. The potential effects of electromagnetic field generated by cabling between offshore wind turbines upon elasmobranch fishes. Report to the Countryside Council for Wales (CCW Contract Science Report No. 488. Available at http://www.offshorewindenergy.org/reports/report_004.pdf.

Gill, B., M. Bartlett, and F. Thomsen. 2013. Potential interactions between diadromous fishes of U.K. conservation importance and the electromagnetic fields and subsea noise from marine renewable energy developments. J. Fish Biol. 81: 664-695.

Gjerdrum, C., D.A. Fifield, and S.I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region. vi + 37 p.

Goff, G.P. and J. Lien. 1988. Atlantic leatherback turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador. Can. Field-Nat. 102(1): 1-5.

González-Costas, F. 2013. An assessment of NAFO roughhead grenadier Subarea 2 and 3 stock. NAFO SCR Doc. 13/027.

González-Troncoso, D., C. Hvingel, B. Healey, J. Morgan, F. González-Costas, R. Alpoim, J-C Mahé, and A. Vázquez. 2013. Assessment of the Cod Stock in NAFO Division 3M. NAFO SCR Doc. 13/041.

Haine, O.S., P.V. Ridd, and R.J. Rowe. 2001. Range of electrosensory detection of prey by *Carcharhinus melanopterus* and *Himantura granulate*. Mar. Freshwater Res. 52:291-296.

Hamazaki, T. 2002. Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, North Carolina, U.S.A., to Nova Scotia, Canada). Mar. Mamm. Sci. 18: 920-939.

Hammill, M.O. and G.B. Stenson. 2000. Estimated prey consumption by harp seals (*Phoca groenlandica*), hooded seals (*Cystophora cristata*), grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*) in Atlantic Canada. J. Northw. Atl. Fish. Sci. 26: 1-23.

Hammill, M.O. and G.B. Stenson. 2006. Abundance of Northwest Atlantic hooded seals (1960-2005). Department of Fisheries and Oceans Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/068. 23 p.

Hammill, M.O. and G.B. Stenson. 2011. Modeling grey seal abundance in Canadian waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/014. iv + 27 p.

Hammill, M.O., G.B. Stenson, T. Doniol-Valcroze, and A. Mosnier. 2013a. Estimating carrying capacity and population trends of Northwest Atlantic harp seals, 1952-2012. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/148. ii + 31 p. (Erratum: July 2013).

Hammill, M.O., G.B. Stenson, F. Proust, P. Carter, and D. McKinnon. 2013b. Feeding by grey seals in the Gulf of St. Lawrence and around Newfoundland. NAMMCO Sci. Publ. 6:135-152.

Harris, L.E., W.E. Gross, and P.E. Emery. 2013. Biology, status, and recovery potential of northern bottlenose whales (*Hyperoodon ampullatus*). DFO Can. Sci. Advis. Sec. Res. Doc. 2013/038.

Harrison, W.G. and W.K.W. Li. 2008. Phytoplankton growth and regulation in the Labrador Sea: Light and nutrient limitation. J. North. Atl. Fish. Sci. 39: 71–82.

Hawkes, L.A., A.C. Broderick, M.S. Coyne, M.H. Godfrey, and B.J. Godley. 2007. Only some like it hot -- quantifying the environmental niche of the loggerhead sea turtle. Diversity Distrib. 13: 447-457.

Hays, G.C., V.J. Hobson, J.D. Metcalfe, D. Righton, and D.W. Sims. 2006. Flexible foraging movements of leatherback turtles across the North Atlantic Ocean. Ecology 87(10): 2647-2656.

Hedd. A, W.A. Montevecchi, L. McFarleneTranquilla, C.M. Burke, D.A. Fifield, G.J. Robertson, R.A. Phillips, C. Gjerdrum, and P.M. Regular. 2011. Reducing uncertainty on the Grand Bank: tracking and vessel surveys indicate mortality risk for common murres in the North-West Atlantic. Animal Conserv. 2011: 1-12.

Hedd. A, W.A. Montevecchi, H. Otley, R.A. Phillips and D.A. Fifield. 2012. Trans-equatorial migration and habitat use by Sooty Shearwaters Puffinus griseus from the South Atlantic during the nonbreeding season. Marine Ecology Progress Series 449: 277-290.

Head, E. and P. Pepin. 2008. Variations in overwintering depth distributions of *Calanus finmarchicus* in the slope waters of the NW Atlantic Continental Shelf and the Labrador Sea. J. North. Atl. Fish. Sci. 39: 49-69.

Head, E.J.H., L.R. Harris, and R.W. Campbell. 2000. Investigations on the ecology of *Calanus* spp. in the Labrador Sea. I. Relationship between the phytoplankton bloom and reproduction and development of *Calanus finmarchicus* in spring. Mar. Ecol. Prog. Ser. 193: 53-73.

Heaslip, S.G., S.J. Iverson, W.D. Bowen, and M.C. James. 2012. Jellyfish support high energy intake of leatherback sea turtles (*Dermochelys coriacea*): Video evidence from animal-borne cameras. PLoS ONE 7(3):e33259. doi:10.1371/journal.pone.0033259.

Helbig, J., G. Mertz, and P. Pepin. 1992. Environmental influences on the recruitment of Newfoundland/Labrador cod. Fish. Oceanogr. 1: 39-56.

Himmelman, J.H. and J.-R. Hamel. 1993. Diet, behaviour and reproduction of the whelk *Buccinum undatum* in the northern Gulf of St. Lawrence, eastern Canada. Mar. Biol. 116: 423-430.

Hooker, S.K. and R.W. Baird. 1999. Deep-diving behaviour of the northern bottlenose whale, *Hyperoodon ampullatus* (Cetacea: Ziphiidae). Proc. R. Soc. London, Biol. Sci. 266: 671-676.

Hooper, T., and M. Austen. 2014. The co-location of wind farms and decapod fisheries in the UK: Mar. Policy 43: 295-300.

Hui, C. 1994. Lack of association between magnetic patterns and the distribution of free-ranging dolphins. J. Mammal. 75:399-405.

Huntington, C.E., R.G. Butler and R.A. Mauck. 1996. Leach's Storm-Petrel (*Oceanodroma leucorhoa*). No. 233 *In* A. Poole and F. Gill (eds.). The Birds of North America. The Academy of Natural Sciences and the American Ornithologists' Union. Philadelphia, PA, and Washington, DC. 32 p.

Huntley, M., K.W. Strong, and A.T. Dengler. 1983. Dynamics and community structure of zooplankton in the Davis Strait and Northern Labrador Sea. Arctic 25(2): 143-161.

Husky (Energy). 2000. White Rose oilfield comprehensive study. Report for Husky Oil Operations Ltd. St. John's, NL. 1011 p.

Husky. 2012. White Rose extension project environmental assessment, December 2012. Available at http://www.cnlopb.nl.ca/environment/whiteroseea.shtml.

IUCN. 2013. 2013 IUCN Red List of Threatened Species. Version 2013.2. Available at http://www.iucnredlist.org. [Accessed 29 November 2013].

James, M.C. 2000. Distribution of the leatherback turtle (*Dermochelys coriacea*) in Atlantic Canada: evident from an observer program, aerial surveys and a volunteer network of fish harvesters. Thesis, Acadia University, Wolfville, NS.

James, M.C., S.A. Sherrill-Mix, K. Martin, and R.A. Myers. 2006. Canadian waters provide critical foraging habitat for leatherback sea turtles. Biol. Conserv. 133: 347-357.

James, M.C., S.A. Sherrill-Mix, and R.A. Myers. 2007. Population characteristics and seasonal migrations of leatherback sea turtles at high latitudes. Mar. Ecol. Prog. Ser. 337: 245-254.

Jaquet, N. and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. Mar. Ecol. Prog. Ser. 135(1-3): 1-9.

Jefferson, T.A., M.A. Webber, and R. Pitman. 2008. Marine Mammals of the World: A Comprehensive Guide to their Identification. Academic Press, London. 573 p.

Jernakoff, P. 1987. An electromagnetic tracking system for use in shallow water. J. Exp. Mar. Biol. Ecol. 113: 1-8.

Johnson, D.L. 2004. Essential fish habitat source document: American plaice, *Hippoglossoides platessoides*, life history and habitat characteristics, Second Edition. NOAA Tech. Mem. NMFS-NE-187.

Jury, S.H., J.D. Field, S.L. Stone, D.M. Nelson, and M.E. Monaco. 1994. Distribution and abundance of fishes and invertebrates in North Atlantic estuaries. ELMR Report No. 13. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 221 p.

JW (Jacques Whitford). 2007. Strategic environmental assessment: Sydney Basin offshore area. JW report to Canada-Newfoundland and Labrador Offshore Petroleum Board. 305 p. + appendices.

Kalmijn, A.J. 1966. Electro-perception in sharks and rays. Nature 212: 1232-1233.

Kalmijn, A.J. 1978. Experimental evidence of geomagnetic orientation in elasmobrach fishes. pp. 347-353. *In* K. Schmidt-Koenig and W.T. Keeton (eds.). Animal Migration, Navigation and Homing. Springer-Verlag, Heidelberg.

Kalmijn, A.J. 1982. Electric and magnetic field detection in elasmobranch fishes. Science 218: 916-918.

Kalmjin, A.J. 2003. Physical principals of electric, magnetic, and near-field acoustic orientation. Chapter 4. Pages 77-91 *in* S.P. Collins and N.J. Marshall, editors. Sensory Processing in Aquatic Environments. Springer.

Kalmijn, A. J. 2000. Detection and processing of electromagnetic and near-field acoustic signals in elasmobranch fishes. Philos. Trans. R. Soc. London [Biol]. 355: 1135-1141.

Kalmjin, A.J. 2003. Physical principals of electric, magnetic, and near-field acoustic orientation. pp. 77-91. *In* S.P. Collins and N.J. Marshall (eds.). Sensory Processing in Aquatic Environments. Springer-Verlag, New York.

Kenchington, E., C. Lirette, A. Cogswell, D. Archambault, P. Archambault, H. Benoit, D. Bernier, B. Brodie, S. Fuller, K. Gilkinson, M. Lévesque, D. Power, T. Siferd, M. Treble, and V. Wareham. 2010a. Delineating coral and sponge concentrations in the biogeographic regions of the east coast of Canada using spatial analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/039. vi + 202 p.

Kenchington, E., D. Power, and M. Koen-Alonso. 2010b. Associations of demersal fish with sponge grounds in the Northwest Atlantic Fisheries Organizations Regulatory Area and adjacent Canadian waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/039. vi + 27 p.

Kenchington, E., D. Power, and M. Koen-Alonso. 2013. Associations of demersal fish with sponge grounds on the continental slopes of the northwest Atlantic. Marine Ecology Progress Series, 477: 217-230.

Kirschvink, J. L., A. E. Dizon, and J. A. Westphal. 1986. Evidence from strandings for geomagnetic sensitivity in cetaceans. J. Exp. Biol. 120: 1-24.

Klinowska, M. 1985. Cetacean live stranding sites relate to geomagnetic topography. Aquatic Mammals 11(1): 27-32.

Kulka, D.W. and C.M. Miri. 2003. The status of thorny skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3L, 3N, 3O and Subdivision 3Ps. NAFO SCR Doc. 03/57.

Kulka, D.W. and C.M. Miri. 2007. Update on the status of thorny skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3L, 3N, 3O, and Subdivision 3Ps. NAFO SCR Doc. 07/33.

Kulka, D.W., M.R. Simpson, and T.D. Inkpen. 2003. Distribution and biology of blue hake *(Antimora rostrata* Günther 1878) in the northwest Atlantic with comparison to adjacent areas. J. Northw. Atl. Fish. Sci. 31: 299-318.

Kulka, D., C. Hood, and J. Huntington. 2008. Recovery strategy for Northern Wolffish (*Anarhichas denticulatus*) and Spotted Wolffish (*Anarhichas minor*), and management plan for Atlantic Wolffish (*Anarhichas lupus*) in Canada. Fisheries and Oceans Canada: Newfoundland and Labrador Region. St. John's, NL. x + 103 p.

Lacoste, K.N. and G.B. Stenson. 2000. Winter distribution of harp seals (*Phoca groenlandica*) off eastern Newfoundland and southern Labrador. Polar Biol. 23: 805-811.

Lang, A.L. 2007. Seabird abundance near Terra Nova offshore oil development during late spring 2006. LGL Rep. SA919. Rep. by LGL Limited, St. John's, NL, for Petro-Canada, St. John's, NL. 11 p.

Lang, A.L. and V.D. Moulton. 2008. Marine mammal and seabird monitoring of Petro-Canada's 3-D seismic program in the Jeanne d'Arc Basin, 2007. LGL Rep. SA938. Rep. by LGL Limited, St. John's, NL, for Petro-Canada, St. John's, NL. 32 p. + appendices.

Lang, A.L, V.D. Moulton, and R.A. Buchanan. 2006. Marine mammal and seabird monitoring of Husky Energy's 3-D seismic program in the Jeanne d'Arc Basin, 2005. LGL Rep. SA836. Rep. by LGL Limited, St. John's, NL, for Husky Energy Inc., Calgary, AB. 63 p. + appendices.

Lavigne, D.M. and K.M. Kovacs. 1988. Harps and hoods: Ice breeding seals of the Northwest Atlantic. University of Waterloo Press, Waterloo, Ontario. 174 p.

Lawson, J.W. and J.F. Gosselin. 2009. Distribution and preliminary abundance estimates for cetaceans seen during Canada's Marine Megafauna Survey – A component of the 2007 TNASS. DFOCan. Sci. Advis. Sec. Res. Doc. 2009/031. 28 p.

Lawson, J.W., and J.-F. Gosselin. Unpublished. Fully-corrected cetacean abundance estimates from the Canadian TNASS survey. Working Paper 10. National Marine Mammal Peer Review Meeting. Ottawa, Can. 28 p.

Lawson, J.W., and T.S. Stevens. 2013. Historic and current distribution patterns, and minimum abundance of killer whales (*Orcinus orca*) in the north-west Atlantic. J. Mar. Biol. Assoc. UK. doi:10.1017/S0025315413001409.

Lawson, J.W., S. Benjamins, and G.B. Stenson. 2004. Harbour porpoise bycatch estimates for Newfoundland's 2002 nearshore cod fishery. Fisheries and Oceans Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2004/066. 33 p.

Lawson, J.W., T. Stevens, and D. Snow. 2007. Killer whales of Atlantic Canada, with particular reference to the Newfoundland and Labrador region. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/062. 16 p.

Lazier, J.R.N. and D.G. Wright. 1993. Annual velocity variations in the Labrador Current. J. Phys. Oceanogr. 23: 659-678.

Lesage, V. and M.O. Hammill. 2001. The status of the grey seal, *Halichoerus grypus*, in the Northwest Atlantic. Can. Field-Nat. 115(4): 653-662.

LGL (Limited). 2003. Orphan Basin strategic environmental assessment. Rep. No. SA767. Rep. by LGL Limited, St. John's, NL, for Canada-Newfoundland Offshore Petroleum Board, St. John's, NL. 244 p.

LGL. 2005. Orphan Basin exploration drilling program environmental assessment. LGL Rep. SA825. Rep. by LGL Limited, St. John's, NL, Canning & Pitt Associates, Inc., St. John's, NL, SL Ross Environmental Research Limited, Ottawa, ON, Oceans Limited, St. John's, NL, Lorax Environmental, Vancouver, BC, and PAL Environmental Services, St. John's, NL, for Chevron Canada Limited, Calgary, AB, ExxonMobil Canada Ltd., St. John's, NL, Imperial Oil Resources Ventures Limited, Calgary, AB, and Shell Canada Limited. 353 p.

LGL. 2006a. Orphan Basin exploration drilling program environmental assessment addendum. LGL Rep. SA825. Rep. by LGL Limited, St. John's, NL, Canning & Pitt Associates, Inc., St. John's, NL, SL Ross Environmental Research Limited, Ottawa, ON, Oceans Limited, St. John's, NL, Lorax Environmental, Vancouver, BC, and PAL Environmental Services, St. John's, NL, for Chevron Canada Limited, Calgary, AB, ExxonMobil Canada Ltd., St. John's, NL, Imperial Oil Resources Ventures Limited, Calgary, AB, and Shell Canada Limited. 142 p. + appendices.

LGL. 2006b. Husky White Rose development project: New drill centre construction & operations program environmental assessment. LGL Rep. SA883. Rep. by LGL Limited, St. John's, NL, for Husky Energy Inc., Calgary, AB. 299 p. + appendices.

LGL. 2007a. Environmental assessment of Petro-Canada's Jeanne d'Arc Basin 3-D seismic program. LGL Rep. SA882. Rep. by LGL Limited, St. John's, Oceans Limited, St. John's, NL, Canning & Pitt Associates, Inc., St. John's, NL, and PAL Environmental Services, St. John's, NL, for Services, St. John's, NL, for Petro-Canada, St. John's, NL. 264 p. + appendices.

LGL. 2007b. Husky delineation/exploration drilling program for Jeanne d'Arc Basin area, 2008-2017, environmental assessment. LGL Rep. SA935. Rep. by LGL, St. John's, NL, in association with Canning & Pitt Associates, Inc., Oceans Ltd., and PAL Environmental Services, for Husky Energy Inc., Calgary, AB. 231 p. + appendices.

LGL. 2007c. Supplement to: Orphan Basin controlled source electromagnetic survey program environmental assessment. LGL Rep. SA937. Rep. by LGL Limited in association with Canning & Pitt Associates Inc., St. John's, NL, for ExxonMobil Canada Ltd., St. John's, NL. 15 p. + appendix.

LGL. 2008a. Environmental assessment of StatoilHydro's Jeanne d'Arc Basin area seismic and geohazard program, 2008-2016. LGL Rep. SA947a. Rep. by LGL Limited, Canning & Pitt Associates Inc., and Oceans Ltd., St. John's, NL, for StatoilHydro Canada Ltd., St. John's, NL. 174 p. + appendices.

LGL. 2008b. Environmental assessment of StatoilHydro Canada Ltd. exploration and appraisal/delineation drilling program for offshore Newfoundland, 2008-2016. LGL Rep. SA947b. Rep. by LGL Limited, Canning & Pitt Associates Inc., and Oceans Ltd., St. John's, NL, for StatoilHydro Canada Ltd., St. John's, NL. 292 p. + appendices.

LGL. 2009a. Orphan Basin controlled source electromagnetic survey program environmental assessment: Supplement 2009. LGL Rep. SA1038. Rep. by LGL Limited, St. John's, NL, for ExxonMobil Canada Ltd., St. John's, NL. 19 p. + appendices.

LGL. 2009b. Orphan Basin exploration drilling program environmental assessment: Validation 2010. LGL Rep. SA1012. Rep. by LGL Limited, St. John's, NL, for Chevron Canada Resources, Calgary, AB. 63 p. + appendix.

LGL. 2010. Environmental assessment of Chevron's offshore Labrador seismic program, 2010-2017. LGL Rep. SA1031. Rep. by LGL Limited in association with Oceans Ltd., St. John's, NL, for Chevron Canada Resources, Calgary, AB. 248 p. + appendix.

LGL. 2011a. Environmental assessment of Statoil's geophysical program for Jeanne d'Arc and Central Ridge/Flemish Pass Basins, 2011-2019. LGL Rep. SA1121. Rep. by LGL Limited, in association with Canning & Pitt Associates Inc., and Oceans Ltd., St. John's, NL, for Statoil Canada Ltd., St. John's, NL. 227 p. + appendices.

LGL. 2011b. Environmental assessment of Chevron's North Grand Banks regional seismic program, 2011-2017. LGL Rep. SA1119. Rep. by LGL Limited in association with Canning and Pitt Associates Inc., St. John's, NL, and Oceans Ltd., St. John's, NL for Chevron Canada Limited, Calgary, AB. 226 p. + appendices.

LGL. 2012a. Environmental Assessment of Husky's Jeanne d'Arc Basin/Flemish Pass regional seismic program, 2012-2020. LGL Rep. SA1144. Rep. by LGL Limited in association with Canning and Pitt Associates Inc., St. John's, NL, and Oceans Ltd., St. John's, NL, for Husky Energy, St. John's, NL. 320 p. + appendices.

LGL. 2012b. Orphan Basin exploration drilling program environmental assessment: Update 2012. LGL Rep. SA1160. Rep. by LGL Limited, St. John's, NL, for Chevron Canada Limited, Calgary, AB. 57 p. + appendix.

LGL. 2012c. Environmental assessment of WesternGeco's Seismic Program for Jeanne d'Arc Basin, 2012–2015. LGL Rep. SA1150. Rep. by LGL Limited, in association with Canning & Pitt Associates Inc., and Oceans Ltd., St. John's, NL, for WesternGeco Canada, Calgary, AB. 233 p. + appendices.

LGL. 2013a. Orphan Basin exploration drilling program environmental assessment: Validation 2013/2014. LGL Rep. SA1210. Rep. by LGL Limited, St. John's, NL, and Mahone Bay, NS, for Chevron Canada Limited, Calgary, AB. 38 p. + appendix.

LGL. 2013b. Environmental assessment of HMDC's 2D/3D/4D seismic projects 2013-Life of field, Newfoundland offshore area. LGL Rep. SA1207. Rep. by LGL Limited, St. John's, NL, for Hibernia Management and Development Company Ltd., St. John's, NL. 228 p. + appendices.

LGL and Grontmij. 2012. Shell Kanumas A/S Environmental Impact Assessment Shallow Coring in Baffin Bay, Northwest Greenland, 2012. Report prepared by LGL Ltd., King City, ON, in association with Grontmij A/S Granskoven 8, 2600 Glostrup, Denmark. 148 p.

LGL and GX Technology Canada Ltd. 2013. Environmental assessment of GXT's LabradorSPAN 2-D Seismic, Gravity and Magnetic Survey, 2013-2015. LGL Rep. SA1199. Rep. by LGL Limited, St. John's, NL, and GX Technology, Calgary, AB. 286 p. + appendices.

Lien, J., G.B. Stenson, and P.W. Jones. 1988. Killer whales (*Orcinus orca*) in waters off Newfoundland and Labrador, 1978-1986. Rit Fiskideildar 11: 194-201.

Lien, J., D. Nelson, and J.D. Hai. 1997. Status of the White-beaked Dolphin, *Lagenorhynchus albirostris*, in Canada. Rep. for the Committee on the Status of Endangered Wildlife in Canada.

Lock, A.R., R.G.B. Brown, and S.H. Gerriets. 1994. Gazetteer of marine birds in Atlantic Canada. An atlas of seabird vulnerability to oil pollution. Canadian Wildlife Service, Environmental Conservation Branch, Environment Canada, Atlantic Region. 137 p.

Lohmann, K.J. 1985. Geomagnetic field detection by the western Atlantic spiny lobster, *Panulirus argus*. Mar. Behav. Physiol. 12:1-17.

Lohmann, K.J., and A.O.D. Willows. 1987. Lunar-modulated geomagnetic orientation by a marine mollusk. Science 235:331-334.

Lohmann, K.J., A.O.D. Willows, and R.B Pinter. 1991. An identifiable molluscan neuron responds to changes in earth-strength magnetic fields. J. Exp. Biol. 161:1-24.

Lohmann, K.J., and C.M.F. Lohmann. 1994a. Detection of magnetic inclination angles by sea turtles: a possible mechanism for determining latitude. J. Exp. Biol. 194: 23-32.

Lohmann, K.J. and C.M.F. Lohmann. 1994b. Acquisition of magnetic directional preference in hatchling loggerhead sea turtles. J. Exp. Biol. 190: 1-8.

Lohmann, K.L., and C.M.F. Lohmann. 1996a. Orientation and open-sea navigation in sea turtles. J. Exp. Biol., 199: 73-81.

Lohmann, K.L., and C.M.F. Lohmann. 1996b. Detection of magnetic field intensity by sea turtles. Nature 380: 59-61.

Lohmann, K.J., N.D. Pentcheff, G.A. Nevitt, G.D. Stetten, R.K. Zimmer-Faust, H.E. Jarrard, and L.C. Boles. 1995. Magnetic orientation of spiny lobsters in the ocean: Experiments with undersea coils. J. Exp. Biol. 198: 2041-2048.

MacLeod, C.D. and A. D'Amico. 2006. A review of beaked whale behavior and ecology in relation to assessing and mitigating impacts of anthropogenic noise. J. Cetac. Res. Manage. 7(3): 211-221.

MacLeod, C.D., M.B. Santos, and G.J. Pierce. 2003. Review of data on diets of beaked whales: evidence of niche separation and geographic segregation. J. Mar. Biol. Assoc. UK. 83(3): 651-665.

MacLeod, C.D., W.F. Perrin, R. Pitman, J. Barlow, L.T. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). J. Cetac. Res. Manage. 7(3): 271-286.

MacLeod, D. 2000. Review of the distribution of Mesoplodon species (order Cetacea, family Ziphiidae) in the North Atlantic. Mamm. Rev. 30(1): 1-8.

Mallory, M.L., I.J. Stenhouse, G. Gilchrist, G. Robertson, J.C. Haney, and S.D. MacDonald. 2008. Ivory Gull (*Pagophila eburnean*). *In* A. Poole (ed.). The Birds of North America Online. Cornell Lab of Ornithology. Ithaca, NY.

[Retrieved 29 November 2013 from the Birds of North America Online: http://bna.birds.cornell.edu.bnaproxy.birds.cornell.edu/bna/species/175.

Mansfield, K.L., V.S. Saba, J.A. Keinatch, and J.A. Musick. 2009. Satellite tracking reveals a dichotomy in migration strategies among juvenile loggerhead turtles in the Northwest Atlantic. Marine Biology 156: 2555-2570.

Marra, L.J. 1989. Sharkbite on the SL Submarine Lightwave Cable System: History, causes, and resolution. IEEE J. Oceanic Eng. 14(3): 230-237.

Matthews, C.J.D. and S.H. Ferguson. 2011. Diet of Eastern Canadian Arctic/Northwest Atlantic killer whales (*Orcinus orca*) described using stable isotope ratos (d^{15}N and d^{13}C) in teeth. p. 193 *In* Abstr. 19th Bienn. Conf. Biol. Mar. Mamm., Tampa, Florida, 27 November-2 December. 344 p.

Matthews, C.J.D., S.P. Luque, S.D. Petersen, R.D. Andrews, and S.H. Ferguson. 2011. Satellite tracking of a killer whale (*Orcinus orca*) in the eastern Canadian Arctic documents ice avoidance and rapid, long-distance movement into the North Atlantic. Polar Biol. 34: 1091-1096.

Matthews, M.-N.R. 2012. *Underwater Sound Propagation from Shallow Coring Operations in Baffin Bay: Shell 2012 Shallow Coring Operations in Baffin Bay.* JASCO Document 00308, Version 3.0. Technical report for LGL Ltd., by JASCO Applied Sciences. 61 p.

McAlpine, D.F., M.C. James, J. Lien, and S.A. Orchard. 2007. Status and conservation of marine turtles in Canadian waters. Ecology, conservation and status of reptiles in Canada. Herpetological conservation 2: 85-112.

McFarlane Tranquilla. L.A, W.A. Montevecchi, A. Hedd, D.A. Fifield, C.M. Burke, P.A. Smith, P.M. Regular, G.J. Robertson, A.J. Gaston and R.A. Phillips. 2013. Multiple-colony winter habitat use by murres *Uria spp*. in the Northwest Atlantic Ocean: Implications for marine risk assessment. Mar. Ecol. Prog. Ser. 472: 287-303.

Mellinger, D.K., S.L. Nieukirk, K. Klinck, H. Klinck, R.P. Dziak, P.J. Clapham, and B. Bransdóttir. 2011. Confirmation of right whales near a nineteenth-century whaling ground east of southern Greenland. Biol. Lett. 7: 411-413.

Meyer, C.G., K.N. Holland, and Y.P. Papastamatiou. 2004. Sharks can detect changes in the geomagnetic field. J. R. Soc. Interface 2, doi: 10.1098/rsif.2004.0021.

Miles, W., S. Money, R. Luxmoore, and R.W. Furness. 2010. Effects of artificial lights and moonlight on petrels at St Kilda. Bird Study 57: 244-251.

Miller, J.D., and I.S. Hotzel. 1984. Iceberg flux estimation in the Labrador Sea. pp. 298-304. *In* V.J. Linardini (ed.). Proceedings of the 3rd International Offshore Mechanics and Arctic Engineering Symposium, Vol. 3. Society of Mechanical Engineers, New York.

Montevecchi. W.A., A. Hedd, L.A. McFarlane Tranquilla, D.A. Fifield, C.M. Burke, P.M. Regular, G.K. Davoren, S. Garthe, G.J. Robertson, and R.A. Phillips. 2012. Tracking seabirds to identify ecologically important and high risk marine areas in the western North Atlantic. Biological Conservation 156: 62-71.

Moore, F. R. 1975. Influence of solar and geomagnetic stimuli on the migratory orientation of Herring Gull chicks. Auk 92:655-664.

Morgan, M.J. 2000. Interactions between substrate and temperature preference in adult American plaice (*Hippoglossoides platessoides*). Mar. Fresh. Behav. Phys. 33: 249-259.

Morgan, M.J., D. Garabana, R.M. Rideout, E. Román, A. Pérez-Rodriguez, and F. Saborido-Rey. 2013. Changes in distribution of Greenland halibut in a varying environment. ICES J. Mar. Sci. 70: 352–361.

Moulton, V.D., B.D. Mactavish, and R.A. Buchanan. 2005a. Marine mammal and seabird monitoring of Chevron Canada Resources' 3-D seismic program on the Orphan Basin, 2004. LGL Rep. SA817. Rep. by LGL Ltd., St. John's, NL, for Chevron Canada Resources, Calgary, Alb., ExxonMobil Canada Ltd., St. John's, Nfld., and Imperial Oil Resources Ventures Ltd., Calgary, Alb. 90 p. + appendices.

Moulton, V.D., J. Christian, R.A. Pitt, B.D. Mactavish, and R.A. Buchanan. 2005b. Orphan Basin 3-D seismic program, environmental assessment update, 2005. LGL Rep. SA839. Rep. by LGL Limited and Canning & Pitt Associates Inc., St. John’s, NL, for Chevron Canada Resources, Calgary, AB, ExxonMobil Canada Ltd., St. John’s, NL, and Imperial Oil Resources Ventures Limited, Calgary, AB. 51 p. + appendix.

Moulton, V.D., B.D. Mactavish, and R.A. Buchanan. 2006. Marine mammal and seabirds monitoring of Chevron Canada Limited's 3-D seismic program on the Orphan Basin, 2005. LGL Rep. SA843. Rep. by LGL Limited, St. John's, NL, for Chevron Canada Limited, Calgary, AB, ExxonMobil Canada Ltd., St. John's, NL, Shell Canada Limited, Calgary, AB, and Imperial Oil Resources Ventures Ltd., Calgary, AB. 111 p. + appendices.

Murillo, F.J., P.D. Muñoz, A. Altuna, and A. Serrano. 2011. Distribution of deep-water corals of the Flemish Cap, Flemish Pass, and the Grand Banks of Newfoundland (Northwest Atlantic Ocean): Interaction with fishing activities. ICES J. Mar. Sci. 68(2): 319-332.

NAFO (Northwest Atlantic Fisheries Organization) website. 2013. Available at http://www.nafo.int/fisheries/frames/regulations.html.

Nakashima, B.S. and J.P. Wheeler. 2002. Capelin (*Mallotus villosus*) spawning behaviour in Newfoundland waters - the interaction between beach and demersal spawning. ICES J. Mar. Sci. 59: 909-916.

NARWC (North Atlantic Right Whale Consortium). 2013. North Atlantic Right Whale Consortium 2013 Annual Report Card. Accessed on 2 December 2013 at http://www.narwc.org/pdf/2013_Report_Card.pdf.

Nelson, D. and J. Lien. 1996. The status of the long-finned pilot whale, *Globicephala melas*, in Canada. Can. Field-Nat. 110: 511-524.

Nettleship, D.N. and T.R. Birkhead. 1985. The Atlantic alcidae. Academic Press, London. 574 p.

Nishi, T., G. Kawamura, and K. Matsumoto. 2004. Magnetic sense in the Japanese eel, *Anguilla japonica*, as determined by conditioning and electrocardiography. J. Exp. Biol. 207: 2965-2970.

Nishi, T. and G. Kawamura. 2005. *Anguilla japonica* is already magnetosensitive at the glass eel phase. J. Fish Biol. 67: 1213-1224.

NOAA (National Oceanic and Atmospheric Administration). 1999. Essential fish habitat source document: Altantic mackerel, *Scomber scombrus*, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-141. Rep. prepared for the U.S. Department of Commerce, Woods Hole, MA. 44 p. Available at http://www.nefsc.noaa.gov/nefsc/publications/tm/tm141/tm141.pdf.

NSIDC. 1995, updated annually. International ice patrol (iip) iceberg sightings data base. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.

O'Boyle, R. 2001. Meeting on turtle bycatch in Canadian Atlantic fisheries. CSAS Proceedings Series. 2001/17.

O'Brien, K. and H. Whitehead. 2013. Population analysis of endangered northern bottlenose whales on the Scotian Shelf seven years after the establishment of a marine protected area. Endang. Species Res. 21(3): 273-284.

Oceans (Limited). 2012. Physical environment of the WesternGeco Seismic area in Orphan Basin, Flemish Pass and the North-east Grand Banks. Unpubl. Rep. by Oceans Limited, St. John's, NL, for LGL Limited, St. John's, NL. 230 p.

Oceans. 2014. Physical Environmental Study for the Southern Grand Banks Seismic Program, 2014-2018. Unpubl. Rep. by Oceans Limited, St. John's, NL, for LGL Limited, St. John's, NL. 101 p.

O'Hara, P.D. and L.A. Morandin. 2010. Effects of sheens associated with offshore oil and gas development on the feather microstructure of pelagic seabirds. Mar. Poll. Bull. 60: 672-278.

Ollerhead, L.M.N., M.J. Morgan, D.A. Scruton, and B. Marrie. 2004. Mapping spawning times and locations for 10 commercially important fish species found on the Grand Banks of Newfoundland. Can. Tech. Rep. Fish. Aquat. Sci. 2522.

Olsen, E., W.P. Budgell, E. Head, L. Kleivane, L. Nøttestad, R. Prieto, M.A. Silva, H. Skov, G.A. Víkingsson, G. Waring, and N. Øien. 2009. First satellite-tracked long-distance movement of a sei whale (*Balanoptera borealis*) in the North Atlantic. Aquat. Mammals 35(3): 313-318.

One Ocean. 2013. Protocol for seismic survey programs in Newfoundland and Labrador. One Ocean, St. John's, NL. 23 p.

Orr, D., P.J. Veitch, K. Skanes, and D.J. Sullivan. 2009. Northern shrimp (*Pandalus borealis*) off Labrador and northeastern Newfoundland. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/062. vi + 119 p.

Ottensmeyer, C.A. and H. Whitehead. 2003. Behavioural evidence for social units in long-finned pilot whales. Can. J. Zool. 81: 1327-1338.

OWET (Oregon Wave Energy Trust). 2010. Effects of electromagnetic fields on marine species: A literature review. Available at http://mhk.pnnl.gov/wiki/images/4/4f/Effects_of_Electromagnetic_Fields_on_Marine_Species.pdf.

Palka, D., A.J. Read, A.J. Westgate, and D.W. Johnston. 1996. Summary of current knowledge of harbour porpoises in US and Canadian Atlantic waters. Rep. Int. Whal. Commn. 46: 559-565.

Paul, S.D., A. Hanke, S.C. Mith, and J.D. Neilson. 2010. An examination of loggherad sea turtle (Caretta caretta) encounters in the Canadian swordfish and tuna longline fishery. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/088, vi + 32 p.

Pepin, P. and J.A. Helbig. 1997. Distribution and drift of Atlantic Cod (*Gadus morhua*) eggs and larvae on the northeast Newfoundland Shelf. Can. J. Fish. Aquat. Sci. 54: 970-685.

Pepin, P., E. Colbourne, and G. Maillet. 2011. Seasonal patterns in zooplankton community structure on the Newfoundland and Labrador Shelf. Prog. Ocean. 91: 273-285.

Pereira, J.N., V.C. Neves, R. Prieto, M.A. Silva, I. Cascão, C. Oliveira, M.J. Cruz, J.V. Medeiros, J.P. Barreiros, F.M. Porteiro, and D. Clarke. 2011. Diet of mid-Atlantic Sowerby's beaked whales *Mesoplodon bidens*. Deep Sea Research Part I 58(11): 1084-1090.

Petro-Canada. 1996. Development application Terra Nova development environmental impact statement. Prepared by Petro-Canada on behalf of Terra Nova Proponents (Petro-Canada, Mobil Oil Canada Properties, Husky Oil Operations Ltd., Murphy Oil Ltd., and Mosbacher Operating Ltd.).

Powles, P.M. 1965. Life history and ecology of American plaice (*Hippoglossoides platessoides* F.) in the Magdalen Shallows. J. Fish. Res. Board Can. 22: 565-598.

Prieto, R., M.A. Silva, I. Cascão, M.J. Cruz, C.I.B. Oliveira, G. Waring, and J. Gonçalves. 2010. The importance of oceanic fronts in the Labrador Sea to North Atlantic sei whales (*Balaenoptera borealis*). Clues from satellite telemetry. Pres.4th Arctic Frontiers Conf. "Living in the High North". 24-29 Jan. 2010, Tromsø, Norway.

Read, A.J. 1999. Harbour porpoise *Phoecena*. pp. 323-355 *In* S.H. Ridgeway and R. Harrison (eds.). Handbook of marine mammals. Volume 6: The second book of dolphins and porpoises. Academic Press. San Diego.

Reeves, R.R., E. Mitchell, and H. Whitehead. 1993. Status of the northern bottlenose whale, *Hyperoodon ampullatus*. Can. Field-Nat. 107: 490-508.

Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. Society for Marine Mammalogy.

Richards, P.M., S.P. Epperly, S.S. Heppell, R.T. King, C.R. Sasso, F. Moncada, Gonzalo Nodarse, D.J. Shaver, Y. Medina, and J. Zurita. 2011. Sea turtle population estimates incorporating uncertainty: A new approach applied to western North Atlantic loggerheads *Caretta caretta*. Endang. Species Res. 15: 151-158.

Robertson, G.J. 2002. Current status of the Manx Shearwater (*Puffinus puffinus*) colony on Middle Lawn Island, Newfoundland. Northeastern Naturalist 9: 317-324.

Robertson, G.J. and R.D. Elliot. 2002. Changes in seabird populations breeding on Small Island, Wadham Islands, Newfoundland. Canadian Wildlife Service, Atlantic Region, Technical Report Series No. 381.

Robertson, G.J., D. Fifield, M. Massaro, and J.W. Chardine. 2001. Changes in nesting-habitat use of large gulls breeding in Witless Bay, Newfoundland. Can. J. Zool. 79: 2159-2167.

Robertson, G.J., J. Russell, and D. Fifield. 2002. Breeding population estimates for three Leach's Storm-Petrel colonies in southeastern Newfoundland, 2001. Canadian Wildlife Service, Atlantic Region Technical, Report Series No. 380.

Robertson, G.J., S.I. Wilhelm, and P.A. Taylor. 2004. Population size and trends of seabirds breeding on Gull and Great Islands, Witless Bay Islands Ecological Reserve, Newfoundland, up to 2003. Canadian Wildlife Service, Atlantic Region Technical Report Series No. 418.

Rodríguez, A. and B. Rodríguez. 2009. Attraction of petrels to artificial lights in the Canary Islands: Effects of the moon phase and age class. Ibis 151: 299-310.

Rodway, M.S., H.M. Regehr, and J.W. Chardine. 2003. Status of the largest breeding concentration of Atlantic Puffins, Fratercula arctica, in North America. Can. Field Nat. 117: 70-75.

Rochette, R., S. Morissette, and J.H. Himmelman. 1995. A flexible response to a major predator provides the whelk *Buccinum undatum* L. with nutritional gains. J. Exp. Mar. Biol. Ecol. 185: 167-180.

Rogers, E. and L.F. Bosart. 1986. An investigation of explosively deepening oceanic cyclones. Monthly Weather Rev. 114: 702-718.

Ronconi, R.A., P.G. Ryan, and Y. Ropert-Coudert. 2010a. Diving of great shearwaters (*Puffinus gravis*) in cold and warm water regions of the South Atlantic Ocean. PLos One 5(11; e15508). 7 p.

Ronconi, R.A., H.N. Koopman, C.A.E. McKinstry, S.N.P. Wong, and A.J. Westgate. 2010b. Inter-annual variability in diet of non-breeding pelagic seabirds *Puffinus* spp. at migratory staging areas: evidence from stable isotopes and fatty acids. Mar. Ecol. Prog. Ser. 419: 267-282.

Russell, J. 2008. Population estimate for the colony of Leach's Storm-Petrels (*Oceanodroma leucorhoa*) breeding on Green Island, Fortune Bay, southeastern Newfoundland in 2008. Department of Fisheries and Oceans internal report.

SARA website. 2014. Species at Risk Public Registry. Available at http://www.sararegistry.gc.ca/default_e.cfm.

Savenkoff, C., F. Grégoire, M. Castonguay, D.P. Swain, D. Chabot, and J.M. Hanson. 2005. Main prey and predators of Atlantic mackerel (*Scomber scrombus* L.) in the northern and southern Gulf of St. Lawrence during the mid-1980s, mid-1990s, and early 2000s. DFO Can. Tech. Rep. Fish. Aq. Sci. 2619. 36 p.

Scheffer, V.B. 1958. Seals, sea lions and walruses: A review of the Pinnipedia. Stanford University Press, Stanford, USA.

Scott, W.B. and M.G. Scott. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219. 731 p.

Selzer, L.A. and P.M. Payne. 1988. The distribution of white-sided (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States. Mar. Mamm. Sci. 4: 141-153.

Sette, O.E. 1943. Biology of the Atlantic mackerel (*Scomber scombrus*) of North America. Fishery Bulletin of the Fish and Wildlife Service, Vol. 50, No.38. Prepared for the U.S. Department of the Interior and Fish and Wildlife Service, Woods Hole, MA. 91 p.

Sherrill-Mix, S.A., M.C. James, and R.A. Myers. 2008. Migration cues and timing in leatherback sea turtles. Behav. Ecol. 19: 231-236.

Simpson, M.R., L.G.S. Mello, C.M. Miri1, and M. Treble. 2011. A pre-COSEWIC assessment of three species of Wolffish (Anarhichasdenticulatus, A. minor, and A. lupus) in Canadian waters of the Northwest Atlantic Ocean. C S A S Canadian Science Advisory Secretariat Research Document 2011/12 Newfoundland & Labrador Region. 69 p.

Simpson, M.R. and C.M. Miri. 2012. Assessment of thorny skate (*Amblyraja radiata* Donovan, 1808) in NAFO Divisions 3LNO and Subdivision 3Ps. NAFO SCR Doc. 12/28.

Simpson, M.R., D. Chabot, K. Hedges, J. Simon4, C.M. Miri, and L.G.S. Mello. 2013. An update on the biology, population status, distribution, and landings of wolffish (Anarhichus denticulatus, A. minor, and A. lupus) in the Canadian Atlantic and Arctic Oceans. Canadian Science Advisory Secretariat (CSAS) Research Document 2013/089 Newfoundland and Labrador, Quebec, Maritimes, and Central and Arctic Regions December 2013. 82 p.

Spotila, J.R. 2004. Sea turtles: A complete guide to their biology, behavior, and conservation. The Johns Hopkins University Press, Baltimore, Maryland. 227 p.

Stein, M. 2007. Oceanography of the Flemish Cap and adjacent waters. J. Northw. Atl. Fish. Sci. 37: 135-146.

Stenhouse, I.J. 2004. Canadian management plan for Ivory Gull (*Pagophila eburnea*). Canadian Wildlife Service, St. John’s, NL.

Stenhouse, I.J. and W.A. Montevecchi. 1999. Increasing and expanding populations of breeding Northern Fulmars, *Fulmarus glacialis*, in the Northwest Atlantic. Waterbirds 22: 382-391.

Stenhouse, I.J., G.J Robertson, and W.A. Montevecchi. 2000. Herring Gull *Larus argentatus* predation on Leach’s Storm-Petrels *Oceanodroma leucorhoa* breeding on Great Island, Newfoundland. Atlantic Seabirds 2: 35-44.

Stenson, G.B. and B. Sjare. 1997. Seasonal distribution of harp seals, *Phoca groenlandica*, in the Northwest Atlantic. ICES. C.M. 1997/10p.

Stenson, G.B., S. Benjamins, and D.G. Reddin. 2011. Using bycatch data to understand habitat use of small cetaceans: Lessons from an experimental driftnet fishery. ICES J. Mar. Sci. 68(5): 937-946.

Stevick, P.T., J. Allen, P.J. Clapham, N.A. Friday, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsboll, J. Sigurjonsson, T.D. Smith, N. Oien, and P.S. Hammond. 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. Mar. Ecol. Prog. Ser. 258: 263-273.

Stevick, P.T., J. Allen, P.J. Clapham, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsboll, R. Sears, J. Sigurjonsson, T.D. Smith, G. Vikingsson, N. Oien, and P.S. Hammond. 2006. Population spatial structuring on the feeding grounds in North Atlantic humpback whales (*Megaptera novaeangliae*). J. Zool. 270(2): 244-255.

Stewart, B.S. and S. Leatherwood. 1985. Minke whale--*Balaenoptera acutorostrata*. pp. 91-136. *In* S.H. Ridgeway and R. Harrison (eds.). Handbook of marine mammals. Volume 3: The sirenians and baleen whales. Academic Press. San Diego.

Stewart, K.R., M.C. James, S. Roden, and P.H. Dutton. 2013. Assignment tests, telemetry and tag-recapture data converge to identify natal origins of leatherback turtles foraging in Atlantic Canadian waters. J. Animal Ecol. Doi: 10.1111/1365-2656.12056.

Suncor Energy. 2013. Environmental assessment of Suncor Energy's Eastern Newfoundland Offshore Area 2D/3D/4D Seismic Program, 2014–2024. LGL Rep. SA1233. Rep. by LGL Limited, St. John's, NL, for Suncor Energy, St. John's, NL. 210 p. + appendices.

Telfer, T.C., J.L. Sincock, G.V. Byrd, and J.R. Reed. 1987. Attraction of Hawaiian seabirds to lights: Conservation efforts and effects of moon phase. Wild. Soc. Bull. 15: 406-413.

Templeman, W. 1973. Distribution and abundance of the Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum), in the Northwest Atlantic. ICNAF Res. Bull. 10: 83-98.

Templeman, W. 1982. Development, occurrence, and characteristics of egg capsules of thorny skate, *Raja radiata*, in the Northwest Atlantic. J. Northw. Atl. Fish. Sci. 3(1): 47-56.

Templeman, W. 1987. Differences in sexual maturity and related characteristics between populations of thorny skate (*Raja radiata*) in the Northwest Atlantic. J. Northw. Atl. Fish. Sci. 7 (2): 155-168.

TEWG (Turtle Expert Working Group). 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Tech. Memo. NMFS-SEFSC-555. U.S. Dept. Commerce. 116 p.

Thomas, L., M.O. Hammill, and B.W. Bowen. 2011. Estimated size of the Northwest Atlantic grey seal population 1977-2010. DFO Can. Sci. Advis. Sec. Res. Doc. 201/017. iv + 23 p.

Toews, M.W. and D.J.W. Piper. 2002. Recurrence interval of seismically triggered mass-transport deposition at Orphan Knoll, continental margin off Newfoundland and Labrador. Natural Resources Canada, Geological Survey of Canada Current Research, 2002-17. 8 p.

Tricas, T., and A. Gill. 2011. Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

Tsoflias, S.L., J. Hutchinson, C. Dandridge, J. Nicholls, R.E. Henman, R. Buchanan, and R. Fechhelm. 2012. Environmental impact assessment of marine electromagnetic survey techniques. Paper presented at the SPE/APPEA International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, Perth, Australia, 11-13 September, 2012. 12 p.

United States Geological Survey, Conservation Division. 1979. OCS Platform Verification Program. Reston, Virginia.

Walker, M.M., C.E. Diebel, and J.L. Kirschvink. 2003. Detection and use of the earth's magnetic field by aquatic vertebrates. pp 53-74 *In* S.P. Collins and N.J. Marshall (eds.). Sensory Processing in Aquatic Environments. Springer, New York.

Ware, D.M. and T.C. Lambert. 1985. Early life history of Atlantic mackerel (*Scomber scombrus*) in the southern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. 42: 577-592.

Wareham, V.E. 2009. Updates on deep-sea coral distributions in the Newfoundland and Labrador and Arctic Regions, Northwest Atlantic. pp. 4-22 *In* K. Gilkinson and E. Edinger (eds.). The ecology of deep-sea corals of Newfoundland and Labrador waters: Biogeography, life history, biogeochemistry, and relation to fishes. Can. Tech. Rep. Fish. Aquat. Sci. 2830. vi + 136 p.

Wareham, V.E. and E.N. Edinger. 2007. Distribution of deep-sea coral in the Newfoundland and Labrador Region, Northwest Atlantic Ocean. Bull. Mar. Sci. 81(Supplement 1): 289-313.

Waring, G.T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker. 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. Mar. Mamm. Sci. 17: 703-717.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E Rozel (eds.). 2013. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments–2012. Vol. 1. 419 p. Accessed on 14 November 2013 at http://www.nmfs.noaa.gov/pr/sars/pdf/ao2012.pdf. Vol. 2. 79 p. Accessed on 14 November 2013 at http://www.nmfs.noaa.gov/pr/sars/pdf/ao2012_10stocks.pdf.

Wenner, C.A., and J.A. Musick. 1977. Biology of the morid fish, *(Antimora rostrata)* in the western North Atlantic. J. Fish. Res. Board Can. 34: 2362-2368.

Weinrich, M.T., C.R. Belt, and D. Morin. 2001. Behavior and ecology of the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) in coastal New England waters. Mar. Mamm. Sci. 17: 231-248.

Westerberg, H. and M.L. Begout-Anras. 2000. Orientation of silver eel (*Anguilla anguilla*) in a disturbed geomagnetic field. pp. 149-158. *In* Advances in Fish Telemetry. Proceedings of the Third Conference on Fish Telemetry. Moore, A. and I. Russel. (eds.). Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, UK.

Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. Mar. Ecol. Prog. Ser. 242: 295-304.

Whitehead, H. 2003. Sperm whale societies: Social evolution in the ocean. University of Chicago Press, Chicago. 431 p.

Whitehead, H. and S.K. Hooker. 2012. Uncertain status of the northern bottlenose whale *Hyperoodon ampullatus*: Population fragmentation, legacy of whaling and current threats. Endang. Spec. Res.19: 47-61.

Whitehead, H. and L.S. Weilgart. 2000. The sperm whale: Social females and roving males. pp. 154-172 *In* J. Mann, R. Connor, P.L. Tyack, and H. Whitehead (eds.). Cetacean Societies: Field Studies of Dolphins and Whales. University of Chicago Press. Chicago.

Whitehead, H., A. Faucher, S. Gowans, and S. McCarrey. 1997. Status of the northern bottlenose whale, *Hyperoodon ampullatus*, in the Gully, Nova Scotia. Can. Field Nat. 111: 287-292.

Williams, U. and J. Chardine. n.d. The Leach's storm-petrel: General information and handling instructions.

Wiltschko, W., and R. Wiltschko. 1995. Magnetic Orientation in Animals. Springer-Verlag, Berlin.

Woodruff, D.L., J.A. Ward, I.R. Schultz, V.I. Cullinan, and K.E. Marshall. 2012. Effects of Electromagnetic Fields on Fish and Invertebrates. Effects on Aquatic Organisms Fiscal Year 2011 Progress Report. Prepared for the U.S. Department of Energy. Available at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20813Final.pdf.

Wu, Y, T. Platt, C.C.L. Tang, and S. Sathyendranath. 2008. Regional differences in the timing of the spring bloom in the Labrador Sea. Mar. Ecol. Prog. Ser. 355: 9-20.

Personal Communications

Dr. J. Lawson, DFO, St. John's, NL, 2013

G. Sheppard, DFO, St. John's, NL, 2013

9.0 Appendices

Appendix A: Consultation Report

Appendix B: CWS Protocols

Appendix A

Consultation Report

Industry and Agency Consultations for Electromagnetic Geoservices Canada, Inc.'s (EMGS) Offshore Newfoundland CSEM Survey, 2014-2018

During preparation of the environmental assessment for EMGS's proposed 2014-2018 CSEM survey, 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 survey 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 location maps, were sent to the relevant agencies and industry stakeholder groups in early January 2014. 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 EMGS's proposed survey were undertaken with the following agencies, stakeholders and interest groups:

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

Issues and Concerns

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

Fisheries and Oceans Canada

DFO's EA and Major Projects' manager did not have any specific concerns or questions about the proposed CSEM survey. He noted that DFO would be providing comments on the proposed program, and potential interactions with fish, fisheries, marine mammals and DFO RV surveys, though the C-NLOPB's EA review process.

Environment Canada

EMGS and its consultants met with relevant Environment Canada managers to provide further general information on controlled source electromagnetic surveys and more specific details about the proposed 2014-2018 offshore Newfoundland CSEM program. Following a short presentation by EMGS's representative, EC managers had several questions about the retrieval of the receivers and potential effects on seabirds and sharks. EC managers asked if the concrete contains any deleterious substances that may not comply with the Board's "offshore chemicals selection criteria".

EMGS's representative explained how the receivers are detached from the concrete base to which they are attached and noted that the concrete material is designed to dissolve into sand after resting on the seabed for 9-12 months. It was also noted that the chemical composition of the concrete would be discussed in the EA document.

EMGS is not aware of any CSEM-related reactions from or impacts on marine fish species such as sharks or rays, and previous studies examining any such effects will be referenced in the EA. Regarding potential impacts on seabirds on the ocean surface, it was noted that the strength of the electromagnetic field is about the same level as a television set, and this field does not extend very far upwards above the source when it is being towed by the survey vessel. EC managers suggested that relevant studies on sea bird impacts listed on the Board's website should be referenced in the EA.

Nature Newfoundland and Labrador (NNL)

Following a short presentation by EMGS, NNL representatives asked several questions about CSEM technology. These dealt with the bandwidth, frequency and power supply of the source, the operating speed of the vessel when towing, and potential effects (i.e. disturbance) on fish or other marine animals from the electro magnetic field.

EMGS's representative noted that the source operates at a very low frequency, draws about 1,200 amps and receives its power supply from the vessel. He also explained that the receivers are able to "listen" to the earth's magnetic field and that the strength of the electro-magnetic field of the technology is about the same as the earth's background level.

Fish, Food and Allied Workers Union / One Ocean

EMGS met with the FFAW representatives and One Ocean's Director of Operations. Following EMGS's presentation, a number of general issues and comments were raised and discussed. These included questions about how CSEM technology works, the size of the area to be surveyed in 2014 and the anticipated starting date, among other general questions.

FFAW's Petroleum Industry Liaison manager representative pointed out that the proposed survey area includes fishing areas beyond 200 miles where Canadian vessels would be harvesting shrimp during survey operations. He noted that 2013 was the first year that these vessels have been allowed to fish shrimp in this offshore area.

FFAW representatives noted that they would expect the survey vessel to have an FLO on board and that the Union would arrange this with EMGS. One Ocean's manager suggested that the vessel might wish to access DFO VMS data from her office. It was also recommended that, prior to the start of the survey, the proponent should meet again with the FFAW and One Ocean when the 2014 survey area has been finalized. EMGS's representative noted that, depending on the size of the area to be surveyed, he would expect activities would commence in early May and continue for about three months.

The FFAW noted that, in 2014, there may be three other (seismic) survey vessels active in the same general area as the one EMGS is proposing to survey, and asked if this would mean any increase in potential impacts on fisheries activities. EMGS representative said he did not think this would be an issue.

In his final comments, the FFAW Petroleum Industry Liaison manager said that the Union would like to have a copy of the slides from the presentation for the purpose of briefing other FFAW officials and fisher reps. He also noted that the FFAW would prefer a "short" EA document.

Association of Seafood Producers (ASP)

ASP's Executive Director responded that he had no immediate questions about the proposed program, but he would contact the proponent's consultant if anything comes to mind. He also had some general comments on the nature of the data depicted in the species harvesting maps received from the proponent's consultants. These questions were addressed in a follow-up email to ASP's Executive Director,

Ocean Choice International

OCI's representative reported that his firm would be actively harvesting shrimp, turbot and redfish in the proposed survey area over during the next 6-8 months. He also noted that it would be very useful if the species harvesting maps could also include NAFO catch information, i.e. harvesting locations of foreign fishing vessels.

Other Fishing Industry Stakeholders

To date, there has been no response from other fisheries industry stakeholders contacted for the EMGS CSEM EA.

Other Communications

On 6 February 2014, EMGS inquired of Transport Canada (TC) whether or not their vessel would require a Coastal Trading Letter of Compliance. The TC response was that a Coastal Trading Letter of Compliance was not required for the EMGS vessel.

Appendix 1. Agencies and Persons Consulted

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

Fisheries and Oceans Canada

Jason Kelly, Co-ordinator, Environmental Assessment & Major Projects, Oceans, Habitat & Species at Risk Branch

Environment Canada (Environmental Protection Branch)

Glenn Troke, EA Co-ordinator
Natasha Boyd, Permit Officer, Marine Programs
Joshua Mailhiot, EA Officer
Shelley Decker, EA Analyst

Transport Canada

Randy Decker, Senior Environmental Assessment Officer

Nature NL (and member organizations)

Dr. Len Zedel
Dr. Allan Stein

One Ocean

Maureen Murphy, Director of Operations

Fish, Food and Allied Workers Union (FFAW)

Johan Joensen, Petroleum Industry Liaison
Robin Saunders-Lee

Association of Seafood Producers

E. Derek Butler, Executive Director

Ocean Choice International

Rick Ellis, Fleet Manager

Icewater Seafoods

Dennis Slade, Fisheries Consultant

Tom Osbourne, Plant Manager, Arnold's Cove

Clearwater Seafoods Limited Partnership

Catherine Boyd, Manager, Corporate Affairs

Newfound Resources Ltd. (NRL)

Brian MacNamara, President

Groundfish Enterprise Allocation Council (GEAC); Canadian Association of Prawn Producers (CAPP)

Bruce Chapman, Executive Director (GEAC and CAPP)

Appendix B

CWS Protocols

Birds and Oil - CWS Response Plan Guidance

In all circumstances where a polluter is identified the burden of cleanup and response lies with the polluter. However, responsibility for government overview of a response to an oil spill depends on the source of the spill. The identified **lead agency** has responsibility to monitor an oil spill response and to take control if an appropriate response is not undertaken by a polluter or their agent.

Lead agency responsibilities lie with:

- **Environment Canada**
  - For spills and incidents on federal lands and from federal vessels
  - Potentially for land-based incidents in waters frequented by fish
  - May take lead if environment is not being protected by other leads, Cabinet Directive 1973
- **Canadian Coast Guard**
  - For spills from ships
  - All spills of unknown sources in marine environment
- **Provincial Department of Environment**
  - For spills from land-based sources
- **Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and Canada-Nova Scotia Offshore Petroleum Board (C-NSOPB)**
  - For spills related to offshore oil and gas exploration and production
- **Transport Canada**
  - To investigate ship source and mystery spills in the marine environment

The Canadian Wildlife Service has the responsibility for licensing activities which involve the handling or disturbance of birds, and of providing advice and often direction to other agencies, responders and the polluter during oil spill incidents.

1. Hazing[1]

Purpose: Prevent birds from coming in contact with oil

Options:

- Hazing by helicopter
- Hazing by FRC or other watercraft
- Release of scare devices (e.g. Breco Buoys, Phoenix Wailer)
- Use of hazing sound makers: propane cannons, whizzers, bangers, pyrotechnic devices etc.

Scare devices have a limited range of influence and likely are not a viable option with a large slick. Use of Breco Buoys and Phoenix Wailers can be used but we consider them to be largely ineffective in the situation of a large slick. Logistically, helicopter hazing would be difficult unless it was possible for a helicopter to remain on a platform offshore overnight. Hazing by FRC or other vessels would be ideal.

[1] There are several scare techniques which may be effective and do not require a permit, however a permit under the Migratory Bird Regulations **is required** for the use of aircraft or firearms (defined as capable of emitting at projectile at more than 495 feet per second). Propane cannons, blank pistols or pyrotechnical pistols firing crackers shells with **less than 495fps are legal without a permit**. Most scare tactics are relatively short lived in terms of effectiveness as birds acclimatize to the disturbance so scare techniques should be alternated to be effective.

Short-term focused hazing by the most expedient means should be attempted to move the birds away from the slick, if logistical conditions permit. Vessels at the site should have the ability to use sound makers (propane canons, pyrotechnic devices) to disperse birds in local areas. Such equipment should be deployed immediately to these ships with trained personnel to operate them. The vessels on site should be tasked to actively search and monitor for congregations of birds which could be vulnerable to oiling. If such groups are found then attempts should be made to disperse the birds away from the oil.

2. Disperse oil

Purpose: Prevent birds from contacting oil by getting oil off the surface of the water as soon as possible.

Options:

- Dispersants
- Mechanical dispersal with FRCs or other vessels
- Natural dispersal by environmental conditions

For small spills, mechanical dispersal would be the preferred method.

3. Bird Collection[2]

Purpose: Implement a humane response to oiled birds as required by Environment Canada's National Policy on Oiled Birds and Oiled Species At Risk (http://www.ec.gc.ca/ee-ue/default.asp?lang=En&n=A4DD63E4-1)

Options:

- The only option would be a ship-based effort to detect and collect dead and live oiled birds, both within the slick and adjacent to it.

All vessels in or near the slick should understand the need to collect birds. All vessels should have dip-nets, large plastic collecting bags to hold dead birds, and cloth bags or cardboard boxes in which to hold live oiled birds. Efforts should be made to retrieve live oiled birds to ensure they are dealt with humanely.

4. Wildlife monitoring

Purpose: Determine potential impact of spill

Options:

- Ship-based surveys for oiled and unoiled wildlife
- Aerial surveys for oiled and unoiled wildlife. Will require structured surveys (e.g. strip or transect surveys of spill area)
- Placement of CWS staff on vessels and aircraft

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[2] Only those individuals authorized to do so (nominee on an existing federal salvage permit) can be involved with the collection of migratory birds.

Dedicated ship-based bird surveys should be initiated immediately. Ideally arrangements should be made to have a CWS observer on vessels or flights. In addition trained seabird observers need to be placed on all vessels monitoring a slick. This should continue until the slick is dispersed.

5. Beached Bird Surveys

Purpose: Determine impact of spill on wildlife and retrieve any live oiled wildlife on beaches.

Options:

- Conduct daily beached bird surveys during the incident and until one week after slick has been removed or dissipated.

CWS or other government officials (CCG, Enforcement Officers) will oversee the collection of dead and live oiled birds[3] as instructed in CWS' protocol for collecting birds during an oil spill response. This would only be required in circumstances where a large number of birds are potentially oiled or if the spill occurs in a sensitive area.

6. Drift Blocks

Purpose: Drift blocks may be deployed in slick to provide an estimate of bird mortality.

Options:

- Release from vessel
- Release from aircraft

The deployment of drift blocks would only be expected if there was a large spill and blocks should be released as soon as possible after a spill (CWS should be consulted to determine protocol for drift block deployment and tracking). The polluter or their agent would be expected to ensure drift blocks are tracked and collected as appropriate.

7. Live oiled bird response

Purpose: Implement a humane response to oiled birds as required by Environment Canada's National Policy On Oiled Birds And Oiled Species At Risk

Options:

- Rehabilitation
- Euthanization

CWS will be consulted to determine the appropriate response and treatment strategies which may include cleaning and rehabilitation or euthanization. CWS policy specifically requires that species at risk or other species of concern be rehabilitated.

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[3] Only those individuals authorized to do so (nominee on an existing federal salvage permit) can be involved with the collection of migratory birds.

PROTOCOL FOR COLLECTING BIRDS DURING AN OIL SPILL RESPONSE

Anyone collecting migratory birds must be a nominee on an existing federal salvage permit

Collection of dead birds

1) Every time a beach is swept, select two oiled birds to be retained as possible evidence, preferably from different parts of the beach. For each of these two birds:
   - Individually wrap the bird in aluminum foil,
   - Place the wrapped bird in its own evidence bag,
   - Completely fill out a chain of custody form,
   - Write on the bag the date and location, and record that bird was found dead, and
   - Place evidence bag in a secure place until retrieved by appropriate Environment Canada personnel.

2) To avoid oil cross-contamination, it is vital that:
   - Clean gloves are used prior to handling each bird, and
   - Birds are wrapped in foil as soon as they are found.

3) Place each remaining bird found on the beach in its own generic plastic bag, and:
   - Write on the bag the date and location, and record that the bird was found dead,
   - Record on the bag whether the bird was OILED or NOT OILED, and
   - Treat bird parts the same as whole birds.

4) If it is not feasible to individually bag all birds found on the beach:
   - Put remaining oiled birds in one or more large bags,
   - Put remaining un-oiled birds in separate large bag(s) from oiled birds,
   - Write on each bag the date and location, and record that birds were found dead,
   - Record on the bags contain OILED or NOT OILED birds, and
   - Keep birds from different beaches in separate bags.

5) Make arrangements to retrieve all oiled and un-oiled birds with:
   - CWS personnel if oiled wildlife rehabilitation response is NOT in place, or
   - Wildlife rehabilitator if oiled wildlife rehabilitation response is in place.

Collection of live birds

A. If oiled wildlife response is NOT in place:

1. If you are permitted to humanely euthanize the oiled bird, do so following the standard protocol and:
   - Individually wrap two euthanized birds in aluminum foil,
   - Place the wrapped bird in its own evidence bag,
   - Completely fill out a chain of custody form,
   - Write on the bag the date and location, and record that bird was found alive, and
   - Place evidence bag in a secure place until retrieved by appropriate Environment Canada personnel.

2. Record and bag remainder of euthanized oiled birds as outlined in points 3, 4 and 5 on reverse side of this form.

3. If you are not permitted to euthanize oiled birds, do not feel comfortable doing so, or have found a bird listed under COSEWIC (e.g., Harlequin Duck, Ivory Gull):
   - Place the oiled bird in a cardboard box,
   - Label box with date and location where bird was recovered, and
   - Place in warm, quiet area until handed over to CWS personnel for euthanisation or rehabilitation.

B. If oiled wildlife response is in place:

1. Place the oiled bird in a cardboard box,
2. Label box with date and location where bird was recovered, and
3. Place in warm, quiet area until handed over to wildlife rehabilitator for rehabilitation or euthanisation.

Important information when catching and placing birds in box:

- Handle birds with gloves, preferably disposable ones, and
- Lid and walls of box must have sufficient holes to allow proper ventilation.

Place only one murre, seaduck, or other large bird per box

Two dovekies may be placed together in box if both are only slightly oiled (i.e., <25% of body covered)

PROTOCOL FOR COLLECTING DEAD BIRDS FROM PLATFORMS
(*FOR BIRDS THAT ARE NOT ASSOCIATED WITH A POLLUTION EVENT*)

Anyone collecting migratory birds must be a nominee on an existing federal salvage permit

Dead birds are occasionally found on ships or platforms offshore. If more than 10 birds are 10 birds are found dead in the same event, they need to be collected and sent ashore to ashore to Canadian Wildlife Service personnel at Environment Canada. This will help us help us determine the cause of death.

1) While wearing disposable gloves, place dead bird in a plastic bag and tie shut. Whenever Whenever possible, birds should be placed individually in a plastic bag or wrapped in aluminum in aluminum foil. *If bird is oiled, it is especially important to wrap in foil and place in its own bag in its own bag (see Protocol for collecting oiled birds during an oil spill response).*

2) Write directly on the bag with permanent marker OR attach a label to the bag with the with the following information:
   i. Date the bird was collected
   ii. Location of where the bird was found (e.g., Terra Nova FPSO, or location of vessel) vessel)
   iii. Name and contact information of person who collected the bird
   iv. Identification of the bird, if possible (e.g., gull, petrel, songbird, etc.)
   v. Any other information that might be relevant (e.g., fog conditions, wind, etc.) etc.)

3) Store bag(s) in a cool place (e.g., outdoors during winter or in cooler with ice packs) that is packs) that is sheltered from scavenging birds. Freeze birds if they are to be retained for more retained for more than several days.

4) If birds cannot be brought ashore, document the incident on the datasheet provided. *Note: All* provided. *Note: All birds associated with a pollution event, and all birds associated with any with any incident where more than 10 birds are found in the same event, need to be collected be collected and sent ashore.*

5) After removing and disposing of gloves, thoroughly wash hands with disinfecting soap. soap.

Once ashore, make arrangements with Environment Canada's Canadian Wildlife Service Wildlife Service to pick up stored bag(s). In Newfoundland and Labrador, call (709) 772-(709) 772-5568 (Sabina Wilhelm) to arrange for the collection of seabirds. In Nova Scotia, Nova Scotia, call EC-CWS at 902-426-9641 (Carina Gjerdrum) or 426-1900 (Andrew (Andrew Boyne).

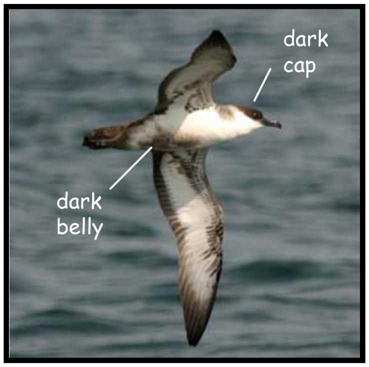
Environment Canada Environnement Canada
Atlantic Region Région de l'Atlantique

June 2012

Pelagic Seabirds of Atlantic Canada

Shearwaters and Fulmars

Greater Shearwater

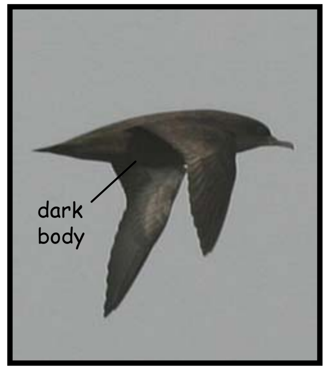


White Hagdown, White Bawk

Manx Shearwater

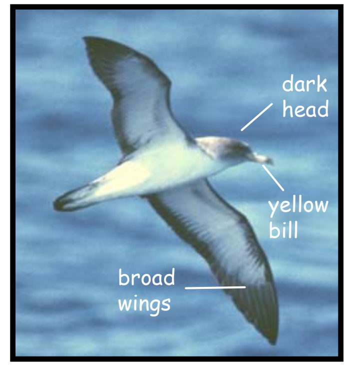
Hagdown, Bawk

Sooty Shearwater



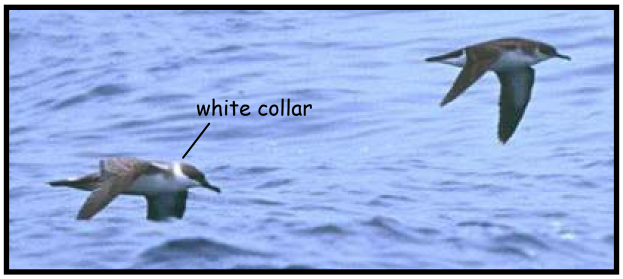
Black Hagdown, Black Bawk

Cory's Shearwater



Hagdown, Bawk

Greater (left) and Manx Shearwater

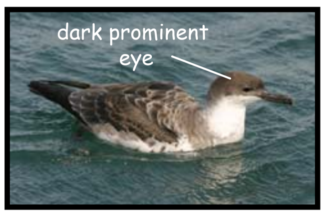


Cory's (left) and Manx Shearwater

Northern Fulmar

Noddy, John Down

Greater Shearwater



Storm-Petrels

Wilson's

pale
coverts

Leach's

Mother Carey's Chicken, Carey Chick

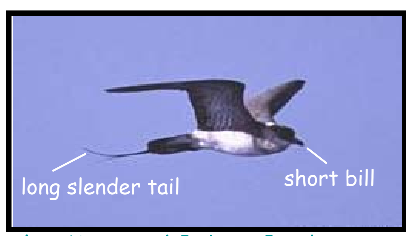
Jaegers and Skuas

Pomarine Jaeger

both
have
slow
steady
wing
beats

Parasitic Jaeger

Long-tailed Jaeger



Great Skua

All Jaegers are commonly known as Shit-eater, Shit King and Bo'sun Bird

Sea Hen, Grand Goose

Gannets

Northern

Adult

Immature

Gaunt, Gannet

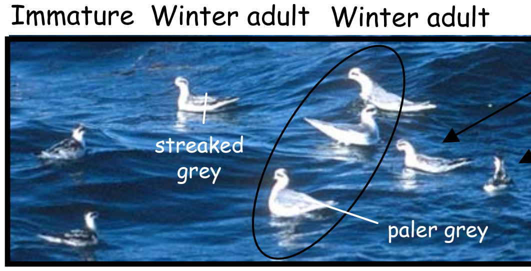
Phalaropes

Red-necked

Immature Winter adult

Red

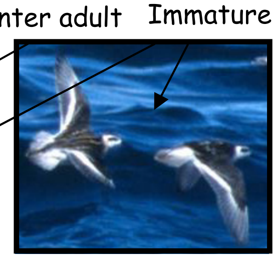
Winter adult



Whale Bird

Red-necked

Winter adult Immature



Gale Bird, Gill Bird,
Poverty Bird

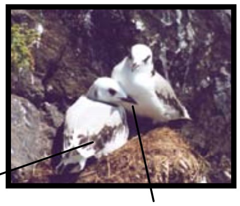
Environment Canada Atlantic Region
Environnement Canada Région de l'Atlantique
PETRO-CANADA

Black wing-tipped Gulls

Black-legged Kittiwake

Breeding adult

Winter adult



Immature (1st winter)

bold black wing pattern

black bill

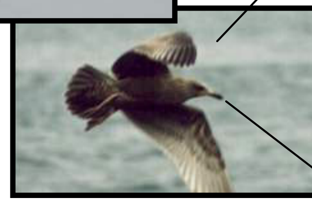
Tickelace, Tickle ass

Herring Gull

Adult

has brownish head in winter

more uniform brown than GBBG in 1st and 2nd winter



Immature (1st winter)

Sea Gull, Blue Gull, Glue Gull, Bluey

black bill in 1st winter and black tip in 2nd winter for both species

Great Black-backed Gull

Adult

marbled underwing coverts

Immature (2nd or 3rd winter)

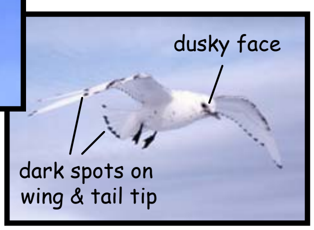
Saddleback, Saddler

White-winged Gulls

Ivory Gull

Adult

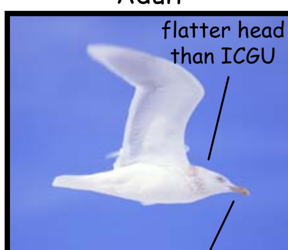
Immature



Ice Partridge, Ice Gull, Seal Bird

Glaucous Gull

Adult



longer & larger bill than ICGU

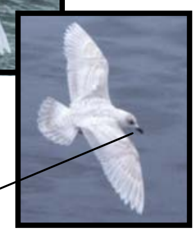
Immature (2nd winter)

Large Ice Gull, Burgomaster, White Minister

Iceland Gull

Adult

Immature (1st winter)



black bill in 1st winter and black tip in 2nd winter for both species

White-winged Gull, Ice Gull

Winter-plumaged Auks

Thick-billed Murre

white gape line

Dovekie

Bullbird

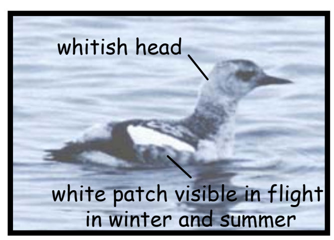
Common Murre

Murre

Razorbill

Tinker

Black Guillemot



Sea Pigeon, Pigeon

Atlantic Puffin

Adult Immature

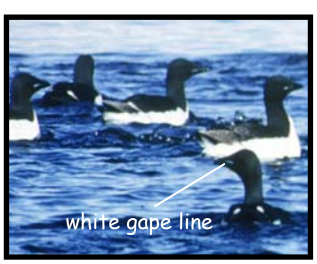
Sea Parrot, Hatchet-bill

Breeding-plumaged Auks

Common Murre

can appear browner than TBMU and RAZO

Thick-billed Murre

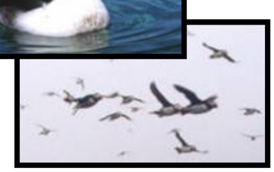


Turre

Razorbill

Black Guillemot

Atlantic Puffin



Names in green refer to Newfoundland and Labrador common names

The Leach's Storm-Petrel:
General information and handling instructions

Urban Williams (Petro-Canada)
&
John Chardine (Canadian Wildlife Service)

The Grand Banks is an area that is frequented by large numbers of seabirds, representing a variety of species. Large populations are found in this area in both summer and winter, and come from the Arctic, northern Europe, and the south Atlantic, as well as from colonies along the Newfoundland Coast. One of the species found in the area of the Terra Nova Field is the Leach's Storm-Petrel (*Oceanodroma leucorhoa*).

The Bird:
Leach's Storm-Petrels are small seabirds, not much bigger than a Robin. They have relatively long wings and are excellent fliers. Leach's Storm-Petrels are dark brown in colour and show a conspicuous white patch at the base of the tail. In the hand, you can easily notice a small tube at the top of their bill, and you will also notice that the birds have a peculiar, not unpleasant smell (although some Newfoundlanders call these birds "Stink Birds"). Storm-Petrels are easy prey for gulls and other predators, and so to protect themselves from predation, Leach's Storm-Petrels are only active at night when on land at the breeding colonies.

Nesting Habitat:

Leach's Storm-Petrels are distributed widely in the northern hemisphere, however, their major centres of distribution are Alaska and Newfoundland. The bird breeds on offshore islands, often in colonies numbering tens or hundreds of thousands of pairs, even millions at one colony in Newfoundland. The nest is a chamber, sometimes lined with a some grass, located at the end of a narrow tunnel dug in the topsoil.. Depending on the colony, burrows may be under conifer or raspberry thickets or open grassland.

Reproduction:

In Newfoundland, Leach's Storm-Petrels lay their single egg in May and June. The egg is incubated by both parents alternately, sometimes for stretches exceeding 48 hours. The egg is incubated for 41-42 days, which is a long time for such a small egg. The peak hatching period is in the last half of July. The young petrel remains in the tunnel for about 63-70 days. Once breeding is over in late-August or early September, the birds disperse from the colonies and migrate to their wintering grounds in the Atlantic. September is the most important period for migration of Storm-Petrels to the offshore areas such as near the Terra Nova field.

Populations:

Canada alone supports more than 5 million pairs of Leach's Storm-Petrels. Most of them are found in Newfoundland. The Leach's Storm-Petrel colony located on Baccalieu Island is the largest known colony of this species.

Nesting sites for Leach's Storm-Petrels are found along the southeast coast of Newfoundland. These are - i) Witless Bay Islands (780,00 nesting pairs), ii) Iron Island (10,000 nesting pairs), iii) Corbin Island (100,000 nesting pairs), iv) Middle Lawn Island (26,000 nesting pairs), v) Baccalieu Island (3,336,000 nesting pairs), vi) Green Island (72,000 nesting pairs), and vii) St. Pierre Grand Columbier (100,000 nesting pairs).

Feeding Habits:

Leach's Storm-Petrels feed at the sea surface, seizing prey in flight. Prey usually consists of myctophid fish and amphipods. The chick is fed planktonic crustaceans, drops of stomach oil from the adult bird, and small fish taken far out at sea. Storm-Petrels feed far out from the colony and it would be reasonable to assume that birds nesting in eastern Newfoundland can be found feeding around the Terra Nova site.

The Problem:

As identified in the C-NOPB Decision 97-02, seabirds such as Leach's Storm-Petrels are attracted to lights on offshore platforms and vessels. Experience has shown that Storm-Petrels may be confused by lights from ships and oil rigs, particularly on foggy nights, and will crash into lighted areas such as decks and portholes. Fortunately, this type of accident does not often result in mortality, however, once on deck the bird will sometimes seek a dark corner in which to hide, and can become fouled with oil or other contaminants on deck.

Period of Concern:

Leach's Storm-Petrels are in the Terra Nova area from about May until October and birds could be attracted to lights at any time throughout this period. The period of greatest risk of attraction to lights on vessels appears to be at the end of the breeding season when adults and newly fledged chicks are dispersing from the colonies and migrating to their offshore wintering grounds. September is the most important period for migration of storm-petrels to the offshore areas. Past experience suggests that any foggy night in September could be problematic and may result in hundreds or even thousands of birds colliding with the vessel.

The Mitigation:

On nights when storm-petrels are colliding with the vessel, the following steps should be taken to ensure that as many birds as possible are safely returned to their natural habitat.

- All decks of the vessel should be patrolled as often as is needed to ensure that birds are picked up and boxed (see below) as soon as possible after they have collided with the vessel. After collision, birds will often "freeze" below lights on deck or seek dark areas underneath machinery and the like.
- Birds should be collected by hand and gently placed in small cardboard boxes. Care should be taken not to overcrowd the birds and a maximum of 10-15 birds should be placed in each box, depending upon its size. The birds are very easy to pick up as they are poor walkers and will not fly up off the deck so long as the area is well-lit. They will make a squealing sound as they are picked up- this is of no concern and is a natural reaction to be handled (the birds probably think they have been captured to be eaten!).
- When the birds are placed in the box the cover should be put in place and the birds left to recover in a dark, cool, quiet place for about 5-10 minutes. The birds initially will be quite active in the box but will soon settle down.
- Following the recovery period, the box containing the birds should be brought to the bow of the boat or to some other area of the vessel that has minimal (if any) lighting. The cover should be opened and each bird individually removed by hand. The release is usually accomplished by letting the bird drop over the side of the vessel. There is no need to throw the bird up in the air at release time. If the birds are released at a well-lit part of the vessel they usually fly back towards the vessel and collide again.
- If any of the birds are wet when they are captured (i.e. they drop into water on the deck) then they should be placed in a cardboard box and let dry. Once the bird is dry it can be released as per the previous instruction. Also, temporarily injured birds should be left for longer to recover in the cardboard box before release.
- Any birds contaminated with oil should be kept in a separate box and not mixed with clean birds. Contact Canadian Wildlife Service at (709) 772-5585 in NL or (902) 426-1900 in NS for instructions on how to deal with contaminated birds.
- In the event that some birds are captured near dawn and are not fully recovered before daylight, they should be kept until the next night for release. Storm-Petrels should not be

released in daylight as at this time they are very vulnerable to predation by gulls. Birds should be kept in the cardboard box in a cool, quiet place for the day, and do not need to be fed.

- Someone should be given the responsibility of maintaining a tally of birds that have been captured and released, and those that were found dead on deck. These notes should be kept with other information about the conditions on the night of the incident (moonlight, fog, weather), date, time, etc). THIS IS A VERY IMPORTANT PART OF THE EXERCISE AS IT IS THE ONLY WAY WE CAN LEARN MORE ABOUT THESE EVENTS.

Handling Instructions:

- Leach's Storm-Petrels are small, gentle birds and should be handled with care at all times.
- It is recommended that the person handling the birds should wear thin rubber gloves or clean, cotton work gloves. The purpose of the gloves is to protect both the Storm-Petrel and the worker.
- As mentioned Storm-Petrel's have a strong odor that will stick to the handler's hands. Washing with soap and water will remove most of the smell.
- Handling Leach's Storm-Petrels does not pose a health hazard to the worker, however some birds may have parasites on their feathers, such as feather lice. These parasites do not present any risk to humans, however, as a precaution we recommend wearing cotton work gloves or thin rubber gloves while handling birds and washing of hands afterwards.

Wilson's Storm Petrels:

A relative of the Leach's Storm-Petrel is the Wilson's Storm-Petrel. They breed in the south Atlantic and Antarctica and migrate north in our spring to spend the summer in Newfoundland waters. This species is very numerous on the Grand Banks in the summer, and shares the same nocturnal habits as the Leach's Storm-Petrel. Thus it is possible that Wilson's Storm-Petrels may also be attracted to the lights of a vessel at night. The two species are very similar and should be handled in the same way as described above for our Leach's Storm-Petrel.

Permits:
A permit to handle storm-petrels issued by the Canadian Wildlife Service will be held on board the vessel to cover personnel involved in bird collision incidents.

STRANDED BIRD ENCOUNTERS

When you find a bird on deck at night, please provide the following information (instructions are on back)

Vessel/Platform Name____
Recorder's Name(s) ____

Date	Wind direction	Beaufort Sea state	Visibility (clear, overcast, fog)	Species*	Number	Bird condition when found (oiled, wet, dry, dead)	Comments

**** Note: If you do not know the species, please try to indicate whether it is a gull, petrel, songbird, gannet, etc.***

* Please return to Carina Gjerdrum, Environment Canada, 45 Alderney Drive, Dartmouth, Nova Scotia B2Y 2N6 **carina.gjerdrum@ec.gc.ca**

Phone (902) 426-9641
Fax (902) 426-6434

STRANDED BIRD ENCOUNTERS

INSTRUCTIONS FOR RECORDING INFORMATION ON STRANDED BIRD ENCOUNTERS

Vessel/Platform: Give the name of the vessel or platform on which you are working.
Recorder's Name: Indicate the person(s) recording information.

Date: Give the date that the birds were encountered.
Wind direction: the direction from which the wind is blowing.
Beaufort Sea state: the wind force measured on Beaufort scale.
Visibility: indicate whether it is a clear night (can see stars), overcast, or foggy.
Species: the species of bird encountered.
Number: the number of birds encountered at that particular time.
Condition: the condition of the bird when encountered (wet, dry, oiled, dead, etc.)

Beaufort Sea State

0 = calm (glassy) 0 knots
1 = light (ripples) 1 - 3 knots
2 = breeze (wavelets) 4 - 6 knots
3 = gentle breeze (large wavelets) 7 - 10 knots
4 = moderate breeze (whitecaps) 11 - 16 knots
5 = fresh breeze (spray, waves) 17 - 21 knots
6 = strong breeze (wave crests) 22 - 27 knots
7 = near gale (streaks, foam) 28 - 33 knots
8 = whole gale (moderate waves) 34 - 40 knots
9 = strong gale (high waves) 41 - 47 knots
10 = storm (breaking seas) 48 - 55 knots
11 = Hurricane - > 60 knots

* Please return to Carina Gjerdrum, Environment Canada, 45 Alderney Drive, Dartmouth, Nova Scotia B2Y 2N6 **carina.gjerdrum@ec.gc.ca**

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